

SCOPE, SEQUENCE, and COORDINATION

A National Curriculum Project for High School Science Education

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Student Materials

Learning Sequence Item:

933

Cell Structures and Their Functions

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Science as Inquiry

What's It All About? Algae!**What does a microscopic view of algae reveal?****Overview:**

Have a closer look at pond scum to see what they really look like.

Procedure:

Your teacher will give several living specimens of blue-green algae to observe. You will make temporary wet mounts of these cells and observe them under high power. Your goal is to compare and contrast these cells with cells which you have already studied.

Questions:

1. Do all living cells possess a cell membrane? A cell wall? Organelle? Explain.
2. What features do these algae cells have in common with plant cells and animal cells?
3. What features do these algae cells have which are not shared with other cells that you have studied?

Science as Inquiry

Cool, Clear Water**How does salt water affect cells?****Overview:**

How do you feel after you have soaked in a hot tub of water for a long time? A little pruned? See what happens to Elodea cells in a similar situation.

Procedure:

Remove two leaves from the Elodea which your teacher has given to you. Prepare wet mounts of each leaf. On one leaf, put two or three drops of tap water and add a coverslip. On the other leaf, put two or three drops of 6% salt water and add a coverslip. After two or three minutes observe each leaf under low and high power. Describe what you see.

Questions:

1. What differences did you observe between the leaf in tap water and the leaf in salt water?
2. How do you account for these differences?
3. Can you relate this activity to how most cells deal to water in most environments?

Science as Inquiry

Green Measles**What do chloroplasts look like?****Overview:**

Plants cells are special and have special parts. Look closely to see if you can identify these parts.

Procedure:

Mount a leaf of Elodea on a slide using a drop of aquarium water and a coverslip. The leaves of young growing tips work best. Examine the leaf under both low and high power magnification with the microscope. Sketch diagrams of several cells.

Questions:

1. What is the color and location of the chloroplasts?
2. Describe the movement of the chloroplasts in the cells?
3. How is the structure of a leaf related to its function of food making?

Science as Inquiry

Cavorting Beasties**How can we see digestion, secretion and cell movement?****Overview:**

Repeat Leeuwenhoek's experiments and see these small beasts.

Procedure:

Examine the living cultures of Euglena, Amoeba, and Paramecium. How would you describe them? You will also be given Elodea—a water plant. You will make temporary wet mounts of these organisms and observe them under high power. Your teacher will explain how to slow down these organisms using Protoslow. Compare these organisms and observe their behavior. Record in your journal similarities and differences among them. You will also observe activities such as locomotion and digestion in some of these organisms.

Questions:

1. What features are similar among these organisms? What features are different?
2. Did you notice any behavior activities in Euglena? In Paramecium? In Amoeba? Describe these patterns.
3. Describe how Amoeba and Paramecium feed. How do the activities of these organisms compare with human activities.

Science as Inquiry

Bricks of the Body**What are the parts of the cell?****Overview:**

A picture is worth a thousand words. Make a model to communicate even more.

Procedure:

Your task as a team is to create a model of cell using a variety of materials that you have chosen. Decide what type of cell to build and what materials to use. Be as creative as you wish, but keep the cost of materials down. Once you have decided on the materials, you will have two to three days to collect and bring these items to class. In building your model, keep in mind the type of cell you are creating—and that your model is three dimensional. After you have completed the model, design a key which corresponds to the parts of the cell. You will have three to five minutes to present your model to the class. Remember this is a team effort!

Questions:

1. How would you improve your model to be more like a living cell?
2. How does the shape of your cell represent a shape of a living cell?
3. How did you represent all the organelles found in your cell? What organelles did you leave out? Can you describe the functions of these organelles? Why did you omit them from your model?
4. Do any of the organelles in your models have similar functions to organs of the human body? If they do, explain these similarities.

