SCOPE, SEQUENCE, and COORDINATION

A National Curriculum Project for High School Science Education

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National Science Education Standard—Life Science

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.

Most cell functions involve chemical reactions. Food molecules taken into cells are broken down to provide the chemical constituents needed to synthesize other molecules. Both breakdown and synthesis are made possible by a large set of protein catalysts called enzymes. the breakdown of some of the food molecules enables the cell to store energy in specific chemicals that are used to power the many functions of the cell.

Plant cells contain chloroplasts, the site of photosynthesis. Plants, and some other organisms, use solar energy to combine molecules of carbon dioxide and water into complex, energy rich organic compounds. This process of photosynthesis provides a vital connection between the sun and the energy needs of living systems.

Teacher Materials

Learning Sequence Item:

933

Cell Structures and Their Functions

March 1996
Adapted by: William T. George, Jon Fiorella, and Linda W. Crow

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Cell Structures that Underlie Cell Functions. There are distinctions among the most important organelles—nucleus, ribosome, mitochondrion, and chloroplast. Students should offer support for the cell concept, comparing cell functions with human biological functions. Describe and discuss chloroplasts of plant cells. *(Biology, A Framework for High School Science Education, p. 86.)*

Contents

This micro-unit was adapted by **William T. George** (Georgetown Day School, Washington, D.C.),
Jon Fiorella (Fox Lane High School, Bedford, N.Y.), and **Linda W. Crow** (Baylor College of Medicine, Houston, Texas)

933

Learning Sequence

Cell Structures that Underlie Cell Functions. There are distinctions among the most important organelles—nucleus, ribosome, mitochondrion, and chloroplast. Students should offer support for the cell concept, comparing cell functions with human biological functions. Describe and discuss chloroplasts of plant cells. *(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
What's It All About? Algae! Activity 1 Cool, Clear Water Activity 2 Green Measles Activity 3 Cavorting Beasties Activity 4 Bricks of the Body Activity 5 Let It All Hang Out Activity 6 Chromatography Using Green Leaves Activity 7 Plant Energy Assessment 1 Cell Statements Assessment 2 Organelle Trouble Assessment 3 Sites of Photosynthesis Assessment 4 In the Guard Cells Assessment 5 Changing Colors Assessment 6 Leaf Pigment Solutions Assessment 7 Evidence for Pigments Assessment 8 Pigment Uses Assessment 10 Testing Concentrations Assessment 10 Fall Colors Assessment 11		Autumn Leaves **Reading 1**	

Suggested Sequence of Events

Event # 1

Lab Activity

1. What's It All About? Algae! (30 minutes)

Event #2

Lab Activity

2. Cool, Clear Water (30 minutes)

Event #3

Lab Activity

3. Green Measles (45 minutes)

Event #4

Lab Activity

4. Cavorting Beasties (45 minutes)

Event #5

Lab Activity

5. Bricks of the Body (45 minutes)

Alternative or Additional Activity

6. Let It All Hang Out (45 minutes)

Event #6

7. Chromatography Using Green Leaves (60 minutes)

Event #7

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

The following reading is included with the Student Materials

Reading 1 Autumn Leaves

Suggested additional readings:

Dobell, Clifford, Antony van Leeuwenhoek and His "Little Animals." Russell & Russell, Inc., 1958, pp. 1–3, 112; 116–123.

Walsby, A.E., "Prochlorophytes: Origins of Chloroplasts." *Nature*, Vol. 320, March 1986, p. 212.

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.

Teacher Sheet

Science as Inquiry

What's It All About? Algae!

What does a microscopic view of algae reveal?

Overview:

This activity provides students with basic observation experiences of prokaryotic blue-green algae. Wet mounts can be used or the newer plastic sandwich vials (demo slides) are easily used in this activity.

Materials:

Per lab group:
compound microscope
glass slides
cover slips
Fresh cultures
- Nostoc
- Gloeocapsa
- Oscillatoria

Procedure:

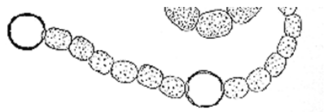
Have students make temporary wet mounts of Nostoc, Gloeocapsa, and Oscillatoria. Students should make comparisons of the cells making up these prokaryotes to cell models which they have constructed or living protists which they have observed. Observations should be made on high power or oil immersion for best results. Students will need help in viewing cell walls, cell membranes, slime sheaths, cytoplasm, and chromoplasm.

Background:

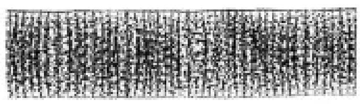
Observations of blue-green algae can be hindered by the use of high intensity lights (fluorescent light works best), so be careful about exposing these cultures to direct sunlight or high intensity bulbs. Often this light exposure will bleach them and eventually kill them. Do loosen caps on tubes, use sterile materials and subculture every five days. They do best in a soil-water medium although generic algae growth medium will also work.. If you choose to make this medium be careful of the soil that you use. Keep in mind media is commercially available. Carolina Biological is a good source for both cultures and medium.

