

SCOPE, SEQUENCE, and COORDINATION

A National Curriculum Project for High School Science Education

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National Science Education Standard—Life Sciences

The Cell

Cells have particular structures that underlie their functions. Every cell is surrounded by a membrane that separates it from the outside world. Inside the cell is a concentrated mixture of thousands of different molecules which form a variety of specialized structures that carry out such cell functions as energy production, transport of molecules, waste disposal, synthesis of new molecules, and the storage of genetic material.

Teacher Materials

Learning Sequence Item:

932

Cells: A First-Hand View

March 1996

Adapted by: Lois M. Range and Linda W. Crow

Cell Structures That Underlie Cell Functions. Students should understand how we know that cells are the fundamental unit of all organisms. They should examine how plant and animal cells are different (*Biology, A Framework for High School Science Education*, p. 86).

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Suggested Sequence of Events

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2. Plant and Animal Cells

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1. Cells: Plants vs. Animals
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3. Pond Scum
4. The Jell-O™ Cell

932

Learning Sequence

Cell Structures that Underlie Cell Functions. Students should understand how we know that cells are the fundamental unit of all organisms. They should examine how plant and animal cells are different (*Biology, A Framework for High School Science Education, p. 86*).

Science as Inquiry	Science and Technology	Science in Personal and Social Perspectives	History and Nature of Science
<p>Plant and Animal Cells Activity 2</p> <p>Cells: Plant vs. Animal Assessment 1</p> <p>Pond Scum Assessment 3</p> <p>The Jell-O™ Cell Assessment 4</p>			<p>Robert Hooke's Cells Activity 1</p> <p>Robert Hooke's Accounts of Cork Cells Reading 1</p> <p>Cells: Robert Hooke Assessment 2</p> <p>The History of Biological Ideas Reading 2</p>

Suggested Sequence of Events

Event #1

Lab Activity

1. Robert Hooke's Cells (45 minutes)

Event #2

Lab Activity

2. Plant and Animal Cells (45 minutes)

Event #3

Readings from Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives, and History and Nature of Science

The following readings are included with the Student Materials:

- Reading 1 Robert Hooke's Accounts of Cork Cells
Reading 2 The History of Biological Ideas

Suggested additional reading:

"Near-Field Microscopes Beat the Wavelength Limit." *Science*, July 1, 1988, pp. 25–26.

Assessment items are at the back of this volume.

Assessment Recommendations

This teacher materials packet contains a few items suggested for classroom assessment. Often, three types of items are included. Some have been tested and reviewed, but not all.

1. Multiple-choice questions accompanied by short essays, called justification, that allow teachers to find out if students really understand their selections on the multiple choice.
2. Open-ended questions asking for essay responses.
3. Suggestions for performance tasks, usually including laboratory work, questions to be answered, data to be graphed and processed, and inferences to be made. Some tasks include proposals for student design of such tasks. These may sometimes closely resemble a good laboratory task, since the best types of laboratories are assessing student skills and performance at all times. Special assessment tasks will not be needed if measures such as questions, tabulations, graphs, calculations, etc., are incorporated into regular lab activities.

Teachers are encouraged to make changes in these items to suit their own classroom situations and to develop further items of their own, hopefully finding inspiration in the models we have provided. We hope you may consider adding your best items to our pool. We also will be very pleased to hear of proposed revisions to our items when you think they are needed.

History and Nature of Science

Robert Hooke's Cells**What do cells look like?****Materials:****Per lab group:**

cork
bean sprouts
paper towels
1 singled-edged razor blade
1 forceps
lens paper
1 dropper
iodine stains
2 microscope slides
2 coverslips
water

Procedure:

This activity relies on the proper use of a microscope. If students seem unfamiliar with the microscope, provide a copy of the technique sheet "How to Use a Microscope." In addition, they will also be making a wet mount and using a stain. A technique sheet is available concerning these routine lab procedures.

A solution of iodine will be used to stain the bean sprout cells. Iodine is slightly poisonous and stains easily. Although it wears off of skin, it will permanently stain clothing. To make a liter of this solution, dissolve 20 g of potassium iodide in 200 mL of distilled water. Add 20 g of iodine and stir. Finally, add enough distilled water to produce a one-liter volume. Store in amber bottles to prevent decomposition.