Science as Inquiry

Let It All Hang Out**What are the parts of the cell?****Overview:**

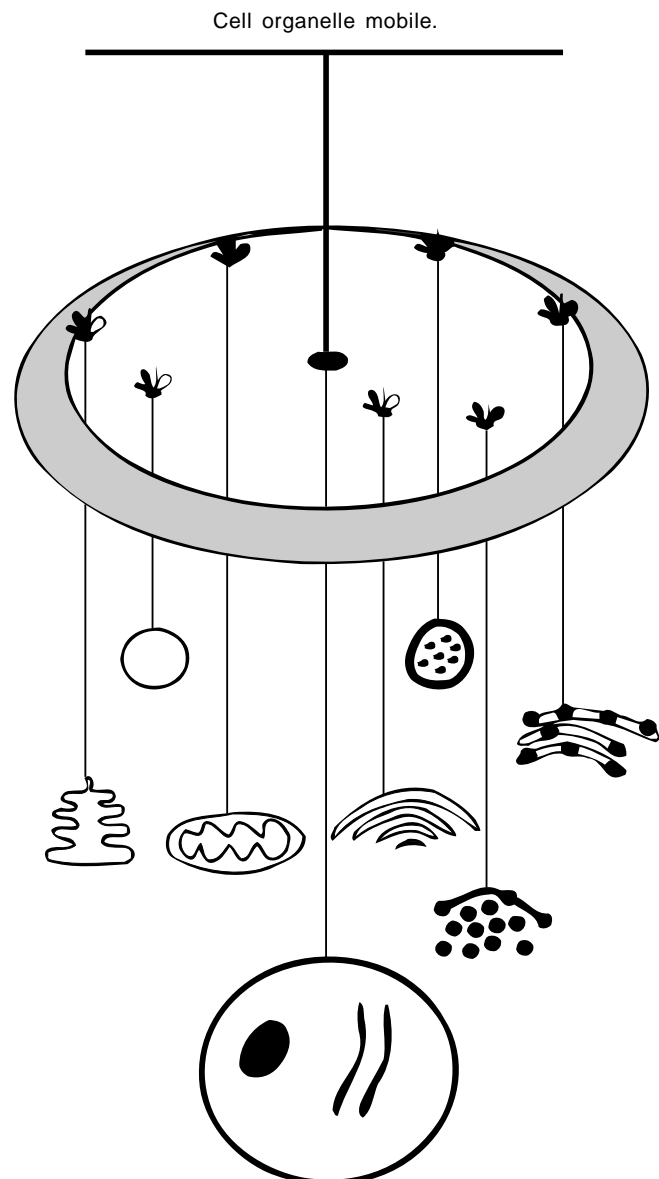
Mobils are models too. Use the cell for this mobile.

Procedure:

Work in pairs to construct a cell mobile. The design can be modified as long as you create a balanced mobile for display. Before you begin building the mobile, list the organelles you wish to include (think about their function). Each organelle should have a name, however the technical name does not have to be used. See if you can create a name which suggests a function of the organelles you list. These names should be attached to in some way to the organelle. You may want use other materials not given to you by your teacher. Ask your teacher for help in finding these items.

Questions:

1. In what ways could you improve the construction of your mobile to accurately represent a cell?
2. Describe the functions of each organelle represented in your mobile?
3. How do the functions of the organelles relate to the human body functions? How do cells relate to the human body? Explain?



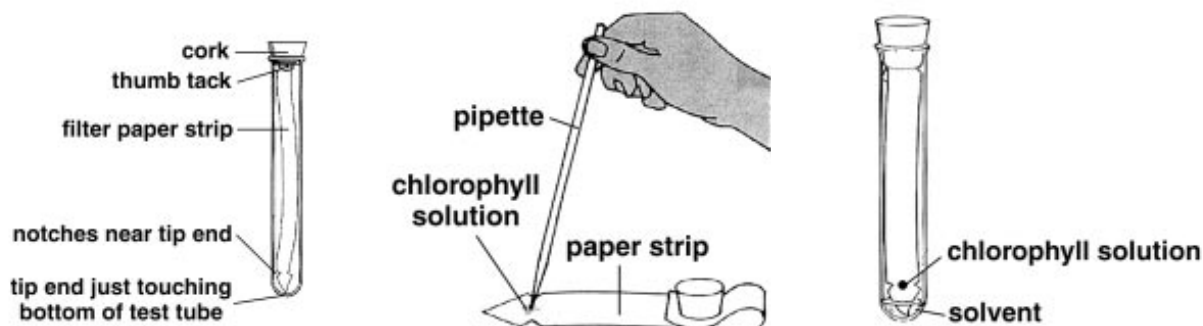
Science as Inquiry

Chromatography Using Green Leaves**How can chromatography be used?****Overview:**

Find how to separate this biological mixture in this activity.