Normally to make soil-water medium you will need calcium carbonate, good garden soil and distilled water. A pinch of calcium carbonate is first added to the bottom of the container and covered with about 1/2 inch of garden soil. This soil cannot contain any fertilizer or high concentrations of peat. The container is filled 3/4 full with distilled water and steam for two hours on two consecutive days. A pressure cooker is the best device to use for this steaming.

Blue-green algae are prokaryotic and do not have their DNA in a nucleus with a nuclear membrane as a barrier. They also do not contain mitochondria or chloroplasts. It is thought that they were the first organisms that could survive on land. Modern day examples of this algae often use nitrogen from the atmosphere as a source of a nutrient material.



Nostoc



Oscillatoria

Nostoc resembles a necklace of beads, interrupted by a larger, clearer bead. These beads are individual cells making up a larger colony. They appear granular with no definite nucleus. Oscillatoria appears as long, unbranched filaments that are rectangular in shape and the cells appear as smaller rectangular areas filled with granulated material. Gloeocapsa have a gelatin sheath around its cells. Again all of these algae are prokaroytic and have no nuclear membrane. Students should notice that it is absent and the cells look somewhat unorganized inside.

Variations:

Other variety of blue-green algae could also be viewed. Some interesting types are Anabaena, Calothrix, Eucapsis, Phormidium, and Tolypothrix. All of these cultures are available commercially.

Adapted from:
Brown, R. H., and Roy Wishard, Biology Laboratory Text, Kendall/Hunt Publishing Co.
Morholt , E. and Paul Brandewein, A Sourcebook for the Biological Sciences, San Diego, Calif.: F. Harcourt Brace Jovanovich, 1986.
James, Daniel E., Culturing Algae, N. C.: Carolina Biological Supply Co., 1978.

Science as Inquiry

Cool, Clear Water

How does salt water affect cells?

Overview:

This activity uses Elodea leaves and exposes them to a salt solution. Students observe cells as they become plasmolysed.

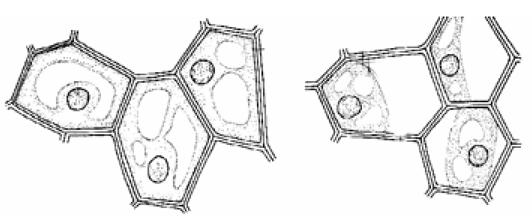
Materials:

Per lab group:
compound microscope
glass slides
cover slips
Elodea
dropper
water
6% salt solution
tweezers

Procedure:

Have students prepare a wet mount of two leaves of Elodea. This can be done on one slide or on separate slides. Have students place two or three drops of tap water on one leaf and two or three drops of 6% salt solution on a second leaf. Students then should add coverslips and wait two or three minutes before observing. Students should locate chloroplasts in relation to the cell wall of both leaves and compare what happened with leaves in tap water and with leaves in salt water. Diagrams of these cells can be made with a description of what took place. Allow students to explain what they think happened to the leaf when covered with salt water. (Please note, if one slide is used for both leaves make sure that the students do not allow the two liquids on the slide to run together. If they do discard leaves and have students start over using fewer drops of liquid.)

Background:



Due to the different concentration of water on the outside and inside of the cells, water from the inside of the cell diffuses out, leaving the cell as a shrunken mass. The cell membrane moves away from the rigid cell wall and the contents of the cell is gathered into a tighter mass. Water vacuoles shrink as the cell shrinks. These cells have become plasmolysed. Normally Elodea cells require 0.9 percent concentration of salt within the cells.

Variations:

Try varying concentrations of salt solution to see if an isotonic solution can be determined. In an isotonic solution, the cells would appear normal.

Adapted from:
Morholt , E. and Paul Brandewein, A Sourcebook for the Biological Sciences, San Diego, Calif.: F. Harcourt Brace Jovanovich, 1986.
James, Daniel E., Culturing Algae, N. C.: Carolina Biological Supply Co., 1978.

Science as Inquiry

Green Measles

What do chloroplasts look like?

Overview:

Chloroplasts are observed as streaming, green bodies in this activity.

Materials:

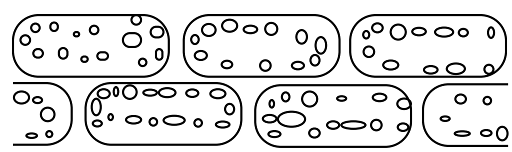
Per lab group:

Elodea plant (anacharis) in aquarium water
glass slides
cover slips
colored pencils
forceps
compound microscope
dropper

Procedure:

Have students mount a leaf of Elodea in water and examine it using both the low and high power of a microscope. They observe and draw what they see.

Background:



When the leaves are young, the tips have chloroplasts moving in the cytoplasm of the cells like streams of water. The cytoplasm is really moving, carrying the chloroplasts like pebbles in a river. This movement is referred to as cyclosis.

