

The Cell

Dr. Dave's Teaching Manual

Second Edition

David Purvis, Ph.D.

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Introduction

This manual will give you, the teacher, everything you need to teach a unit on the cell. From the first topic to the last class, it describes how to set up teaching presentations so that they are dynamic, exciting, and meaningful for students. You will see how easy it is to prepare for classes, and you will discover that this teaching approach allows students to experience real learning and real academic success.

Science is a wonderful topic to teach to children. Instead of lecturing for long periods or bogging students down with an avalanche of worksheets, this manual shows you how to make your presentations interesting and challenging to the mind of a child. This is easy to do—once you know how to do it. Children already possess a natural curiosity for science. This manual shows you how to take advantage of their curiosity and to present lessons in a way that creates an exciting learning environment in your classroom.

This manual describes easy teacher demonstrations that use basic materials such as balloons, playdough, bubble wrap, and plastic sandwich bags. Most of them take only minutes to set up. Fill a plastic bag with colored water as you teach about cell membranes, or display several identical balls of playdough as students learn about bacterial cells. Use balloons to teach about how cells can shrink or swell depending on whether water is moving in or out of them by osmosis. You can be sure that the students will be watching you as you show them a bubble-wrap creature to illustrate cell theory.

Following the teacher presentations, you can run various student activities at levels that are appropriate for your students' abilities. This manual is flexible, and there are many opportunities for integration of core subjects. In addition, you can choose from many demonstrations, visual projects, experiments, group projects, and research projects. A unit on the cell offers opportunities for students to use microscopes to view different cells. Students can prepare and view their own cheek cells, as well as plant, fungal, and protist cells. The manual will also show you how to set up and run several diffusion and osmosis experiments. These experiments engage students in hands-on, inquiry-based science and apply the scientific method, giving students the opportunity to discover and construct knowledge for themselves. The manual also describes how to guide students through a full laboratory report, providing useful information on writing the introduction, materials, procedure, results, and conclusion.

This unit is naturally rich in life science topics. Students first learn about the cell membrane and understand why the membrane must be made of a substance that is not soluble in water. They go on to learn how simple substances such as oxygen, carbon dioxide, sugar, and water pass through the cell membrane by diffusion and osmosis. It can be difficult for young students to appreciate the relative sizes of prokaryotic cells, eukaryotic cells, and viruses, so there are images available for projection that will give the students a sense of these size differences. The students will also learn about the relationships among chromosomes, DNA, and genes, as well as a general description of the genetic code. The manual concludes with lessons on viruses, focusing on the viruses that cause colds and flu.

This manual also offers suggestions for assessment and shows examples of exemplary student work. In addition, it provides tips on classroom management, critical-thinking questions, modifications, clean-up, and safety. The Teacher Resources section contains a variety of

Cell Theory

Objectives

- Students will understand that all living organisms are made of cells.
- Students will describe the function of the cell membrane.

Key Points

- All living organisms are made of cells.
- All cells are surrounded by a membrane.
- The cell membrane contains whatever is inside the cell.
- The first cells viewed under a microscope were from a cork tree.
- Viruses are not made of cells and therefore are not considered living.
- A raw egg with its shell removed serves as an excellent model of a cell.

Vocabulary Words

Cell Theory

Microscope

Cell Membrane

Start the Class

Introduce this unit to the students by explaining to them that an undisputed theory in biology is that all living organisms are made of cells. Challenge the students to name any living organism that is not made of cells. Whatever animal, plant, or microorganism they happen to name, you can affirm that it is made of cells. If the students don't mention bacteria, be sure that you do, stating that even bacteria are organisms that are made of cells, although each bacterium is made of only one cell. Project the description below, which summarizes the three key features of *cell theory*, and go over it with the students.

Cell Theory

The basic unit of life is the cell.
All living organisms are made of cells.
All cells come from cells.

You can pique the students' interest in a later topic by mentioning viruses. Viruses are completely different than other living organisms. They are not made of cells; however, many scientists do not believe that viruses are actually living organisms.

Materials

The students should compile a list of all the materials that they use during the entire experiment. You might recommend that they write a draft of the materials, adding to it as they progress through the experiment, and then make a final version when there are no more materials to add to the list.

