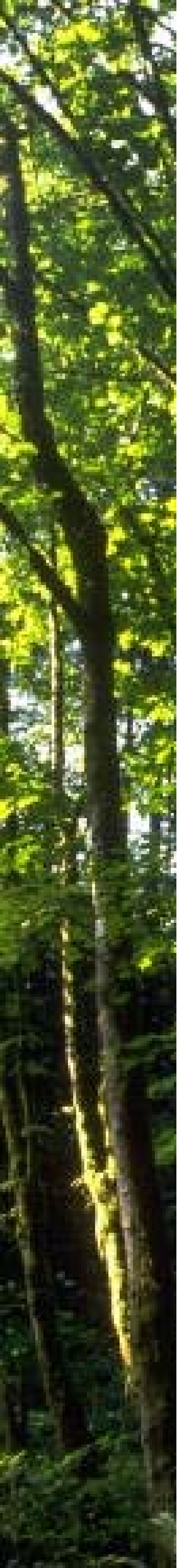


RAIN FOREST TEACHING CURRICULUM

Table of Contents

Welcome to Rain Bird's Rain Forest Teaching Curriculum!

The Rain Bird Rain Forest Teaching Curriculum features "I can relate to that" science learning tools for teachers, students, and parents. The following is a list of answers to some frequently asked questions about the Rain Bird Rain Forest Teaching Curriculum:

What is it?

Rain Bird's Rain Forest Teaching Curriculum is an online educational tool for teachers to use and find specific lesson plans and related course work for kindergarteners through high school seniors. This content is also available online at www.rainbird.com.

What is its purpose?

To teach natural history, ecology, biology, physics, and chemistry through demonstrations, experiments, and classroom activities. Rain Bird and California State Polytechnic University, Pomona (Cal Poly Pomona) designed the program content, which focuses on endangered tropical rain forests in Latin America, South America, Africa, and Southeast Asia as the basis for teaching science through fun, hands-on things children already do and like—art projects, outdoor activities, and classroom demonstrations. The curriculum motivates kids to think about the part each of them plays—or the actions they can take—in preserving and protecting the environment.

Who should use it?

Teachers and parents. Teachers who are seeking a new, fun and engaging resource to teach children about science. Parents who are looking for friendly, but educational how-to's on "bringing science home." But most of all, it offers something for just about anyone and it's just plain fun for kids, no matter what their age.

Is the information easy to use?

Yes! The information is well organized and self-explanatory. The curriculum is arranged with grade-appropriate material (K-1, 1-2, 2-3, 3-4, 4-5, 6, 7, 8, and 9-12). As appropriate, each grade level contains projects that integrate science with art; data gathering, observation, and inference; analysis of physical matter; in-class demonstrations to be performed by teachers for students; and at-home projects that illustrate scientific principles in a manner both understandable and meaningful to school-age children.

Why the focus on rain forests?

Rain Bird has always supported and educated its consumers on the importance of the "Intelligent Use of Water." The curriculum ties into this philosophy because rain forests provide oxygen and consume carbon dioxide, playing a pivotal role in the climate control of our planet. This affects wind, rainfall, humidity, and temperature worldwide. Rain Bird is deeply concerned about the environment and has always promoted stewardship of Earth's resources, or which water is among the most precious. Some 30 million species of plants and animals—a majority of all things living on Earth—exist interdependently in tropical rain forests. In addition, rain forests are rich with plants vital in creating modern medicines.

What has the response to the curriculum been?

Thousands of online visitors each month learn about the important role tropical rain forests play in the world. And, because the information is being so well received, Rain Bird has expanded its commitment to university-level education through its partnership with California State Polytechnic University, Pomona. Jointly, they will unveil in 2002 three Rain Bird Learning Centers at Cal Poly Pomona's BioTrek Project, located on the Cal Poly campus.