The chloroplast contains chlorophyll and other pigments that are used in the process of photosynthesis. In higher plants, a single cell can contain as many as 1000 chloroplasts. Each chloroplast has 1 ∞ 10^9 molecules of chlorophyll!

At this stage, and with this magnification, the students will only be able to see the chloroplast as small, green moving particles within the cell. This is enough. Internal structure that cannot be seen is not required at this time. Lead students to associate the green material with the chloroplasts.

Variations:

Other water plants, such as Spirogyra, may also be used to observe chloroplasts in plant cells. Spirogyra is a common pond algae that is filamentous in nature with a single- or double-spiral chloroplast. Some paramecium (Paramecium bursaria) also contain chloroplasts because they contain a symbiotic partner (Zoochlorella).

Adapted from:
Morholt, Evelyn, and Paul Brandewein, A Sourcebook for the Biological Sciences, San Diego, Calif.: Harcourt, Brace, 1986.

Science as Inquiry

Cavorting Beasties

How can we see digestion, secretion and cell movement?

Overview:

Using cultures of euglena, paramecium, amoeba, and elodea, students identify organelles that can be seen with a common, compound microscope.

Materials:

Per lab group:

Living cultures
- Euglena
- Paramecium
- Amoeba
- Elodea
- yeast

Indicator

Congo Red Solution

compound microscope

glass slides

cover slips

depression slides

Methyl cellulose (Protoslow)

Procedure:

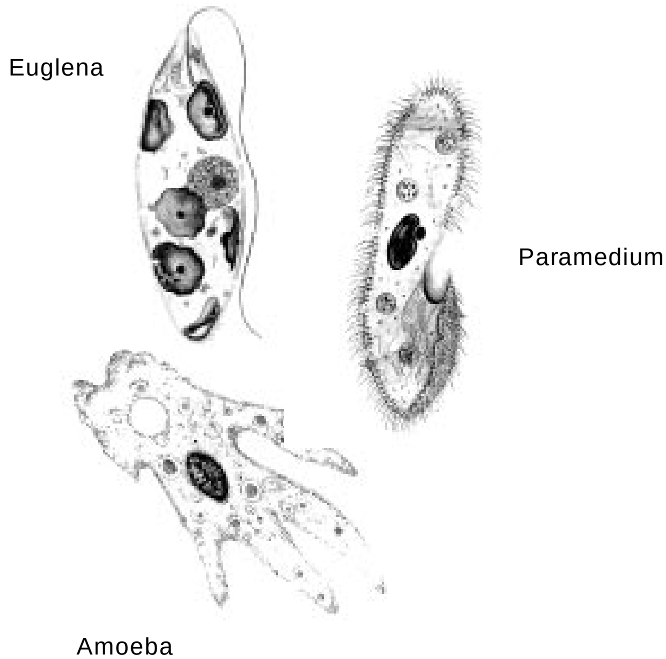
Part A. Observation of cell organelles found in protists: Have students familiarize themselves with Learning Sequence 9.32 before working on this activity. Living protist cultures can be obtained from most biological supply companies. Instructions for maintaining cultures are sent with specimens. Have students prepare temporary wet mounts of protists (Protoslow should be used to slow down protists). For organelle study, Euglena, Amoeba, and Paramecium will show the following clearly: chloroplast (Euglena), nucleus (Euglena, Amoeba, and Paramecium), food and water vacuoles (Amoeba and Paramecium), flagellum (Euglena), cilia (Paramecium), mitochondria (Amoeba), cell membrane (all protists).

Part B. Cell movement can be demonstrated by observing Elodea as well as these protists: Have students obtain a fresh leaf from a sprig of Elodea and locate the chloroplast within the cell. After several minutes, have them describe any observable movement (cytoplasmic streaming will occur within minutes). Students should then observe Amoeba—focusing on cytoplasm—and compare this with what they observed in Elodea. They should then observe Paramecium and Euglena for other organelles used in locomotion and compare each of them.

Cell digestion can be demonstrated with Paramecium. Prepare a yeast culture in a medium containing Congo Red solution. Yeast cells grown with Congo Red will pick up a red stain. Have students add a few drops of the stained yeast culture to a depression slide with living Paramecium and observe. Paramecium will feed on yeast. Students will observe the pathway of stained yeast cells being digested in food vacuoles of the Paramecium. They should be familiar with techniques using a compound microscope, particularly low and high power capabilities—and students should be capable of making wet mounts successfully.

Background:

Observation of basic cell organelles can easily be done using some basic protists. Keep in mind the use of electron micrograph photographs is inappropriate at this time. In subsequent grade levels, this study of cells will be expanded to include more detail.



