SCOPE, SEQUENCE, and COORDINATION

A National Curriculum Project for High School Science Education

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SS&C Research and Development Center
Gerry Wheeler, *Principal Investigator*
Erma M. Anderson, *Project Director*
Nancy Erwin, *Project Editor*
Rick McGolerick, *Project Coordinator*
Arlington, Va., 703.312.9256

Evaluation Center
Frances Lawrenz, *Center Director*
Doug Huffman, *Associate Director*
Wayne Welch, *Consultant*
University of Minnesota, 612.625.2046

Houston SS&C Materials Development and Coordination Center
Linda W. Crow, *Center Director*
Godrej H. Sethna, *School Coordinator*
University of Houston-Downtown, 713.221.8583

Houston School Sites and Lead Teachers
Jefferson Davis H.S., Lois Range
Lee H.S., Thomas Ivy
Jack Yates H.S., Diane Schranck

California Coordination Center
Tom Hinojosa, *Center Coordinator*
Santa Clara, Calif., 408.244.3080

California School Sites and Lead Teachers
Sherman Indian H.S., Mary Yarger
Sacramento H.S., Brian Jacobs

Iowa Coordination Center
Robert Yager, *Center Director*
University of Iowa, 319.335.1189

Iowa School Sites and Lead Teachers
Pleasant Valley H.S., William Roberts
North Scott H.S., Mike Brown

North Carolina Coordination Center
Charles Coble, *Center Co-Director*
Jessie Jones, *School Coordinator*
East Carolina University, 919.328.6172

North Carolina School Sites and Lead Teachers
Tarboro H.S., Ernestine Smith
Northside H.S., Glenda Burrus

Puerto Rico Coordination Center*
Manuel Gomez, *Center Co-Director*
Acenet Bernacet, *Center Co-Director*
University of Puerto Rico, 809.765.5170

Puerto Rico School Site
UPR Lab H.S.

* * * * * * * * * * * *

Pilot Sites
Site Coordinator and Lead Teacher
Fox Lane H.S., New York, Arthur Eisenkraft
Georgetown Day School, Washington, D.C., William George
Flathead H.S., Montana, Gary Freebury
Clinton H.S., New York, John Laffan*

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Student Materials

Learning Sequence Item:

932

Cells: A First-Hand View

March 1996
Adapted by Lois M. Range and Linda W. Crow

Contents

This micro-unit was adapted by **Lois M. Range** (Jefferson Davis High School, Houston) and
Linda W. Crow (Baylor College of Medicine, Houston)

History and Nature of Science

Robert Hooke's Cells

Robert Hooke was the first to look at cells and other materials. In fact, he was the person who first called them cells. You will repeat Hooke's experiment using cork. Thin slice down the side of a cork with a single-edged razor. Place this slice on the platform of a microscope. The thinner the slice the better the view. Draw the cork under low and high power. Remember, detail is important in microscopic drawings. If you are unfamiliar with the microscope refer to the technique sheet "How to Use a Microscope."

Drawing of Cork—Low Power

Drawing of Cork—High Power

After completing your drawings of cork, read the excerpt from Hooke's original work and look at his drawings.

1. How did your drawings compare to Hooke's original drawings?

2. How did the low-power drawing compare to the high-power drawing?

3. How did your drawings compare to Hooke's?

Next you will make a wet mount of the crushed root tip of a bean sprout. If you are unfamiliar with this procedure, see the technique sheet "How to Make a Wet Mount." After making your slide, look at it under the microscope. Draw it below.

Now add some iodine stain to it and look at it again using the microscope. Draw it below.

1. How did the drawings of the bean sprout compare with those of the cork?
2. How did the stain affect what you observed?
3. There are some distinctive structures to identify on your drawings. Identify the following by labeling them: cell wall, nucleus.