Bean sprouts can be bought at most grocery stores in the produce section. To make your own, buy some nonpearlized beans such as pinto or mung and sprout them between layers of wet paper towels. This sprouting will take about five days so start them early enough. Colder temperatures will cause sprouting time to be longer.

Cork Cells

Students first repeat Robert Hooke's investigation of cork cells. However, they will have a distinct advantage over Hooke because they will be using a modern microscope. Have students thinly slice a piece of cork using a single-edged razor blade and then examine this slice using the microscope. Be sure they slice the side of the cork (longitudinally) and not the top or bottom in order to get a good view of the cells.

One important skill students need to develop is to draw what they see both accurately and with great detail. Encourage them to become *scientific artists* (realists not impressionists) using labels when

needed. After they have repeated Hooke's work have them read an excerpt from Hooke's descriptions of what he saw. An excerpt is included with this activity (see following pages) and a longer version of Hooke's observations is found in the student information as Reading 3. In addition have them examine not only Hooke's drawing of the cork cells but some of the other drawings that he made of everything from cloth to fleas. They will be impressed with the enormous amount of detail that he captured using a primitive microscope with only a candle as a light source. Some of these drawings have been included in this material.

Bean Sprouts

In the next part of activity, student crush the root tip of a bean sprout and prepare a wet mount of this material. They examine this crushed material using a microscope. Again they will need to carefully draw what they see. After this initial observation, have them add a drop of iodine solution to this material, wait two to three minutes, and then reexamine the material using the microscope. Have them draw what they observe.

Background:

In 1665, Robert Hooke began a series of observations using a microscope. Although he was not the inventor of the microscope nor the first to use it, he was the first to describe the basic unit of life, the cell. Anton van Leeuwenhoek was the inventor of the microscope and first described *tiny animals* (bacteria, protozoan) that he saw in water.

Compared to today's standards, his microscope was very primitive (Figure 1).

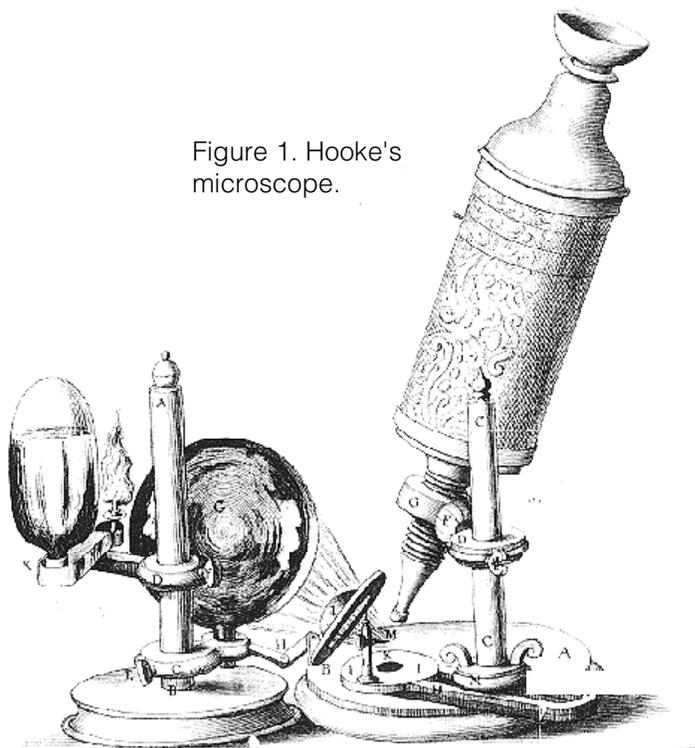


Figure 1. Hooke's microscope.

Its light source was a candle and its magnifying ability was weak. However, the detail that it could reveal, as captured by Hooke's drawings, was amazing (see drawings).

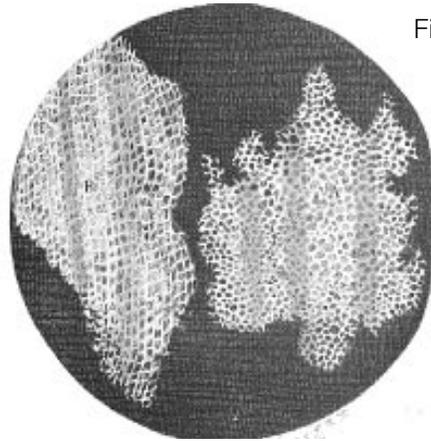


Figure 2. Cork cell.