Euglena are classified as flagellates which means that they move using one or more whip-like structures, flagella. To make Euglena medium, combine 1 liter of spring water, 40 wheat grains, 35 rice grains and 5 mL of dry skim milk. Boil this mixture for five minutes and let stand overnight. Euglena prepare deep vessels with wide-mouths. These cultures should be kept in a well-light area but not in direct sunlight. Euglena move in a circular fashion and can easily be concentrated using light. Place a cardboard cylinder with a one inch slit in one side over the jar so the slit faces a 75-watt lamp. After 10 minutes, remove the cylinder and examine the container without disturbing it. If successful, a thin green line along the side of the container can be seen that can be pick up using a pipette. This positive taxis is related to the beneficial effects of light on the photosynthetic process. Euglena also tend to swim toward weak acids and glucose. It has a negative taxis to gravity and will swim to the top of a vial. It swims always from salt, extremes in temperature and intense light. Chloroplasts, nucleus, cell membrane and flagella are easily identified using only a compound microscope.

Paramecium are classified as ciliates because they have short, hairlike cilia which beat, moving the organism rapidly through the water. Paramecium can move forward or backward while whirling around on their long axes. To slow them, use a commercial agent such as Protoslo that slows them without killing them. To make an appropriate medium, use 6 to 8 grains of boiled wheat grains and add them to pasteurized spring water. Cool to room temperature before using. If 10% nigrosin is added to the culture the contractile vacuoles are more visible. Paramecium are attracted to food materials and repelled by acids. The organelles that are easily identified are: nucleus, vacuole, and cilia. There are several species of paramecium that have exhibit basic size differences and some structure differences.

Amoeba are an example of a shape-less protozoa and the moves using the pseudopodia, false foot. They usually congregate on the bottom or sides of a container. Rice grains usually provide an appropriate addition to the wheat medium. Vacuoles, mitochondria, and nuclei are easily identified. There are several species of Amoeba available.

After identifying organelles, cell movement and digestion can be studied in more detail. A fresh leaf of Elodea in a wet mount can easily show the streaming of the cytoplasm. Paramecium offer a way to see digestive changes in vacuoles. This is not an easy process. The yeast fermenting medium which serves as food for the paramecium is made through the following procedure:

Materials. 1½ tsp. dried yeast, 25 mL graph juice, 20 dried beans or peas, 425 mL spring water, cotton, 1,000-mL flask bottle.

Mix the grape juice and water in the flask. Add the beans and yeast, stirring until the yeast dissolves. Plug the container with cotton and store at 25–30°C for 24–72 hours before using.

The Congo red should not be mixed first in alcohol. This alcohol usually destroys the paramecium. Sometimes it is better to boil the Congo red and yeast suspension and then add it to the paramecium culture. As the food vacuoles digest the yeast, their color will change from bluish green (acid) to orange-red (basic).

Variations:

There are some more colorful protozoa that can be used for this activity. Blepharisma is slow moving, pink organisms that has long cilia and a visible, pulsating membrane. It is quite large and easy to view. Stentor also is another colorful organism. It is bluish in color, trumpet-shaped, and is covered with cilia that are pulsating. Spirostomum is a grayish, cigar-shaped organisms that is covered with cilia. All of these organisms are readily available through commercial sources.

Adapted from:

Brown, R. H., and Roy Wishard, Biology Laboratory Text, Kendall/Hunt Publishing Co.

Brandewein, Paul, and Evelyn Morholt, A Sourcebook for the Biological Sciences, San Diego, Calif.: Harcourt, Brace, Janovich, 1986.

Pendergrass, William R., Carolina Protozoa and Invertebrates Manual, N. C.: Carolina Biological Supply Co., 1980.

Lund, E., “The Feeding Mechanisms of Various Ciliated Protozoa,” Journal of Morphology, 69:563, 1941.

Teacher Sheet

Science as Inquiry

Bricks of the Body

What are the parts of the cell?

Overview:

This activity involves the students in making a model of the cells that they have just observed. There are a lot of materials that can be used for this process. The alternative activity is similar to this one except the students create a mobile of the cell.

Materials:

- pipe cleaners
- clay
- styrofoam
- buttons
- ping-pong balls
- marbles
- cardboard cut-outs
- zip-lock bags
- construction paper
- pop beads
- cotton balls

Perishable—time limit on display
- jello
- fruit

Procedure:

Using a variety of materials, students working in pairs create a model of a cell. The materials used to build the model should be chosen by the students. Most of these items are inexpensive and easy to find.

Session l. Brainstorming (20 minutes): Students choose the type of cell which they want to build (plant, animal, protist, or any other eukaryotic cell). Give them two to three days to collect the materials they need. Session 2. Building the model (one or two 45 minute periods): Students build their models—make sure they construct a key for all organelles included in their cell (the key could also include organelle function). Session 3. Presentation (variable according to the number of groups, 3 minutes per group): Students present models to the class, then place on display in the classroom.

Background:

The cell organelles that were identified in the previous activity should be represent either by shape or color in this model. More than likely the students will be able to identify cell wall, cell membrane, nucleus, chloroplast, vacuole, cilia, mitochondria, and flagella. You will need to decide if the student should only build an animal or plant cell.

Variations:

Students could be limited to certain catagories of materials such as only candy or only hardware parts.

Adapted from:
Many sources over the last 30 years.

an alternative activity for Event 5

Teacher Sheet

Science as Inquiry

Let It All Hang Out

What are the parts of the cell?