About Rain Bird

Rain Bird Corporation, based in Glendora, California, USA, is the world's largest manufacturer of sprinkler and drip irrigation equipment. Founded in 1933, Rain Bird offers the industry's broadest range of irrigation products to golf courses, sports arenas, amusement parks, farms, and commercial and residential developers in more than 130 countries. For more information, visit Rain Bird's web site at www.rainbird.com.

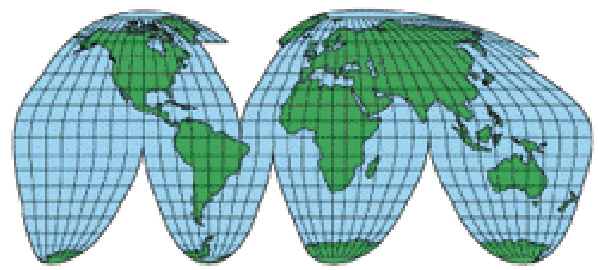
This workbook is brought to you through a partnership between:

Rain Bird, Azusa, California

Science IMPACT, College of Science,
California State Polytechnic University, Pomona

The Rain Forest: An Introduction

What is a tropical rain forest?



A tropical rain forest is a forest that receives 4 to 8 meters of rain each year.

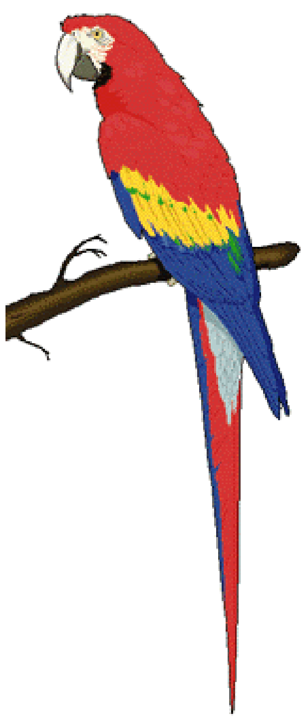
Where are tropical rain forests located?

Rain forests are located within a narrow region near the equator in Africa, South and Central America, and Asia.

Why are tropical rain forests important to our earth?

Rain forests play an important role in the climate control of our planet by having an affect on the wind, rainfall, humidity, and temperature. Within the rain forest, water, oxygen, and carbon are recycled. This natural recycling helps to reduce flooding, soil erosion, and air pollution.

The rain forests support over one half of the plant and animal life on Earth, even though they cover only 2% of the Earth's surface.



Approximately one fourth of the pharmaceuticals (medicines) we use come from plants of the tropical rain forests. According to the National Cancer Institute, 70% of the plants from which we make medicines and that are effective in the treatment of cancer can only be found in the rain forests.

What is happening to our rain forests?

27 million acres of the Earth's rain forests are destroyed each year due to man. The activities which threaten the rain forests are: agriculture, clearing and developing of land, beef cattle ranching, logging, and the building of dams and hydroelectric plants. This results in a loss of 100 acres of rain forest per minute and 80% of the rain forests in the world are now gone. The destruction of the world's rain forests at this rate causes 10,000 plant and animal species to become extinct each year.

Grades K-5 Activities Overview

Curriculum materials are divided into grade level segments. Within the segments for grades K-5, there are four components of curriculum materials:

- **Science Through Art** – These activities integrate science and artistic skills, such as coloring, drawing, painting, and printmaking.

- **Interactive Science Activity** – These activities are experimental in nature, requiring students to take data, make observations of the data and, at higher grade levels, to make inferences from the data.

- **Outdoor Activity** – These activities allow students to gather materials from the field and perform scientific analyses, appropriate to their grade level, on the materials that they bring in from their excursion to the outdoors.

- **In-Class Demonstration** – These activities are demonstrations to be performed for the students by the teacher, using commonly available materials, and primarily related to physical science aspects of rain forest phenomena.