Science as Inquiry

Plant and Animal Cells

Part A
Plant Cells—Lettuce and Onion

Make a wet mount of the upper and lower surfaces of a lettuce leaf. Use forceps to carefully peel a small thin piece from both sides of the leaf. Examine this material under a microscope and draw below.

lettuce: low power	*lettuce: high power*

Make a similar wet mount of the onion bulb—both inner and outer surfaces. Draw what you see using a microscope.

onion bulb: low power	*onion bulb: high power*

Snip the very end portion of a young onion root. Make a wet mount and gently press down on the coverslip to mash this tip. Examine with a microscope and draw below.

onion root: low power *onion root: high power*

Part B
Animal Cells

Use a microscope to examine a prepared slide of a human cheek cell. Draw it below.

cheek cell: low power *cheek cell: high power*

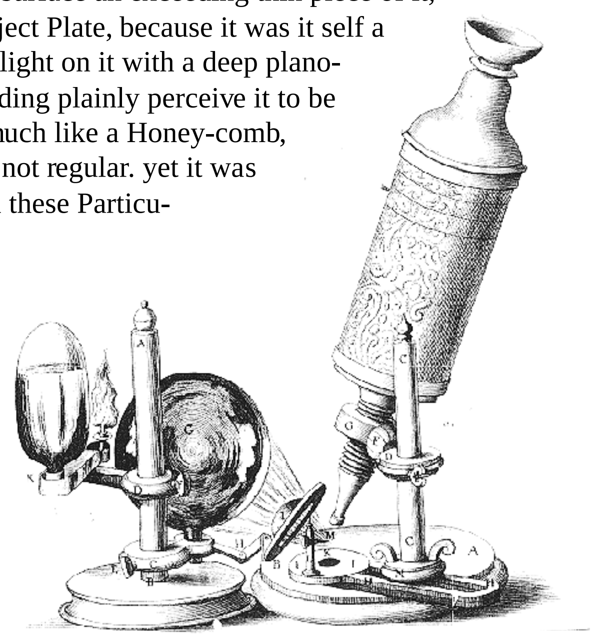
1. How did the inner and outer surfaces of the lettuce leaf compare to one another?
2. How did the onion bulb cells compare to the onion root cells?
3. How can you account for the different cells found in the same plant, such as the onion bulb cells and the onion root cells?
4. How do the cheek cells compare to the lettuce leaf cells?
5. On your drawings label these important structures: cell wall, cell membrane, nucleus.

History and Nature of Science

Of the Schematisme or Texture of Cork, and of the Cells and Pores of Some Other Such Frothy Bodies

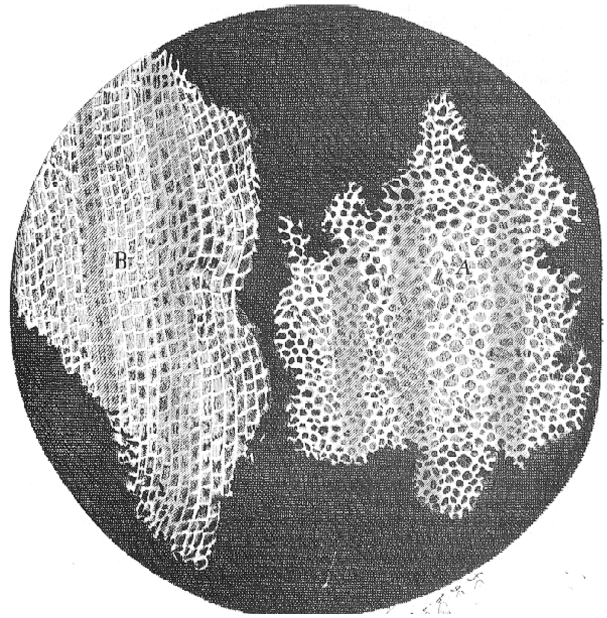
Robert Hooke
from* Micrographia*, London, 1665

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: 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.



First, in that it had a very little solid substance, in comparison of the empty cavity that was contain'd between, for the Interstitia, or walls (as I may so call them) or partitions of those pores were neer as thin in proportion to their pores, as those thin films of Wax in a Honey-comb (which enclose and constitute the sexanangular cells) are to theirs.