Overview:

This activity involves the students in making a model of the cells that they have just observed. There are a lot of materials that can be used for this process. After the create the organelles they organize them in a mobile.

Materials:

Per lab group:
hot glue gun (or commercial glue)
scissors
ruler
poster board
string
black marker
construction paper
Elmer’s glue
markers or crayons
cardboard
tape materials

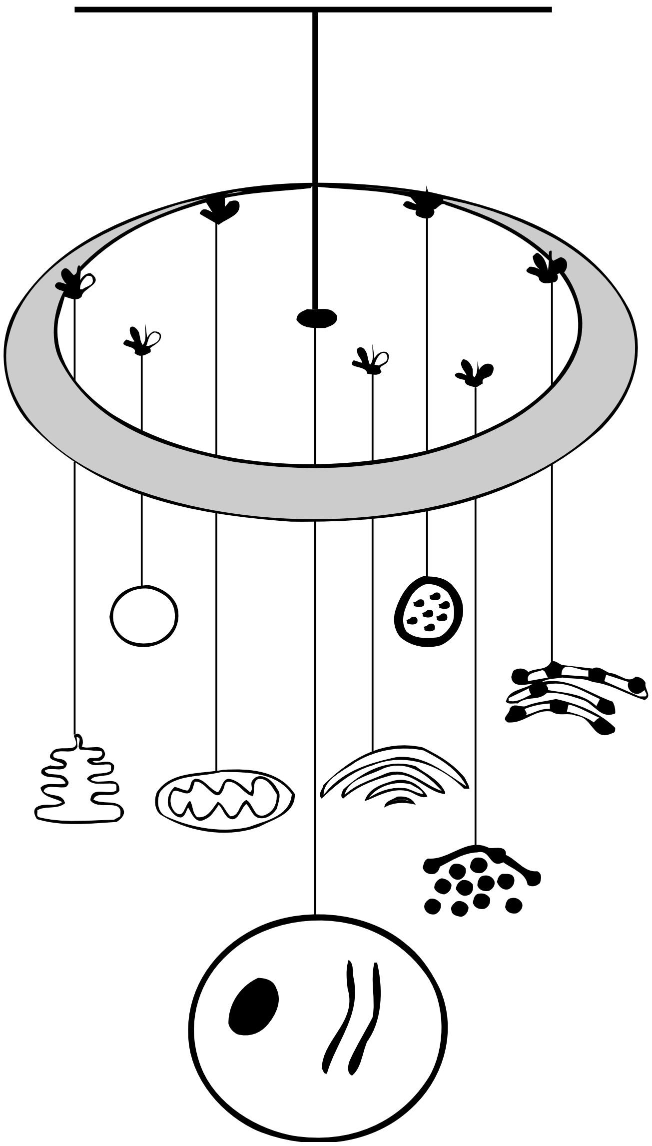
Procedure:

Students work in pairs. They first list on a separate sheet of paper the organelles they have observed from activities completed in Learning Sequence 9.32. You may want to add other organelles which students have read from the anthologies, or other sources.

Have students cut circle (l2 to l8 inches in diameter) out of a piece of stiff cardboard. To construct the cell membrane, have the students obtain a piece of colored construction paper and measure a circle larger than the circumference of the cardboard—about 2 inches wide. Using scissors, they should cut the cell membrane out of the construction paper, then apply a small amount of hot glue to the cardboard, center the construction paper on the board and press firmly into place. The membrane should extend evenly around the cardboard. The cardboard represents the cytoplasm of the cell.

All organelles can now be constructed from poster board and colored with markers or crayons on both sides. The shape and size of organelles should be left to the creativity of the students. Students can be as explicit as they wish with regard to the complexity of the organelles. But they should be able to justify their organelle model. Keep in mind that scale is important (you may have to guide students in this area). Each organelle needs a name. The technical name can be used, however, a synonym related to function can be more effective. (For example, “mitochondria” as “powerhouse,” and “nucleus” as “the command center.”

Cell organelle mobile.



Once all organelles have been constructed, students are ready to assemble the mobile. First, have the students attach the main support string. Using scissors, have them place a small hole in the center of the cardboard circle, thread a long piece of string through the hole and tie a large knot on the underside (to keep the string from being pulled back through the hole). Next, have the students randomly make holes in the cardboard for placement of the organelles (a balanced arrangement is important). Have the students hot glue organelles to strings which has been cut at varying lengths. If names of organelles have been written on paper, have students attach the paper to the string above the organelle (see figure). Students should now attach the strings through the holes made in the cardboard circle and tie with large knots. Once the assemblage is complete and balanced achieved, students can suspend the main string from the ceiling. Each student group will present their mobile to the class.

Background:

The cell organelles that were identified in the previous activity should be represent either by shape or color in this model. More than likely the students will be able to identify cell wall, cell membrane, nucleus, chloroplast, vacuole, cilia, mitochondria, and flagella. You will need to decide if the student should only build an animal or plant cell.