Parts of Report	Criteria
Introduction	<ul style="list-style-type: none">• One paragraph• States the purpose of the experiment• Contains a hypothesis• Includes other predictions about what might happen
Materials	<ul style="list-style-type: none">• A list of all the materials used in the experiment
Procedure	<ul style="list-style-type: none">• The steps of the experiment presented in numerical order: <i>Step 1. Measure circumference of egg</i> <i>Step 2. Remove eggshell by soaking egg in vinegar</i> <i>Step 3. ...</i>
Results	<ul style="list-style-type: none">• Includes accurate measurements• Uses of metric units correctly• Includes a results table created using a ruler or a computer
Conclusion	<ul style="list-style-type: none">• One- or two-paragraph discussion of the experiment<ul style="list-style-type: none">- Explain the results.- Was your hypothesis correct?- What did you learn?- Did you have any problems?- What could you do differently?

Student Activity: Robert Hooke

Have the students complete a worksheet that asks them to imagine that they are Robert Hooke seeing cells through a microscope for the first time. They will write a paragraph describing what they are seeing using their own words. See page 59 in the Teacher Resources section of this manual for the downloadable worksheet.

Teaching Tip: The concept that oil won't dissolve in water is key to understanding why membranes must be made of lipids. Membranes made of sugar or any other substances that dissolve in water would not work; the membrane would simply fall apart. A quick demonstration to illustrate this point is to pour some sugar into a cup of water to show the students how easy it is to dissolve the sugar into the water.

Teacher Demonstration: Margarine Cell Membrane

For this optional demonstration, dip your finger into a glob of margarine, butter, or shortening, and then put your finger in a cup of water to demonstrate that the lipid is *insoluble* in water; the margarine does not rinse off your finger. Another way of demonstrating this is to smear margarine all over the outside of a small plastic container that represents a cell. Place this container into a larger container of water to show that the “lipid” membrane doesn't dissolve in water. Stress again that basic cells could not exist without membranes, which must be made of a substance that cannot be soluble in water.

Teacher Tip: Use a paper towel to smear the container with margarine to help keep your hands clean.

Fact: Margarine is a vegetable oil that is used as a substitute for butter. Unlike oils, margarines are solid at room temperature.



Teacher Demonstration: Candle Wax in Water

Wax is another kind of lipid. You can show the students that, like oil, wax will not mix with water. Hold a burning candle over a cup of water, and allow a few drops of wax to fall into the water. The molten wax will turn into a solid as soon as it hits the cooler water.

While this is an interesting phase transition, the main point is to illustrate that the wax doesn't mix with the water. You can actually remove the solid pieces of wax with your hand to show to the students. Tell the students that most candle wax is made from paraffin, which is a product refined from petroleum. All processed petroleum products, including gasoline, oils, and asphalt, are similar to biological lipids in that they are not soluble in water.



Lipids are classified as *hydrophobic* substances, while sugar is a *hydrophilic* substance. Explain to the students that *hydro* means water, and *phobic* means to be afraid; *hydrophobic* literally means to be afraid of water. Oils, fats, and waxes are all hydrophobic substances because they will not dissolve in water. In contrast, the suffix *philic* means to like or love. *Hydrophilic* thus means to love water. Sugar will dissolve in water and is therefore hydrophilic.

It may be appropriate for some of the students to learn that water is classified as a polar substance, while lipids are nonpolar. A good mnemonic to help the students remember this distinction is for them to imagine a polar bear swimming through water but not oil.

Student Activity: The Eggcellent Experiment, Day 3

Have the students remove their egg from the water and measure its circumference. This measurement will probably be close to the previous measurement. Discuss with the students how the egg swells from its original size because of the movement of water (and vinegar) into it. Keep your discussion simple, as the next topics (diffusion and osmosis) will cover this concept in more detail. Simply explain that water can move through the membrane, and the egg will shrink or swell depending on which direction the water is moving. The more water that flows into the egg, the bigger the egg will get. Have the students record their results in their results table, which should look something like the one below.