Next, in that these pores, or cells, were not very deep, but consisted of a great many little Boxes, separated out of one continued long-pore, by certain Diaphragms....



I no sooner discern'd these (which were indeed the first microscopical pores I ever saw, and perhaps, that were ever seen, for I had not met with any Writer or Person, that had made any mention of them before this), but me thought I had with the discovery of them, presently hinted to me the true and intelligible reason of all the Phaenomena of Cork; As,

First, if I enquir'd why it was so exceeding light a body? my Microscope could presently inform me that here was the same reason evident that there is found for the lightness of froth, all empty Honey-comb, Wool, a Spunge, a Pumice stone or the like: namely a very small quantity, of a solid body, extended into exceedingly large dimensions.

Next, it seem'd nothing more difficult to give an intelligible reason, why Cork is a body so very unapt to suck and drink in Water and consequently preserves it self, floating on the top of Water, though left on it never so long: and why it is able to stop and hold air in a Bottle, though it be there very much condensed and consequently presses very strongly to get a passage out, without suffering the least bubble to pass through its substance. For, as to the first, since our microscope informs us that the substance of Cork is altogether fill'd with Air, and that Air is perfectly enclosed in little Boxes or Cells distinct from one another. It seems very plain, why neither the Water, nor any other Air can easily insinuate it self into them, since there is already within them an *intus existens,* and consequently, why the pieces of Cork become so good floats for Nets, and stopples for Viols, or other close Vessels.

And thirdly, if we enquire why Cork has such a springiness and swelling nature when compress'd? and how it comes to suffer so great a compression, or seeming penetration of dimensions, so as to be made a substance as heavie again and more, bulk for bulk, as it was before compression, and yet suffer'd to return, is found to extend it self again into the same space? Our Microscope will easily inform us, that the whole mass consists of an infinite company of small Boxes or Bladders of Air, which is a substance of a springy nature, and that will suffer a considerable condensation (as I have several times found by divers trials, by which I have most evidently condens'd it into less then a twentieth part of its usual dimensions neer the Earth, and that with no other strength then that of my hands without any kind of forcing Engine, such as Racks, Leavers, Wheels, Pullies, or the like, but this onely by and by) and besides, it seems very probable that those very films or sides of the pores have in them a springing quality, as almost all other kind of Vegetable substances have, so as to help to restore themselves to their former position . . . .

But, to return to our Observation. I told several lines of these pores, and told that there were usually about threescore of these small Cells placed end-ways in the eighteenth part of an Inch in length, whence I concluded there must be near eleven hundred of them, or somewhat more then a thousand in the length of an inch and therefore in a square inch above a million, or 1166400, and in a cubick inch, above twelve hundred Millions, or 1259712, a thing almost incredible, did not our Microscope assure us of it by ocular demonstration; nay, did it not discover to us the pores of a body, which were they diaphragm'd like those of Cork, would afford us in one Cubick Inch, more than ten times as many little Cells, as is evident in several charr'd Vegetables; so prodigiously curious are the works of Nature that even these conspicuous pores of bodies, which seem to be the channels or pipes through which the Succus nutritus, or natural juices of vegetables are convey'd, and seem to correspond to the veins, arteries and other vessels in sensible creatures, that these pores I say, which seem to be the vessels of nutrition to the vastest body in the World, are yet so exceeding small that the Atoms which Epicurus fancy'd would go neer to prove too bigg to enter them, much more to constitute a fluid body in them . . . .

But though I could not with my Microscope, nor with my breath, nor any other way I have yet try'd, discover a passage out of one of those cavities into another, yet I cannot thence conclude, that therefore there are none such, by which the Succus nutritius, or appropriate juices of Vegetables, may pass through them; for, in several of those Vegetables, whil'st green, I have with my Microscope, plainly enough discover'd these Cells or Holes fill'd with juices, and by degrees sweating them out: as I have also observed in green Wood all those long microscopical pores which appear in charcoal perfectly empty of any thing but Air.