Grades K-1 Activities At a Glance

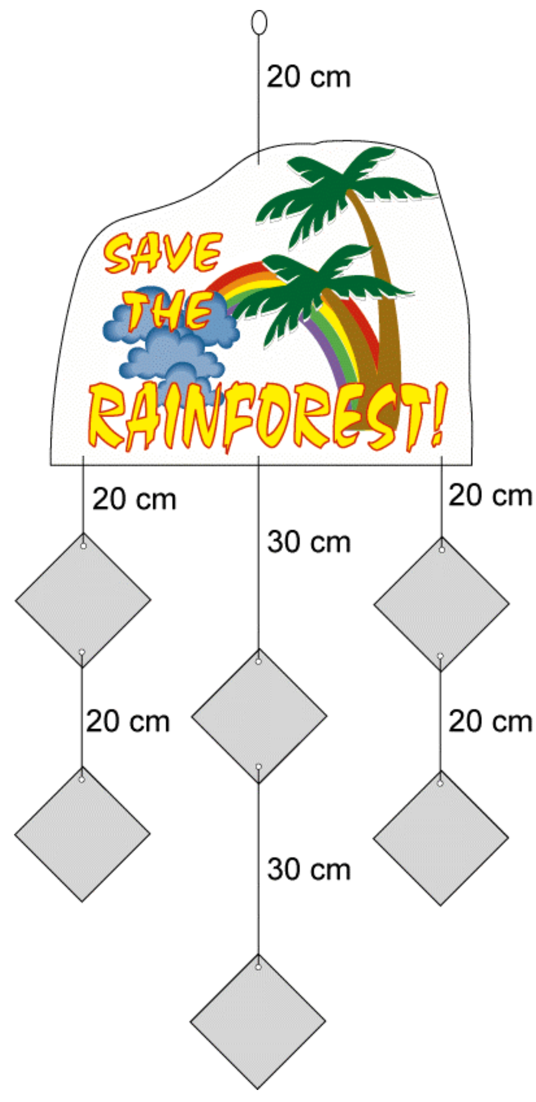
- Science Through Art: Rain Forest Mobile
- Interactive Science Activity: Seed Germination
- Outdoor Activity: Leaf Hunt
- In-Class Demonstration: Rainbow

Grades K-1 Science Through Art Activity: Rain Forest Mobile

In this activity students can learn the names of some of the animals that live in the rain forest. They will do this by cutting out and coloring the pictures of various animals, which are provided.

Materials:

Printouts of rain forest animals, crayons or markers, scissors, glue, yarn or heavy string, colorful construction paper, hole punch.



Procedure:

There are numerous ways to construct a mobile. This is a very simple version which takes the guesswork out of balancing the mobile.

1. Precut twelve construction paper squares of diameter 11 cm on a side for each student (using the paper cutter at your school will save time).

2. Print the pictures of the animals from this web site for the students to color and cut out. Allow the students to select ten construction paper squares in the colors of their choice.

3. Each student will need to paste two paper squares together, back-to-back, so that they have six doublethick squares, perhaps green on one side and yellow on the other, all the same color, or a variety.

4. Three of the double-sided paper squares will need a hole punched at the top and the bottom (with the squares in an orientation which makes them diamond-shaped, as in the diagram) and three of them will require a hole punched at the top only.

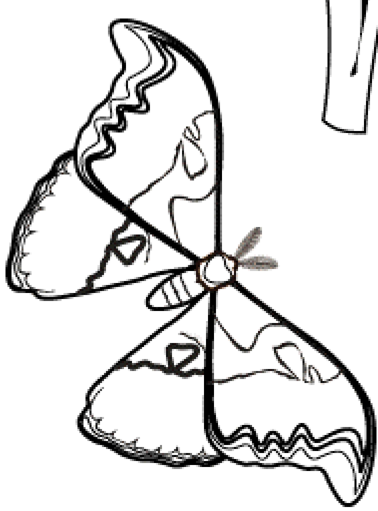
5. The students can now paste the animals they have colored and cut out on both sides of the paper squares. They can use different animals on each side, or the same animals on each side, but they should have a variety.