Have the students prepare a new cup of water in which to soak the egg. Most students enjoy getting to use food coloring. Ask them to choose a color to add to their water. This will allow them to determine whether or not the food coloring can go through the membrane. Caution the students to be conservative with the food coloring—a few drops is all they need.



Eggcellent Experiment Results Table		
Day	Solution	Circumference
1	None	14 cm
2	Vinegar	16 cm
3	Water	16.5 cm
4	Water + food coloring	

Student Activity: Venn Diagram

Have the students complete a Venn diagram comparing the cell membrane to a plastic bag. There are two versions of this worksheet; choose the one that is appropriate for your students. See pages 60-62 in the Teacher Resources section of this manual for the downloadable worksheets and an answer key.

Divide the students into pairs, cut as many dialysis membrane strips as you have student pairs, and soak the strips in water. Prepare a starch-glucose solution by combining about a teaspoon of soluble starch and a healthy heap of glucose in a cup of water. It is important to add a lot of glucose so that its concentration is high enough to be detected by glucose test strips. Mix the solution, and then pour enough cups for each pair of students to have one.

Materials

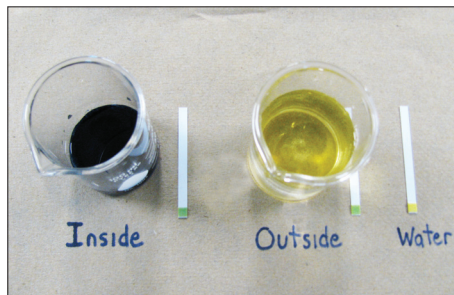
dialysis membranes	water
soluble starch	glucose
string or clamps	pipettes
plastic wrap	cups
glucose test strips	iodine

Give the student pairs a dialysis membrane strip, a small cup of the starch-glucose solution, a pipette, string or clamps, a cup of water, and a small sheet of plastic wrap. Prepare a set of the materials for yourself so that you can use them to demonstrate what to do.

Have the students use the pipette to fill the dialysis membrane strip with the starch-glucose mixture, tie it off with string or clamp it shut with clamps, and then put the sealed bag in a small cup of water. They should cover the cups with plastic wrap and put them in a safe place that you designate for that purpose until the next day.



The next day, provide each pair of students with a few glucose test strips, some iodine, and a small empty cup. Remove your example bag from the cup, and show the students how to open the bag and pour the contents into the empty cup. Tell the students to test for glucose first by dipping a glucose test strip into the cup, and then add a couple of drops of iodine to test for starch. Repeat these tests on the water that was outside the dialysis bag.



Activity Tip: Iodine is a permanent stain, so tell the students that they need to be extra careful with it.

All of the glucose test strips should turn green, indicating the presence of glucose both inside and outside of the dialysis bag. The iodine, however, should only turn dark blue—indicating the presence of starch—when it mixes with the water that was inside the bag, but not when it mixes with the water that was outside of the bag.

Have the students record their results in a table like the one below. Save time for a short discussion about the experiment. Be sure the students understand that the results show that glucose is small enough to pass through the membrane into the water outside of the bag, while the starch molecules must be larger because they stay inside the dialysis bag.

Which Is Bigger?		
	Glucose	Starch
Inside the bag	+	+
Outside the bag	+	–
Size	Smaller	Larger

The students can use the same pin to rip the egg open. They will finally be able to see that the food coloring has in fact passed through the membrane and has colored the inside of the egg. The yolk, however, remains uncolored. Point out that the yolk is surrounded by its own membrane; this membrane has such small pores that it doesn't let the food coloring inside.



When the students are finished examining their eggs, it's time to clean everything up. The easiest way to clean up is to hold a trashcan at the edge of the desks and wipe the broken eggs into it. Be sure the students wash their hands after the cleanup.

Cleanup Tip: Have plenty of paper towels and disinfectant handy.

Green Tip: Rinse the plastic cups and store them for reuse for next year or for other experiments.



The students can record what they have observed on their results table. They should also update their materials list and the procedure in their lab report. Once they have finished that, it is time to write a conclusion.