Procedure:

Attach a filter paper strip to the bottom of a cork with a thumb tack. Adjust the length so that when it is inserted into the test tube it just touches the bottom.



Remove the filter paper strip and lay it on the lab table. Make a pencil dot between the notches. Add a drop of the leaf pigment solution at this dot using the small glass pipette. The solution will flow quickly so hold the pipette on the filter paper for a very short time. A small circle of solution, approximately the diameter of a pencil, is all that is required.

Allow about 30 seconds for the spot to dry. Add another drop of pigment solution to the same spot. Repeat this procedure until 20 applications of the solution have been made. Be sure to allow enough time for drying between applications. The leaf pigments can now be separated using the solvent.

Caution: The solvent is both toxic and highly flammable. All flames in the laboratory must be extinguished and the room must be well-ventilated. Do not inhale the fumes.

Add solvent to a height of 0.5 cm. in the empty test tube. Place the test tube into the test tube rack. Carefully place the filter paper strip into the test tube so that the pointed tip dips into the solvent, but the leaf pigment spot does not touch the solvent.

Do not move the test tube for 10–15 minutes. Remove the filter paper strip from the test tube when the level of solvent is near the top. Examine the filter paper strip for the presence of different bands of color. Circle the different bands before the colors fade.

Questions:

1. How many colored bands appeared on your filter paper strip?
2. Describe the colors and the orders of the bands.
3. Which pigments traveled the fastest up the filter paper strip? Why did this happen?
4. If most leaves appear green, why can't these other pigments normally be seen?
5. At what time of the year might it be possible to see these other pigments in leaves?
6. What are some possible advantages of having several different pigments present in leaves?
7. In what cell organelle will leaf pigments be found?

Science in Personal and Social Perspectives

Autumn Leaves

True or False?

1. Trees with leaves lose them in the fall to make room for new ones the following spring.
2. Trees lose their leaves to fertilize the ground for the following growing season.
3. An early frost ensures a colorful autumn.
4. The wetter the autumn, the more brilliant the leaf colors.

There are many common misconceptions about autumn leaf colors . . . all of the above statements are false.

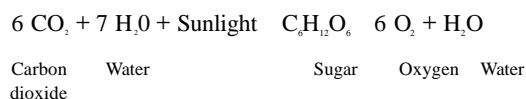
It is September in central Pennsylvania. The forest is preparing for winter. At the top of a hill, a sugar maple tree slowly begins the process of shedding its leaves. As it does, the leaves display some remarkable color changes. The summer green fades slowly and is replaced by a bright yellow. The tall sugar maple is the brightest spot on the hill but only for a few days. The yellow gives way to a rich red-orange. Then the leaves begin to fall to the ground, where they finally turn brown. Down the hillside, a red oak changes, but its leaves turn from green directly to a deep red. Nearby, a tulip tree changes from green to yellow.

What causes these remarkable colors? Why do they change? Why do different trees turn different colors? Why are some autumns more colorful than others?

The colors in leaves are caused by pigments, chemicals that reflect and absorb light selectively. Reflected light bounces off the leaf, and some of it reaches your eye. Absorbed light enters the plant but does not come back out. A green leaf is green because it reflects green light while absorbing the other colors. A red rose is red because it reflects red light and absorbs the rest of the spectrum. Most plant colors are caused by three families of pigments: the chlorophylls, the carotenoids, and the anthocyanins.