Hooke used the term cell because the cork that he examined reminded him of the rectangular rooms that monks used in monasteries. These rooms were called cells. Hooke examined many materials in addition to cork (see drawings).



Figure 3. Flea.

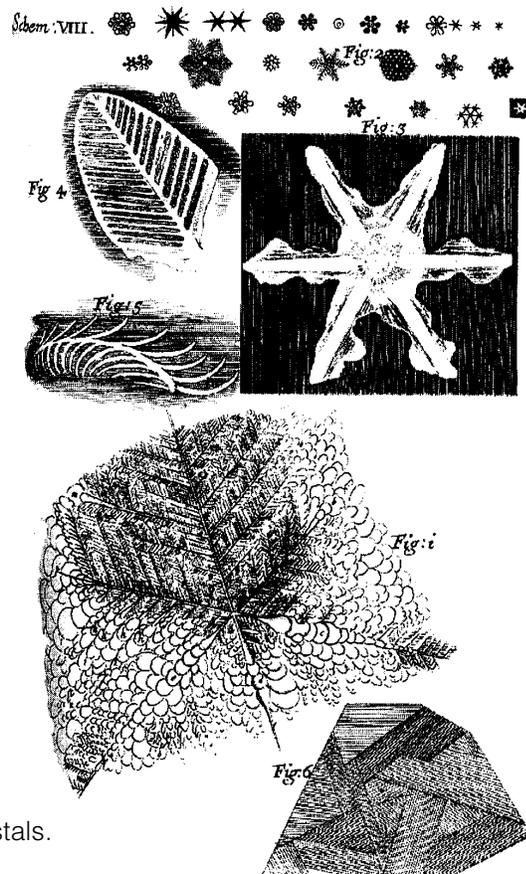


Figure 4. Ice crystals.

The bean sprout cells will resemble the cork cell, but students will be confronted with the problem of observing many layers of cells stacked on top of one another. The iodine will stain the nuclei of these cells, making them easier to use.

Further Variations:

Similar to Hooke's investigation, have students examine other materials using the microscope (cloth, hair, insects). Pond water may also provide some interesting microscope viewing.

Adapted from:

BSCS Biological Science: An Ecological Approach, Sixth Edition. Kendall/Hunt Publishing Company, 1987.

Hooke, R. *Micrographia*, London, 1665.

Kaskel, A., Hummer, P., Kennedy, J., and Oram, R. *Laboratory Biology*. Columbus, Ohio: Charles E. Merrill, 1983.

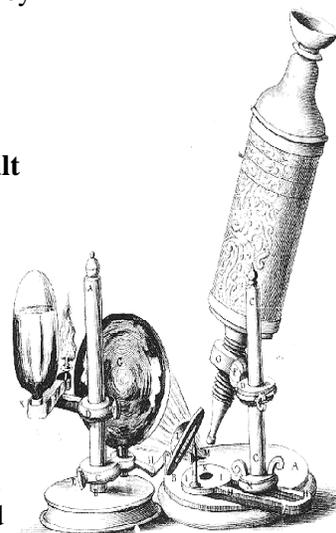
Morholt, E. and Brandewein, P. *A Sourcebook for the Biological Sciences*, Third Edition. New York: Harcourt, 1986.

Excerpt from Robert Hooke's Original Manuscript

*(A more modern translation is provided in **boldface**)*

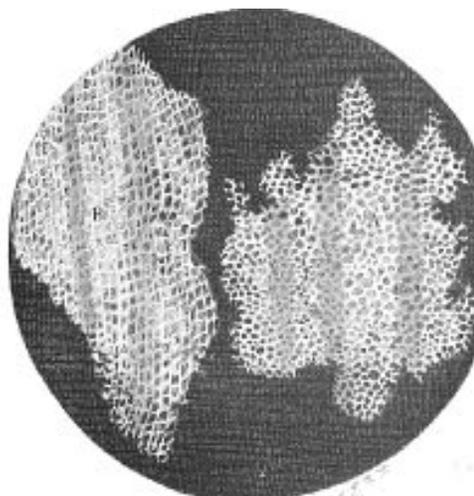
I took a good clear piece of cork, and with a Pen-knife sharpen'd as keen as a Razor, I cut a piece of it off, and thereby left the surface of it exceeding smooth, then examining it very diligently with a Microscope, me thought I could perceive it to appear a little porous; but I could not so plainly distinguish them, as to be sure that they were pores, much less what Figure they were of:

I used a sharp pocket knife to slice a piece of cork. The cut surface of the cork was really smooth. Using a microscope, I examined this slice, but it was hard to see much of anything. It looked like it had some pores or openings, but it was still too difficult to see exactly what was there. A drawing of my microscope follows:



But judging from the lightness and yielding quality of the Cork, that certainly the texture could not be so curious, but that possibly, if I could use some further diligence, I might find it to be discernable with a Microscope. I with the same sharp Pen-knife, cut off from the former smooth surface an exceeding thin piece of it, and placing it on a black object Plate, because it was it self a white body, and casting the light on it with a deep plano-convex Glass, I could exceeding plainly perceive it to be all perforated and porous, much like a Honey-comb, but that the pores of it were not regular, yet it was not unlike a Honey-comb in these particulars.

Cork seems very light and squishy, so I repeated the procedure again but this time I tried to slice an even thinner piece of cork. I also placed this thin slice on a black background so it would stand out. Then I used a magnifying lens to concentrate more light on this slice. I looked into the microscope and this time I could see exactly what was there. The cork looked like a honeycomb with stacks of openings. Some of these openings were not identical, but they were very close to being the same shape and size. I have included a drawing of what I saw.



Science as Inquiry

Plant and Animal Cells**How do plant cells compare to animal cells?****Materials:****Per lab group:**

microscope
lettuce leaves
onion (from grocery store or nursery)—a few pieces
onion bulb with root tips (one sprouted onion will probably provide root tips for 5–6 classes of 30 students each)
human cheek cells—prepared slides
Lugol's solution
1 beaker (150 mL)
4 microscope slides
4 coverslips
1 dropper or pipette
1 forceps
distilled water
toothpicks
optional: methylene blue for cheek cell demonstration

Procedure:**Part A: Plant Cells (Lettuce and Onion)**

Using the lettuce leaves, have students separate a small piece of the outermost skin (epidermis) from both the outside and inside of the leaf. This epidermis will be very translucent and some care should be taken. Be sure to have them keep track of which one came from the inside and which one from the outside of the leaf. They should prepare a wet mount of the lettuce, staining it with Lugol's solutions.

A Lugol's solution can be prepared easily using iodine, distilled water, and potassium iodide. As discussed in Activity 1, iodine is slightly poisonous and stains easily. Although it wears off of skin, it will permanently stain clothing. To make a liter of this solution, dissolve 20 g of potassium iodide in 200 mL of distilled water. Add 20 g of iodine and stir. Finally, add enough distilled water to produce a one liter volume. Store in amber bottles to prevent decomposition.

The best lettuce to use is either iceberg or romaine. The leaves of these lettuces are usually stiff. Be sure that the lettuce is fresh and dry. Wilting can be diminished if the lettuce is kept in cold water. The students need only about 1 square centimeter of material for the slide. Have them use the forceps to carefully peel this layer off.

Onion sets and bulbs usually can be bought at a nursery. The ones in the grocery store will work with some preparation. Place an onion from the grocery store in the top of a container that is filled with water.

Using toothpicks, stick the sides of the onion so the bottom of it rests in the water (Figure 1). After about five days, small roots will begin to grow. It is these young root tips that the students will use.