Conclusion

The conclusion of the lab report is a discussion of the results of the experiment. It should include both a summary of the results and an explanation of the results. It may also include suggestions for changes or additional steps to take if the experiment were repeated. The students can also comment on whether or not their hypothesis was correct, although it is important for them to recognize that an incorrect hypothesis does not mean the experiment was a failure—in this or any other experiment. In fact, many times students learn more when their hypotheses are proved incorrect. The students should include what they learned from this experiment in their conclusion.

One or two paragraphs is a reasonable length for a conclusion for most students. Give the students extra class time to complete their lab reports. When they have finished, review everything that they have learned before starting the next topic in this manual.

Student Activity: Word Searches

Have the students complete a word search that uses vocabulary words that they have learned so far in this unit. There are two different word searches available; use the one that is appropriate for your students. See pages 63-66 in the Teacher Resources section of this manual for the downloadable worksheets and an answer key.

Cell Organelles

Objectives

- Students will compare and contrast prokaryotic and eukaryotic cells.
- Students will describe the function of cell organelles.

Key Points

- Cytoplasm is the watery, jelly-like material found inside all cells.
- Prokaryotes have a single chromosome in the cytoplasm.
- The chromosomes of eukaryotes are contained in a membrane-bound nucleus.
- Prokaryotes also have small, circular pieces of DNA, called plasmids, in their cytoplasm.
- Eukaryotic cells are much larger and more complex than prokaryotic cells.
- The cells of eukaryotes contain several membrane-bound structures called organelles.
- Ribosomes are where proteins are made in the cell.
- The mitochondria produce energy for the cell.

Vocabulary Words

Cytoplasm	Nucleus	Plasmids	Organelle
Mitochondria	Ribosomes	Lysosome	Golgi Body
Endoplasmic Reticulum			

Start the Class

Display two resealable plastic bags to the students, one large and one small. Explain that the small bag represents a prokaryotic bacterial cell, and the large bag represents an eukaryotic cell. The cells of bacteria are simple. Fill the small bag with water, and identify the water as *cytoplasm*.

Now show the students a rubber band; this represents the chromosome of the bacteria. The students will learn more about chromosomes later; for now, define a chromosome simply as a threadlike structure in the cell that carries the genetic information of the organism. Place the rubber band in the small bag, and explain that all prokaryotes only have one chromosome. In contrast, eukaryotic cells have many chromosomes.



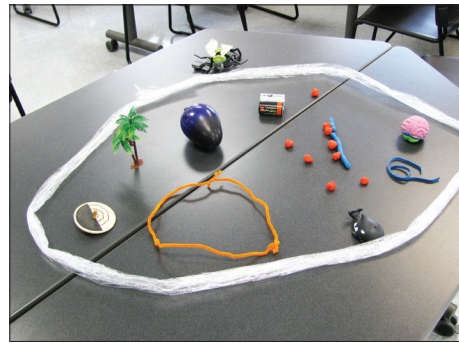
Teaching Tip: Seal the bag when you are finished with this demonstration, and store it somewhere safe; you will need it for the next lesson on plants.

Interested students may choose to learn about additional cell structures such as the cytoskeleton, the nucleolus, peroxisomes, centrioles, cilia, flagella, and microvilli. Most of these are found only in eukaryotic cells, although certain bacteria do have flagella that they use to propel themselves through their environment.

The vocabulary words for cell organelles are challenging for students to learn. Review them as the students complete the following activities. There are a variety of activities to choose from. Select the ones that are appropriate for your students. Alternatively, you could allow the students to choose which ones they might like to do.

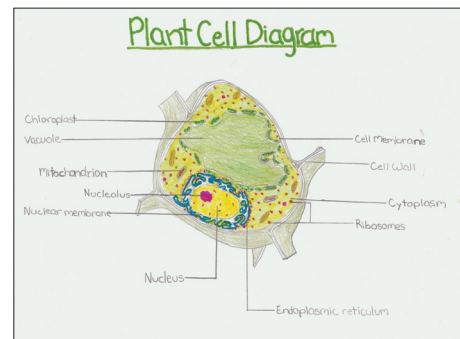
Student Activity: Tabletop Cells

Provide the students with a variety of plastic toys and other objects so that they can make a large tabletop model of the cell. Divide the students into pairs, and have them put their desks together to form a larger surface. Encourage them to be creative when thinking of items that can represent all of the organelles inside the cell. Afterward, have each pair take the rest of the students on a tour of their cell, identifying which object represents each cell organelle and why they chose that object.