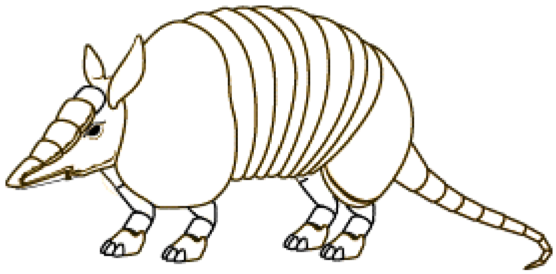
6. Print two "Save the Rain Forest" designs for each student. This design will form the top of the mobile. Have students paste the copies of the design on both sides of card stock or two thicknesses of construction paper. Punch three holes across the bottom and one at the top, as in the diagram.

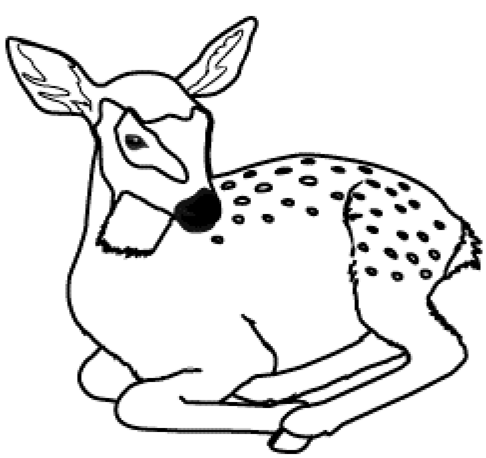
7. Precut the yarn or heavy string for each student in the following lengths: two pieces of approximately 30 cm and five pieces of approximately 20 cm. Lengths may vary from these values, as long as they are the same on both sides of the mobile.

8. One of the 20 cm pieces will require a loop tied at one end so that the mobile can be suspended from the ceiling. Tie the other end through the hole at the top of the "Save the Rain Forest" design.

9. Tie the strings to the bottom of the "Save the Rain Forest" design as shown in the diagram. Construct the mobile by tying the paper squares to the strings as shown.








SAVE THE RAINFOREST!

Grades K-1 Interactive Science Activity: Seed Germination

In this activity the students will learn about seed germination and discover that a plant embryo (or baby plant) exists in every seed. They will also experiment with the effect light has on seed germination, and predict if seeds germinate best in the light or the dark. There should be some discussion of the importance of plants in the rain forest and in other parts of the world - plants supply food, oxygen, shelter for animals and building materials for man, as well as maintain the climate of earth (through carbon dioxide absorption, helping to prevent global warming; some of this information is too sophisticated for K-1 students and should be used with teacher discretion).

Materials:

Dry lima beans (purchased from the market), water, magnifying glasses, plastic beverage cups, paper toweling, aluminum foil.

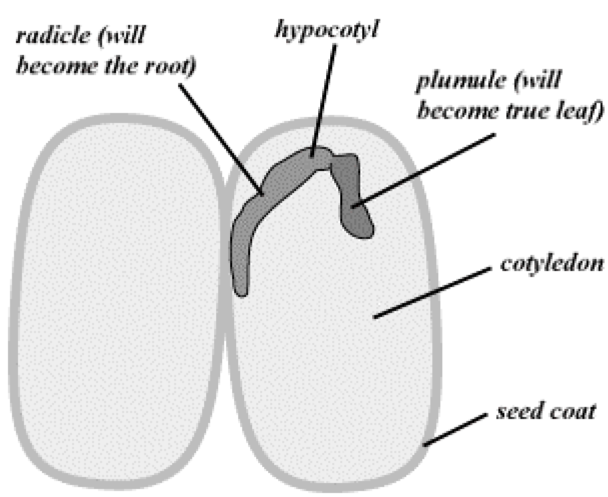
Procedure:

There are two components to this activity: (1) students explore the structure of the seed, and (2) they experiment with the effect of light on seed germination.