Variations:

Students could use solid objects to repre sent the organelles.

Adapted from:
Walker, P., and Elaine Wood, Hands-on General Science Activities With Real-Life Applications, CARE, 1994.
The Center for Applied Research in Education, 1994.

Science as Inquiry

Chromatography Using Green Leaves

How can chromatography be used?

Overview:

Basic chromatography techniques are used to separate plant pigments.

Materials:

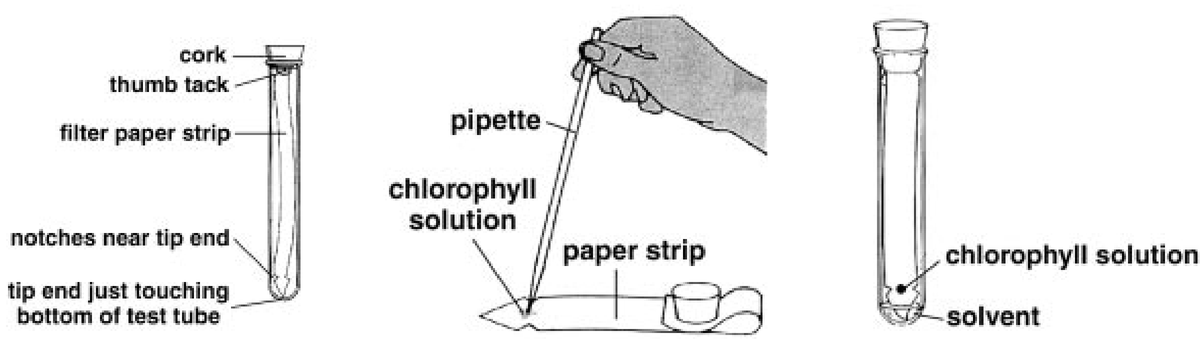
Per lab group:

Whatman #1 or #3 filter paper, 15-cm strips
test tube rack
test tube, 15 x 150-mm
corks
thumbtacks
glass pipette, small
solvent* (mixture: petroleum ether + acetone 9:1)
prepared leaf pigments
ruler

*Caution: Highly toxic and flammable

Procedure:

Students will construct a chromatogram chamber by cutting a 15 cm strip of filter paper to a point. They then cut two small notches about 2 cm from the bottom. They attach this strip to the bottom of the cork (the part that will stick into test tube). Have them adjust the length of the strip so that it just touches the bottom of the test tube.



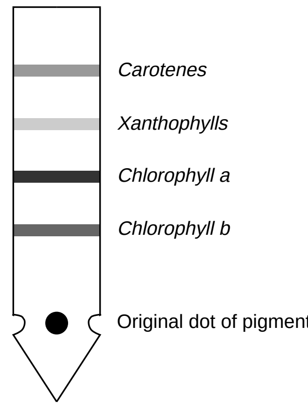
Next students draw a dot between the notches using a pencil. This pencil dot serves as a starting point for the leaf pigment. They place one drop of leaf pigment on this dot and allow it to dry. (To create the leaf pigment, please see the technique sheet, "How to Extract Pigment From Leaves.")

After this first drop has dried, have students repeat the process twenty times. Each time they add the drop of pigment and let it dry. The strip is now ready to be used in the chromatogram chamber.

Students (or teacher) adds solvent to the height of 0.5 cm in the test tube. Be cautious with this solvent. It is highly toxic and flammable. All flames in the laboratory must be extinguished and the room must be well-ventilated. Do not inhale fumes.

Students carefully place the filter paper strip into the test tube so that the pointed end just dips into the solvent. Be sure to remind them that the leaf pigment spot does not touch the solvent.

Have students set aside the test tube for about 10–15 minutes. When the level of solvent if near the top of the paper strip, have students examine the strip. The bands of color will be subtle but should be easily distinguished. Have students circle the different bands before the colors fade.



Background:

Chloroplasts appear green when we observe them in cells, but they actually contain several pigments of different colors. Predominantly, the chlorophylls and carotenoids are these pigments. In higher green plants, there are two different chlorophylls known. The green algae most commonly contain only chlorophyll a and b.

Chlorophyll a and b differ slightly in their chemical structure by only the replacement of a methyl group with a formal group. Chlorophyll a and b also different in their color. Chlorophyll a is blue-green and chlorophyll b is yellow-green.

The carotenoids, beta-carotene, lutein, violaxanthin, neoxanthin, and xanthophylls, are yellow and orange pigments found in both higher plants and green algae. They are thought to protect the chloroplast from totally oxidizing in the presence of light.

Since these pigments differ in their chemical structure, they also differ in their molecular weight. This difference allows some to move faster up the strip of filter paper. The fast moving ones are the carotenes which appear bright yellow. The others is order are: xanthophyll (dull yellow), chlorophyll a (dark blue-green,) and chlorophyll b (dull yellowish-green).