Student Activity: Cell Diagrams

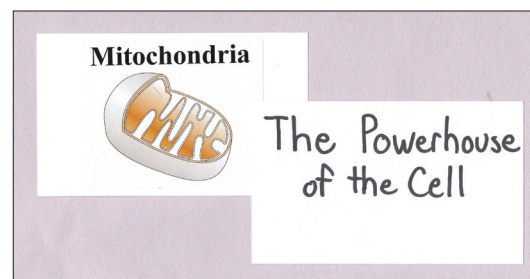
Have the students draw and label a diagram of a cell. The example at right is of a plant cell drawn using colored pencils. Alternatively, students could use a drawing program on a computer to create these diagrams.



Student Activity: Organelle Flashcards

Have the students make flashcards of the eukaryotic cell organelles. Afterward, they can use the flashcards for reviewing and quizzing one another. The flashcards should contain the name of the organelle on one side and its function on the other. More sophisticated flashcards can contain images that the students draw themselves or print from the internet.

Technology Integration: You can also provide the students with specialty paper that consists of perforations to make cards. Make flashcards by printing on both sides of the paper. To make yourself a permanent set of classroom flashcards, laminate the cards.

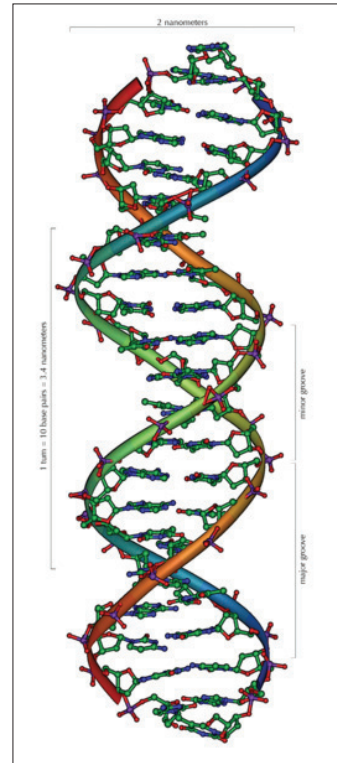


Next, project the image at right, which shows chromosomes in a plant cell. Tell the students that these cells were stained before being put under the microscope. This stain is similar to the methylene blue that they used to stain their cheek cells. The chromosomes in the cells contain all of the plant’s genetic information. Ask the students a key question: “What are chromosomes made of?” The answer is *DNA*. Chromosomes are strands of DNA coiled into long, winding structures.



Teacher Demonstration: DNA

Explain to the students that a chromosome is a long, winding structure made of lots of pieces of DNA that contain all of an organism’s genetic information. DNA stands for *deoxyribonucleic acid*, which can be a difficult term for young students to remember. The coiled structure of DNA is called a *double helix*. Project the image of a double helix at right for the students to see. Compare the structure to a twisting ladder, and explain that an actual DNA molecule is extremely long—so long that it is hard to image its length. This is because it contains all of the genetic information about the cell.



Of course, there is much more to learn about the structure of DNA. DNA is a sequence of only four molecules called adenine, cytosine, guanine, and thymine. Interested students can learn about DNA’s sugar-phosphate backbone, as well as the nucleotide sequence that serves as the actual genetic code itself.

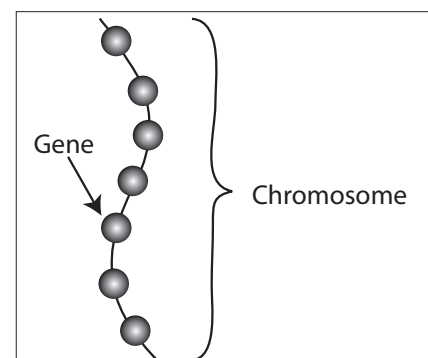
Teacher Demonstration: Genes

Wikipedia

Project the image below, and make the following analogy for the students to help them understand the difference between chromosomes, DNA, and genes. The entire chromosome is like a string of beads. The string of beads is simply a long sequence of DNA, while the individual beads represent genes. A gene is a short sequence of DNA that determines the proteins that a ribosome will make. Remind the students that ribosomes are the organelles that make proteins for the cell.