Now, though I have with great diligence endeavoured to find whether there be any such thing in those Microscopical pores of Wood or Piths, as the Valves in the heart, veins, and other passages of Animals, that open. and give passage to the contain'd fluid juices one way, and shut themselves, and impede the passage of such liquors back again, yet have I not hitherto been able to say any thing positive in it; though, me thinks, it seems very probable, that Nature has in these passages, as well as in those of Animal bodies, very many appropriated Instruments and contrivances, whereby to bring her designs and end to pass, which 'tis not improbable, but that some diligent observer, if helped with better microscopes, may in time detect . . . .

History and Nature of Science

The History of Biological Ideas

Ideas are made by humans, and history is the story of humankind. The development of biological concepts has followed the pattern of the other sciences. People started by observing the variety of organisms and processes in the living world. Only after a long period of organizing data and classifying objects and observations did theoretical concepts begin to be developed. Great scientists could see patterns in the information collected for years and centuries. From these patterns they formed the concepts of modern biology.

Concepts of biology depend on both the people who invented them and the times in which they worked. An idea cannot exist alone; it must relate to the science as a whole. The history of biology makes it clear that science does not proceed in a straight line to success. A great deal of careful work and observation took place between Hooke's observation of "little boxes" in cork and the modern cell theory put forward by Schleiden and Schwann. Recently, the biochemical studies of DNA and RNA have added a great deal to our understanding of cell division. Many scientists must work and much data must be accumulated before old and new evidence can be made meaningful by a unifying concept.

The first compound microscope is generally credited to certain Dutch spectacle makers around the year 1600. A compound microscope consists of two or more lenses. If the lenses are accurately ground, the magnification and clarity of detail is far superior to that obtained by a single lens. But for a long time the lenses were poor, producing images that were blurred and distorted. It was not until about 35 years after the invention of the compound microscope that anyone made use of it to look at living things.

Improvements in the compound microscope were made by Robert Hooke, a seventeenth-century English scientist. Using an ordinary penknife, Hooke sliced a very thin piece of cork and placed it under his microscope for examination. He very carefully described what he saw.

"I could exceedingly plainly perceive it to be all perforated and porous, much like a Honeycomb... these pores, or cells, were not very deep, but consisted of a great many little Boxes."

Hooke used the word *cells* to describe the tiny pores that he saw in the thin pieces of cork. He pictured the cells as "little rooms" or "boxes." Hooke was looking at the cell walls of dead tissue. He certainly did not see "cells" as we think of them today. Nor did he originate the cell theory. He did, however, use the compound microscope as a biological tool. His discovery of small structures within living things encouraged other scientists to use this new tool.

By the beginning of the nineteenth century it was known that the organs of the body are made up of parts called *tissues*. A combination of different kinds of tissues make up of such organs as the heart, brain, and stomach. Some of the fundamental tissues of a vertebrate's body are blood, bones, muscle, cartilage, fat, and nerve.

Adapted with permission from "The History of Biological Ideas." Pp. 274–178 in *Biological Science: Molecules to Man* (BSCS Blue Version). Boston: Houghton Mifflin Company, 1963.

Tissues also make up plant organs such as stems, roots, and leaves. An example of a plant tissue is wood. Scientists of the nineteenth century knew about tissues, but they did not know what tissues themselves were made of.

Although many scientists had made careful observations during the 150 years after the time of Robert Hooke, no one had stated a general theory concerning cells. Then in France in 1824, R.J.H. Dutrochet began comparing plant and animal tissues. He was a careful observer and came very close to a statement of the cell theory when he wrote that:

"...all the organic tissues of animals [are] really globular cells of an extreme smallness, which are united only by cohesion [clinging together]. Thus, all the tissues, all the organs of animals and plants are really only a cellular tissue diversely modified."

Dutrochet believed that living tissues were really tiny cells held together by some kind of glue-like force and that organs were made up of different kinds of tissues.