Variations:

Students can do a similar chromatography experiment by using permanent and water soluble marker pens. A dot of ink can be placed at the tip of the filter paper and then placed in water. Many black markers are composed of several pigments and can create a variety of bands. This can also be done on white t-shirts using the permanent markers and isopropyl alcohol as the solvent.

Fall leaves can be used as the source of the pigment. The different colors of these leaves can be related to the pigments present.

Adapted from:

Kaskel, Hummer, Kennedy, Oram, Laboratory Biology: Investigating Living Systems, Columbus, Ohio: Merrill Publishing Co., 1983.

Morholt, Evelyn, and Paul Brandewein, A Sourcebook for the Biological Sciences, San Diego, Calif.: Harcourt, Brace, Janovich, 1986.

Science as Inquiry

Plant Energy

Item:

The plant lives in full sunlight and requires regular input of water. The plant's cells absorb light and produce glucose for the plant and the insects that live on it. The leaves are broad and deep green on the top with light green on the bottom. What organelle produces the ATP (a molecule that stores food energy) used by the plant to make proteins?

A. chloroplasts
B. Golgi Group
C. mitochondria
D. nucleus.

Justification:

What additional organelles are needed to produce large amounts of energy in the form of ATP? How do they work together?

Answer:

A. Chloroplasts trap light energy and convert it into chemical energy stored in the bonds of glucose. Cellular respiration, which takes place in the mitochondria, releases the ATP energy that was trapped during photosynthesis. This energy is then available for the cell to use to carry out its various functions.

Science as Inquiry

Cell Statements

Item:

The individual parts of each of the cells in your body has a specific function. Which of the following statements about a part of a cell and its function are true?

1. The mitochondria produces useful energy for the cell.
2. Vacuoles store material for the cell.
3. The cell wall prevents water from entering or leaving the cell.

Choose:

A. 1
B. 2
C. 3
D. 1 and 2.

Justification:

Correct any incorrect statement, 1 through 3, above.

Answer:

D. The cell membrane allows water to enter the cell. The cell wall provides structural support for plant cells, but allows water through.

Science as Inquiry

Organelle Trouble

Item:

It has been determined that a certain one-celled organism is having trouble synthesizing proteins in order to repair routine cellular damage. The problem is likely located in the cell's:

A. mitochondria
B. ribosomes
C. Golgi bodies
D. microtubules.

Justification:

Explain the function of two of the possible answers you did not choose.

Answer:

B. Ribosomes are sites of protein synthesis. Chemical activity in the mitochondria provide energy for the cell. Golgi bodies are areas for the storage and packaging of chemicals. Microtubules are cylinders of protein that help support the cell and maintain its shape.

Science as Inquiry

Sites of Photosynthesis

Item:

Chloroplasts are known to be the sites of photosynthesis. Most of the chloroplasts are located in the cells of the upper layers of a leaf. Which of the following is the most probable reason for this?

A. This is the best position to receive most of the light.
B. The chloroplasts are less dense and float to this position.
C. They have to be in this position to give the leaf its green color.
D. It is easiest for them to store sugar at this location.

Justification:

If the job of a chloroplast is to carry out photosynthesis it must be able to trap light. It should therefore be in the best possible location to carry out this function.

Answer:

A. If the chloroplast is going to do its job of carrying out photosynthesis efficiently, it must be situated in such a way that it can trap as much light as possible. The best position of the chloroplast therefore, would be as close to the surface of the leaf as possible.

Science as Inquiry

In the Guard Cells

Item:

Chloroplasts are only found in the guard cells of the epidermal layers of leaves. The most probable reason for this is:

A. It was caused by a mutation.
B. The light draws the chloroplasts to this region.
C. The chloroplasts help the guard cells to regulate the stomates.
D. The sugar produced in photosynthesis attracts the chloroplasts to the guard cells.

Justification:

Chloroplasts are the sites of photosynthesis. The sugar produced by this process draws water into the guard cell causing it to swell up. This results in the formation of the stomate which will allow the movement of gases into and out of the leaf. The rest of the cells of the leaf that contain chloroplasts will then be able to carry out photosynthesis.

Answer:

C. The epidermal layer of cells gives protection and support to the leaf. The openings in the leaf must be regulated to prevent desiccation. This is accomplished by having only selected cells, the guard cells, possessing chloroplasts. When these cells photosynthesize, they produce sugar, which draws water into the cells by osmosis. The guard cells become swollen, or turgid, which forms the stomate. At night, when photosynthesis stops, the guard cells stop producing sugar and lose water, thus becoming flaccid. The stomates close up.

Science as Inquiry

Changing Colors

Item:

Many leaves change color in the autumn. This change is a temperature related reaction. Which of the following pigments is the most temperature sensitive?

A. red
B. orange
C. yellow
D. green.

Justification:

Leaves appear green during the spring and summer. When the cooler temperatures of the autumn arrive, the leaves change from green to shades of red, orange and yellow. Therefore, the green pigments must be the most temperature sensitive.