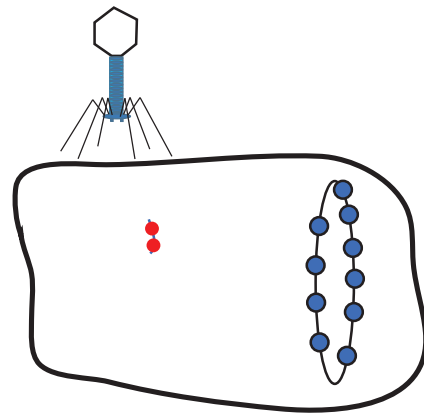
Fact: Most estimates place the number of genes that humans have at 19,000 to 20,000, with each gene coding for different proteins.

Genes are a complex topic, but the important point that the students must understand is that each gene codes for specific proteins.



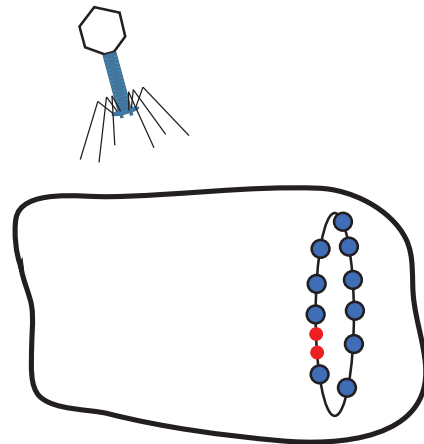
2. Virus Injects DNA

The next step is that the virus *injects* its short piece of DNA into the host cell. Explain to the students that the host cell's chromosome is huge compared to the virus DNA. The image at right shows only ten genes in the chromosome, but the actual host cell's chromosome has thousands of genes. It is much, much larger. The virus DNA, on the other hand, has only has a few genes. Once inside the cell, this short piece of virus DNA goes straight to the host cell's chromosome.



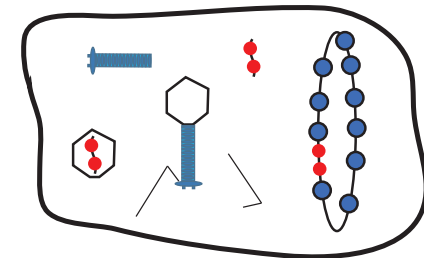
3. Virus Inserts DNA into Host Chromosome

The virus DNA then *inserts* itself right into the host chromosome. Once this happens, the virus takes over the cell. It is able to turn the genes of the cell off, while turning on its own genes. The virus genes are powerful; they completely shut down the cell's own genetic expression. This is why viruses are so difficult to treat.



4. Cell Is Forced to Make a New Virus

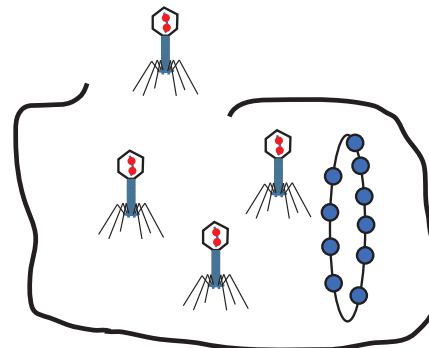
The virus then forces the cell to make more viruses. It sends messenger RNA to the ribosomes and tricks them into make virus proteins. The cell is also forced to make copies of the virus DNA. Finally, the virus orders the cell to put together the protein and the DNA to make a complete virus. Eventually the host cell fills up with viruses.



Vocabulary Tip: Another way of saying that DNA is copied is to say that it is replicated.

5. Cell Bursts and Dies

Once the cell is filled with viruses, it bursts and dies. This means that many new viruses are released into the living environment. If the viruses are infecting cells of the body, they move on and look for other cells to infect. Some infections can move through the body quickly.



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