Chlorophylls

Chlorophylls are responsible for the most abundant plant color green. Chlorophyll pigments are needed for the plant to produce food by photosynthesis, the complicated chemical process whereby plants use water, carbon dioxide from the air, and the energy of sunlight to make carbohydrates. Chlorophyll pigments absorb the energy of the sunlight and pass it on in the form of high-energy electrons that power the chemical reactions of photosynthesis. Chlorophyll is the critical component that converts solar energy into chemical energy. The carbohydrates are eventually converted to simple sugars. Photosynthesis involves many chemical reactions, but in very simplified terms it can be summarized as:



In this reaction the chlorophyll can be regarded as a catalyst—a substance that changes the rate of a

By Brad Lear. Reprinted with permission from "Autumn Leaves," *ChemMatters*, October 1986, pp. 7–10. Copyright 1986 American Chemical Society.

chemical reaction but is not used up by the reaction.

There are several types of chlorophyll, including chlorophyll a, chlorophyll b, and chlorophyll c. All photosynthetic organisms contain chlorophyll a, which is supplemented by b or c in certain plants. Types b and c are considered accessory pigments. They absorb light of slightly different colors than does chlorophyll a, and pass the energy on to chlorophyll a. The accessory pigments extend the range of colors that the leaves can use for photosynthesis, enabling them to produce more food each day.

Inside plant cells, all chlorophylls are bound to a protein, and the combination is insoluble in water. This lack of solubility partly explains the anguish many parents exhibit over grass-stained clothes. Because chlorophyll does not dissolve in water, it is difficult to wash from natural fibers.

Carotenoids

The carotenoid pigments are responsible for the orange, yellow, and some of the red seen in autumn leaves. Instead of capturing light for photosynthesis, the carotenoids protect the tree from the destructive power of chlorophyll. When chlorophyll absorbs light, it produces a high-energy electron that is normally passed to other compounds. However, if there is a shortage of these secondary compounds, the electron may combine with oxygen, then roam the cell destroying molecules at random. This can kill the cell and eventually the entire leaf. The carotenoid pigments are able to join with this energized oxygen temporarily and later release when it can be used constructively.

The colors of the carotenoid pigments help the tree in other ways. They attract pollinating insects and make ripe fruits noticeable to birds and mammals, which eat them and thereby spread the seeds over a wide area.

In tree leaves the carotenoid colors are usually masked by the green of the chlorophylls and can be viewed only when the chlorophyll disintegrates in autumn. An example of the carotenes is the yellow-orange pigment beta-carotene, which is responsible for much of the orange in autumn leaves. It also produces the color of sweet potatoes, pumpkins, certain squashes, and, of course, carrots.

Anthocyanins

The least prevalent but most colorful pigments are the anthocyanin group. Frequently red or blue, they are responsible for the color in 70% of flowers, 85% of fruit, and 90% of red leaves. Four major forms of anthocyanins exist, but more than 100 molecular variations have been discovered. In addition, anthocyanins can change color according to the pH (acid-base condition) of the plant tissue, so that one compound can exhibit a variety of colors. Many plants manufacture several anthocyanins. With different combinations and concentrations, all the colors of the rainbow are possible.

Falling leaves

As autumn approaches, the trees prepare the leaves for abscission, or falling. If this did not happen, the thin leaves would be exposed to the dry winds of winter and would rapidly lose water, which could not be replaced by the tree's frozen roots. The drying process could continue even with frozen leaves. Your grandmother may have been familiar with this phenomenon. Without a modern clothes dryer, how did she dry her clothes in subfreezing weather? Simple . . . she took them outside. They froze stiff, then slowly dried. In cold, dry air, ice slowly evaporates (a process called sublimation). If the tree did not drop its leaves and "shut down" for the winter, it would dry out and die. By dropping their leaves, the deciduous trees are able to grow throughout a larger geographic range because they can survive the harsh northern winters.

Show off

In some ways, the color change of deciduous trees is comparable to a stage actor doing a quick-change act by removing a green shirt to reveal a yellow shirt, removing the yellow shirt to show a red one, and so on. Before the show, the actor must prepare by applying the underlying layers. Similarly, if the maple, oak, and tulip are to show off their proudest colors in the fall, they must begin with a generous supply of each pigment.