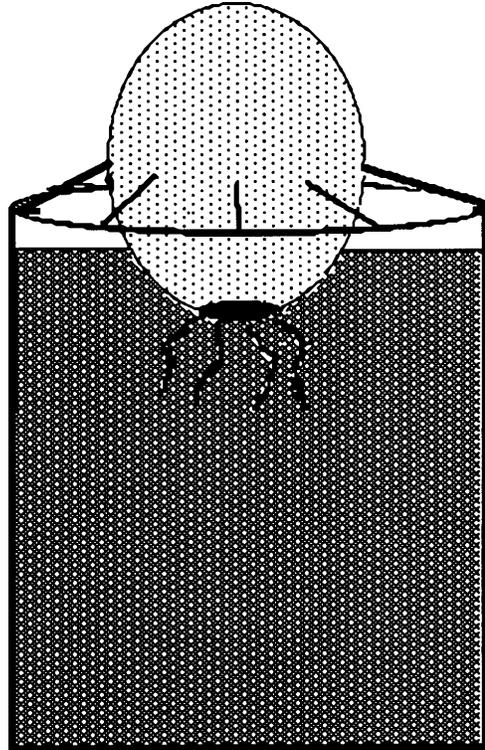


Figure 1. Rooting onion.

Students make wet mounts of the onion tissue from the bulb and the root and observe both of them under a microscope. Parts that can be easily identified are the cell wall and the nucleus.

Part B: Animal Cells (Cheek Cells)

Due to the danger of infection, fresh cheek cells are not used. Prepared slides of cheek cells can be used instead. If you wish, prepare a fresh slide from your cheek as a demonstration. Show the students this slide using a microprojector.

Using the prepared slides, students observe and draw cheek (animal) cells. Have them compare their drawings from parts A and B. Parts that can be easily identified are the cell membrane and the nucleus.

Background:

In the lettuce and onion slides students will see examples of typical plant cells. These cells are easily identified as plant cells because of their rigid cell walls. Within the cell wall, a cell membrane may also be detectable. In addition, a nucleus is easily identified because it stains very darkly. Some specialized cells—guards cells—may also be seen in these slides. These cells guard the stomata, or openings, that

allow air to enter the leaf. There may be some differences in the outer and inner leaves of the lettuce that you use. Some leaf surfaces will have more stomata and guard cells. If the slide is well prepared, chloroplasts (small green bodies) can be seen in these guard cells.

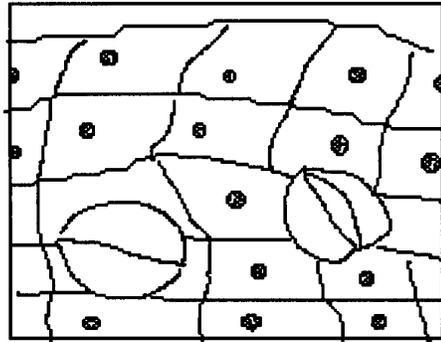


Figure 2. Lettuce cell.

Onion bulb cells will be large and have thicker cell walls than root cells. These differences are related to the functions of these cells. The root cells are usually involved in absorbing water while the bulb cells are used for storage.

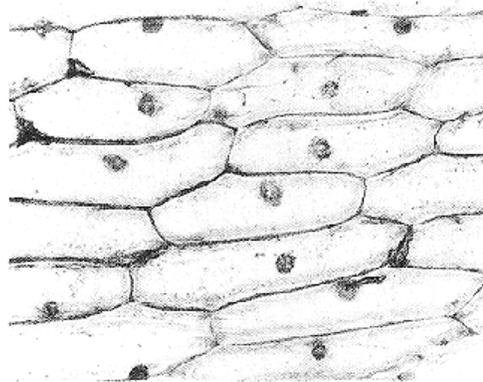


Figure 3. Onion cell.

Cheek cells (animal cells) will not have cell walls. This is characteristic of animal cells. A cell membrane encloses each cell. A dark nucleus can usually be seen.

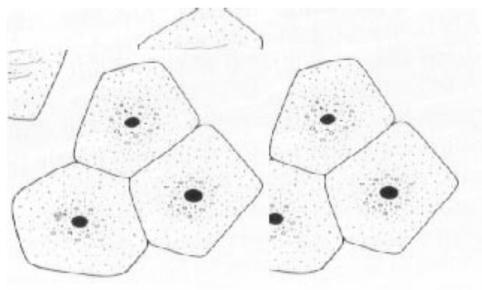


Figure 4. Cheek cell.

Cells are the basic unit of all living things. In each cell there are structures (organelles) that enable it to carry out the living functions it needs. In later grades, electron micrograph photographs will be used to see beyond these basic coarse features. At that time, other organelles will be identified. Observations of cells led to the development of the cell theory. This theory states that all living things are composed of cells and that these cells are the smallest functioning structural unit in living things. The differences in plant and animal cells can be attributed to the different life requirements of plants and animals.