An important observation and generalization resulted a few years later from the research of the Scottish botanist Robert Brown. He observed the leaf cells of orchids. Within each cell he detected a darker, circular portion, which he called a *nucleus*. From these observations he went on to generalize that nuclei were also found in the cells of other flowering plants. However, he did not detect the role of the nucleus in cell division.

The stage was now set for the modern cell theory. The theory came about through the work of two nineteenth-century German biologists, Theodore Schwann and Matthias Schlieden. Schlieden published a paper in 1838 that dealt with the way cells originate. In this paper he set forth the hypothesis that the nucleus plays a major role in the development of the cell. Then he said that each cell leads a kind of double life. One part of its life is independent, pertaining to its own development alone. The other part of the life of the cell is its action as a part of the plant tissue. In other words, every cell that one sees under a microscope, whether from stem, leaf, or root of a plants, acts as though it were a tiny independent organism. But it also contributes to the life of the larger organism of which it is a part.

While Schleiden was working with plant cells, Schwann was observing those of animals. He found that some of his observations on frog cells could easily apply to Schleidens idea of the plant cell. Schwann tested this hypothesis by examining a variety of animal structures, from birds' eggs to muscle fibers. His observations led him to make the following generalizations:

"...the elementary parts of all tissues are formed of cells...it may be asserted that there is one universal principle of development for the elementary parts of organisms, however different, and that this principle is the formation of cells."

Schleiden and Schwann cannot be said to have discovered the cell or even to have named it. But they did state the basic idea that cells make up all living things, and that these cells act independently and yet function together. This basic idea, that cells make up all living things from single-celled organisms to oak trees to men, is now called the cell theory. It explained many of the observations that had been made since the time of Hooke. This new way of considering the structure of plants and animals gave a new spirit to biological research, opening the door to new ideas in many areas of biology.

Improved microscope and staining methods soon led to further discoveries. New facts about the nature of cell division were uncovered. These discoveries helped to correct some of the mistaken ideas of Schleiden and Schwann, especially those which dealt with the nature of cell division. They had thought that cells solidified from fluid, or that tiny new cells formed inside of older ones in simple process.

These new discoveries were made when scientists observed that cells of developing organisms duplicated themselves by means of cell division. Sperm and eggs, essential for sexual reproduction, had not been recognized as cells up until this time. New observations, however, showed that sperms are male reproductive cells and eggs are female reproductive cells. In 1842 it was shown that the pollen grains of plants are formed by cell division. In such cell divisions it was found that the nucleus is always involved.

Finally in 1855 Rudolf Virchow, a German physician and biologist, generalized that cells always multiply by cell division. Virchow's statement in Latin was: *omnis cellula e cellula*, which means that every cell comes from another cell. This generalization contradicted the spontaneous generation arguments. The statement also helped to provide a basis for the idea of evolution as presented by Darwin a few years later.

By 1879, new stains and improved lenses were available. The German biologist Walther Flemming was thus able to follow the nuclear events of cell division. He described the events of cell division very much as you have already studied them. Because of the threadlike chromosomes, Fleming named the process "mitosis," after the Greek word meaning thread.

Little was added to the picture of the fine structure of cells for eighty years after the work of Flemming. His knowledge of the cell was about the same as that in 1922. Since 1930 there has been a tremendous advance in the knowledge of the cell. Why? What happened?

An important new instrument, the electron microscope, was developed in the 1930s and it was soon used in the study of cells. This microscope uses electron waves rather than light rays as its light source. One does not look directly at an object through the electron microscope. Instead, a beam of electrons is directed through an object onto a viewing screen or photographic plate. The photographic plate is then developed, enlarged, and then examined. The electron microscope is capable of magnifying parts of cells approximately 100,000 times. Such magnification has revealed unimagined detail inside cellular particles.

New techniques and instruments such as the electron microscope have enabled scientists to continue their exploration of the cell. New facts and new ideas bring new advances. New instruments have provided an important link in this chain of scientific progress.

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