Component #1:

1. Soak enough lima beans to distribute one per student (have extras on hand for those who drop, lose, smash, etc. their specimen); soak for 30 minutes to loosen the seed coat.

2. Each student should examine the seed and peel off the seed coat, which serves as protection for the seed. This should be discussed‹ask the students why the seed coat is there and why the seed needed to be soaked prior to peeling off the seed coat. Ask them also if they think this is what needs to happen in nature. They should arrive at the conclusion that there needs to be rain, or if we plant seeds, we need to water them. Also discuss that the seed itself is



food for the baby plant until it germinates (or sprouts) and can make its own food by growing in sunlight and being watered by rain or irrigation.

3. Once the seed coat is off, have the students split the seed apart to expose the plant embryo and examine it with a magnifying glass. A diagram of the seed follows:

Component #2:

1. Soak (for about 30 minutes) enough dry lima beans so that each pair of students has six seeds.

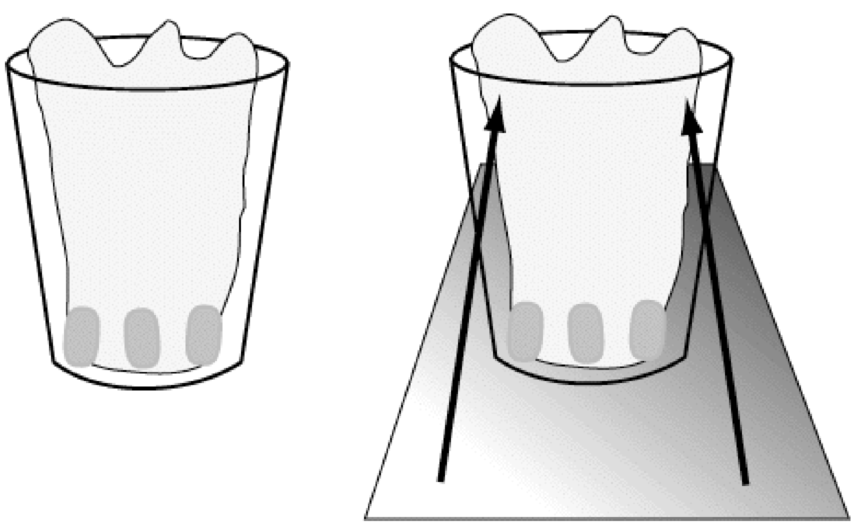
2. Give each pair of students two plastic beverage cups, two paper towels, a shallow pan of water, six soaked lima beans, and enough aluminum foil to wrap one of the cups.

3. Working in pairs the students should soak two paper towels, wring them out, fold each to fit neatly in each of the two plastic cups, and drop three soaked lima beans in each cup, placing the beans between the wet toweling and the inner surface of the cup.

4. Have students completely wrap one of the cups in aluminum foil to block light from reaching the seeds.

5. Use a marker pen, such as a Sharpie, to identify which cups belong to whom and then place them in a location where they can be observed on a daily basis.

6. Have students make observations of their seeds each day and ultimately draw conclusions regarding the growth of plants from the seeds.



Fold aluminum foil up
to cover plastic cup

Questions for Students:

1. What was inside the seed when you opened it?
2. What effect did the difference in light have on the growth of the plants?
3. Why was it important for the towels to be wet?

Grades K-1 Outdoor Activity: Leaf Hunt

Students often overlook plants and their importance. This activity stimulates students to closely observe leaves and identify their characteristics. This simple activity also builds on students' counting and sorting skills.

Materials:

Paper or plastic sacks to collect leaves, magnifying glasses, chart paper and marker pens.

Procedure:

1. Take the students out to the campus to collect leaves (or ask them to bring leaves from their own yards).

2. Once inside, the students can sort the leaves by various characteristics, such as:

    - rough or smooth edges
    - veins in one direction, or branched
    - light or dark green pigment
    - leaves of colors other than green
    - thick or thin
    - lobed or not lobed

3. Using chart paper and marker pens, chart and graph the leaf hunt results.

Grades K-1 In-Class Demonstration: Rainbow

One of the most beautiful displays of physical science in the rain forest is the rainbow, which appears when there are droplets of water in the air. This demonstration allows you to create a rainbow on the ceiling of your classroom, so that all students can see it.