Further Variations:

Have students make wet mounts of animal and plant materials. *Zebrina* (wandering jew) provides another example of plant cells. For animal cells, have students examine a drop from a sample of *Euglena*.

Adapted from:

BSCS Biological Science: An Ecological Approach, Sixth Edition. Kendall/Hunt Publishing Company, 1987.

Kaskel, A., Hummer, P., Kennedy, J., and Oram, R. *Laboratory Biology*. Columbus, Ohio: Charles E. Merrill, 1983.

Morholt, E. and Brandewein, P. *A Sourcebook for the Biological Sciences*, Third Edition, New York: Harcourt, 1986.

Science as Inquiry

Cells: Plant vs. Animal**Item:**

Cells are commonly studied in the lab. If you were examining various unlabeled slides of cells under the microscope, you could tell if the cell was from a plant by the presence of:

- A. a nucleus
- B. a cell membrane
- C. cytoplasm
- D. a cell wall

Justification:

Explain the special function in plant cells of the organelle you chose.

Answer:

The correct choice is D. Cell walls are found only in plant cells.

History and Nature
of Science

Cells: Robert Hooke

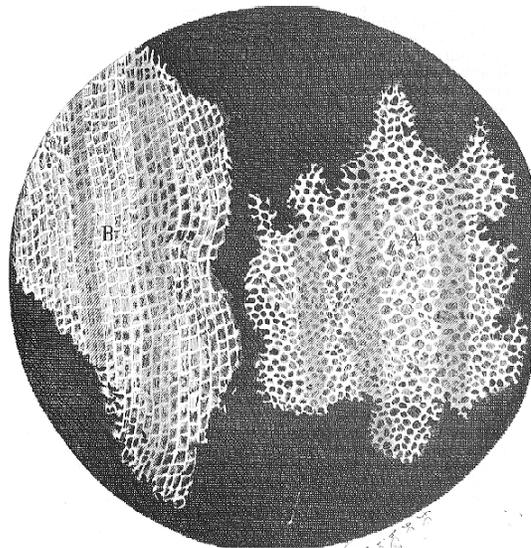
Item:

When Robert Hooke discovered the basic units of living organisms in 1665, he named them “cells” based on the shape he saw under a microscope. Cell means a small box or small room.

- A. What type of cells (plant or animal) was Hooke probably looking at?
- B. Name the part of the cell that probably reminded him of small rooms and describe the structural characteristics of that cell part.

Answer:

- A. plant cells
- B. Plant cells are surrounded by cell walls, which look like tiny rectangular “boxes” when viewed under the microscope.



Robert Hooke's drawing of cork cells. Hooke was describing what we would call the cell wall, for the term "cells" meant little cubicles or rows of small rooms.

Science as Inquiry

Pond Scum**Item:**

Have students make a wet mount with pond water and observe under low power. They should draw diagrams of the materials they examine and place them in their journal.

Possible Student Answers:

Answers will vary. They may observe protozoans, pond scum, flower petals, or any material showing a cellular organization, dead or alive.

Science as Inquiry

The Jell-O™ Cell**Performance Assessment:**

Materials Needed:

- Jell-O™
- pieces of different fruits
- self-clinging plastic wrap
- plastic bags
- cardboard
- sheets of Styrofoam™
- foam board
- containers for Jell-O (metal cups, soufflé cups, etc.)

Working in pairs, your task is to create a model of a cell. First you must decide what type of cell you will produce and what parts it will have. On a sheet of paper, identify the type of cell and its parts. Next to each part describe what you are using in your model to represent this task.

The Jell-O should be made according to the package directions. Cool it until it is almost set and then add your parts. Chill the complete model when finished.

Answer:

Students first choose whether they are making a plant or an animal cell. This choice will somewhat dictate what parts are in the model. Plants have cell walls and chloroplasts while animal cells have only a cell membrane and normally no chloroplasts. The plastic wrapping or plastic bag could be used to represent the cell membrane. The pieces of cardboard or foam could be used to build a rigid cell wall. An example of a possible animal cell is drawn below.