Answer:

D. The equation for a colorful autumn is:

Wet summer + Sunny Fall days + Chilly Fall nights = Brilliant colors

Green pigments, chlorophyll a and chlorophyll b, are easily broken down by the cooler autumn temperatures. This allows the other pigments, which were previously masked, to appear.

Science as Inquiry

Leaf Pigment Solutions

Item:

To carry out the chromatography of leaf pigments a solvent must be prepared. This solvent is a mixture of petroleum, ether and acetone in a 9:1 ratio. Why can't water be used to make a leaf pigment solution?

A. Plants need the water to carry out photosynthesis.
B. The substances we are trying to separate out are not soluble in water.
C. Water has too high a specific heat.
D. The evaporation rate of water is too slow.

Justification:

The leaf pigments can only move up the filter paper if they are soluble in the solvent. The pigments in question are not soluble in water. Therefore, water cannot be used to separate leaf pigments.

Answer:

B.

Science as Inquiry

Evidence for Pigments

Item:

Performance assessment.

Students produce paper chromatograms and explain the results. They should describe the evidence for the pigments of plants using paper chromotography. Students should work alone. Visual barriers are recommended. It is assumed that the students have had previous lab experience and instruction in paper chromotography.

Safety considerations. Skin contact with acetone should be avoided.

Advanced preparation. You will need a set of leaves from a single plant for each student. Ideally the specimens will be in a small plastic bag for each student.

Materials. Plant materials (leaves from the same plant), acetone (nail polish remover), pencil, stapler, blotting paper, pestle and mortar.

Answer:

Science as Inquiry

Pigment Uses

Item:

The pigments in plants can have many uses depending on the characteristics of the particular pigment. Possible uses include dyes and paints and even some possible medicinal purposes. A single plant may have many different pigments in its various parts. One way to separate out the pigments is by chromotography, which is what you will use in this exercise. You will use this technique to determine some basic differences between the various plant pigments which could lead you to some possible uses for each pigment. Photosynthesis dyes and paints do not have photosynthesis in them.

Use the materials provided to create a mixture which will then be used with the blotting paper to produce a chromatogram of the various plant pigments. Create the acetone mixture and set up the chromotography system to produce a chromatogram. Let the chromatogram dry over night and then analyze your results.

Describe the pigments you see on your chromatogram (attach your chromatogram to your answer sheet). How many different pigments are shown? How can you tell?

Which pigments travel the farthest on the paper? Use what you know about molecular weights of different substances to explain this occurrence. What other kinds of material other than plant pigments could chromotography be used for?

Answer:

Science as Inquiry

Testing Concentrations

Item:

Test different types of plants for different concentrations of pigments using paper chromatography. Based on colors of leaves, predict relative concentrations of various pigments (students would be given keys with names and colors of most common chloroplast pigments)

Answer:

Science as Inquiry

Fall Colors

Item:

Fall colors not only please our senses and remind us that summer is ending, they also serve an important purpose for the plants before they leaves fall off. Test green leaves and "fall-colored" leaves from the same plant species (leaves may be frozen until ready for use) and compare the relative concentrations of pigments within the leaves. (Before performing the chromatography, predict what you will find.) Describe your results and try to explain them. What purpose could this serve for the plants?

Answer:

Consumables

Item	Quantity (per lab group)	Activity
6% salt solution	—	2
Amoeba	—	4
buttons	—	5
cardboard	—	6*
cardboard cut-outs	—	5
clay	—	5
colored pencils	—	3
Congo Red solution	—	4
construction paper	—	5, 6*
cotton balls	—	5
cover slips	—	1, 2, 3, 4
depression slide	—	4
dropper	1	2, 3
Elmer's glue	—	6*
Elodea	—	2, 3, 4
Euglena	—	4
fruit	—	5
glass slides	—	1, 2, 3, 4
Gloeocapsa	—	1
jello	—	5
marbles	—	5
marker, black	1	6*
markers or crayons	—	6*
Mythyl cellulose (Protoslow)	—	4
Nostoc	—	1
Oscillatoria	—	1
Paramecium	—	4
ping-pong balls	—	5
pipe cleaners	—	5
pop beads	—	5
poster board	—	6*
prepared leaf pigments	—	7
solvent	—	7
string	—	6*
styrofoam	—	5
tape	—	6*
thumbtacks	—	7

(continued)

water	—	2
Whatman's #1 or #3 filter paper	15-cm strips	7
yeast	—	4
zip-lock bags	—	5

Non-Consumables

Item	Quantity (per lab group)	Activity
compound microscope	1	1, 2, 3, 4
cork (for test tube)	1	7
forceps	1 pr	3
glue gun & glue	1	6*
pipette, glass, small	1	7
ruler	1	6*, 7
scissors	1 pr	6*
test tube, 15 x 150-mm	1	7
test tube rack	1	7
tweezers	1 pr	2

*indicates alternative or additional activity

Key:
1. What's It All About? Algae!
2. Cool, Clear Water
3. Green Measles
4. Cavorting Beasties
5. Bricks of the Body
6. Let It All Hang Out
7. Chromatography Using Green Leaves

Activities

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