For this, the trees need a vigorous and long season of photosynthesis which, in turn, requires certain weather conditions. First, the summer must

be rainy or at least have average rainfall. Photosynthesis requires water; if little is in the ground, the dry leaves will be shed early. Second, the autumn days must be bright and sunny to allow photosynthesis to continue late into the season. Dry or cloudy weather will reduce sugar production, which makes for drab colors.

When the tree finally signals the leaf to cease activity (the exact conditions that trigger this change are not completely understood), the protein to which the chlorophyll is bound breaks down into amino acids that are shuttled down to the roots for storage. These amino acids, sugars, and many other chemicals constitute the sap that rises the following spring.

When the chlorophyll molecule loses its binding protein, it decomposes, and the green color fades from the leaf. It is at this time that the other pigments show through (such as the orange of the beta-carotenes). The more productive the leaf has been (with sunny days and abundant ground water), the greater the concentration of the accessory pigments and the brighter the leaf color. This is when trees such as aspen, silver maple, hickory, birch, and tulip show their bright yellow.

The sugar maple begins the same way, green changing to yellow, but unlike most trees it changes to a third color red-orange. This presented researchers with a paradox, because it begins the process with pigments for only two colors, yet displays three colors. It is like the stage actor putting on two colored shirts, then stripping off three. Where does the red-orange come from?

Sugar color

The leaf is the food factory of the tree, producing sugars that are used for several purposes. Sugars provide nourishment for the tree's living cells, and they are the building blocks of cellulose (the main component of wood). Also, some sugar is used in the leaf to synthesize anthocyanin pigments. As autumn approaches, the tree stops growing (using sugar to make new wood). The sugar manufactured in the leaves is now shuttled to the root system for winter storage.

When the tree is finally ready for abscission, the twig is sealed off from the leaf by a layer of cork cells. This stops the transport of fluids to and

from the leaf. Any sugar left in the leaf when this occurs is trapped there. This leads to the final factor crucial for colorful fall leaves: chilly nights.

When the air turns cold, the sugary fluid produced by the leaves becomes slow flowing, or viscous. Some of the sugar synthesized during the day cannot be transported to the roots at night and remains in the leaf. This leftover sugar is changed by a complicated set of reactions into anthocyanins, the pigments that can produce so many different colors. The more sugar trapped in the leaf at abscission, the greater the amount of anthocyanins produced and the brighter the leaf. This happens when night temperatures fall to about 10°C (50°F) or lower. It does not require the subfreezing temperatures that produce frost. Jack Frost may nip at your nose, but, contrary to common belief, he is not necessary for beautiful autumn colors.

This means that the equation for a colorful autumn is:

Hillside performance

On the Pennsylvania hillside, the sugar maple, tulip tree, and red oak signal their leaves to begin abscission each at its own time. The chlorophyll molecules begin to disintegrate, and valuable nitrogen in the amino acids is transported to the roots for winter storage. With the chlorophyll gone, the carotenoids in the sugar maple and the tulip tree become visible, and the leaves turn bright yellow. The red oak has no carotenoids and changes to the deep red color of its anthocyanins.

The sugar maple is not finished. The large amount of sugar remaining in its leaves produces red anthocyanins that mix with the yellow carotenoids to give the leaves a brilliant orange-red color.

Eventually, all of the pigments disintegrate and the leaves appear brown, the color of the woody fibers that make up the leaves' "skeleton." When the winter winds begin, the leaves of the sugar maple

Wet summer	+	Sunny Fall days	+	Chilly Fall nights	=	Brilliant colors
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and the tulip tree are torn from their branches and fall to the ground. The leaves of the red oak will drop the following spring. The fallen leaves add

important bulk to the soil humus, but, because they contribute only small amounts of potassium and calcium, they make poor fertilizer.

For deciduous trees, dropping leaves is a matter of survival. Fortunately for us, if the conditions are right, those leaves put on quite a show before they are gone.

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