Materials:

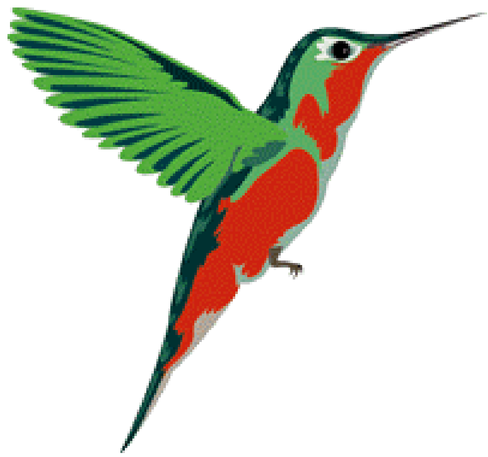
Clear plastic cup, water, overhead projector.

Procedure:

1. Fill the cup with water and place it on the glass of the overhead projector. Turn on the projector.
2. As the water settles down after being placed on the overhead projector, you will see a large circular rainbow on the ceiling of the classroom.

Questions for Students:

1. Which color is on the outside of the rainbow? Which is on the inside?
2. In a real rainbow, which color is on the top?
3. What shape would the classroom rainbow have if a square plastic container were used? (Try it!)



Grades 1-2 Activities At a Glance

- Science Through Art: Leaf and Flower Prints
- Interactive Science Activity: Environmental Conditions and Germination of Radish Seedlings
- Outdoor Activity: Attracting Hummingbirds
- In-Class Demonstration: Light Absorption

Grades 1-2 Science Through Art Activity: Leaf and Flower Prints

In this activity, making leaf and flower prints as an art project will give the students an opportunity to carefully observe leaves and flowers.

Materials:

White or light colored construction paper sheets (any size), poster paint, a variety of leaves and flowers.

Procedure:

Caution should be taken to keep hands as free of paint as possible to avoid smearing the paint and to create sharp images of the plant material.

1. Using poster paint and paint brushes, paint the underside of leaves (this is where the veins are the most pronounced) and then press the painted leaves, one at a time, on the paper, being careful not to smear the paint.

2. Repeat the process with flowers. When painting and pressing the flowers, the open blossom can be painted and then pressed onto the paper, or a closed blossom can be painted and pressed, giving a "side view" of the flower.

3. Allow the prints to dry thoroughly. If the prints are made on 11" by 17" paper and then plastic laminated, they make very attractive table place mats.

Grades 1-2 Interactive Science Activity: Environmental Conditions and Germination of Radish Seedlings

This activity allows students to learn a very simple method for seed germination that can be applied to many variations of this experiment. We will describe the analysis of the effect of nutrients on plant growth here. The same method can be applied to experiments that determine the effects of light, temperature, pH (acid/base conditions), and toxins on plant growth.

As mentioned, the students will explore the importance of nutrients on plant growth. In the rain forest, the soil is actually very nutrient poor because of the large amount of rainfall. The rain water causes the soil nutrients to continually go into solution and move away from the roots of plants. One may wonder then, how it is that the rain forests can be so lush and green when the soil contains so few nutrients?

The answer is decomposition. As plants and animals die and decompose, they release nutrients that are stored in the roots, stems, branches, leaves, flowers, and fruits of plants. Therefore, nutrients are very effectively recycled in the rain forest as plants and animals die and release nutrients during decomposition. The nutrients are then once again absorbed and stored in plant structures.

Materials:

Radish seeds (a couple of packages will be enough for the entire class), water, paper toweling or notebook paper, plastic beverage cups, aluminum foil, liquid fertilizer (plant food purchased from the grocery or home supply store).

Procedure: This activity works well for students working in pairs.

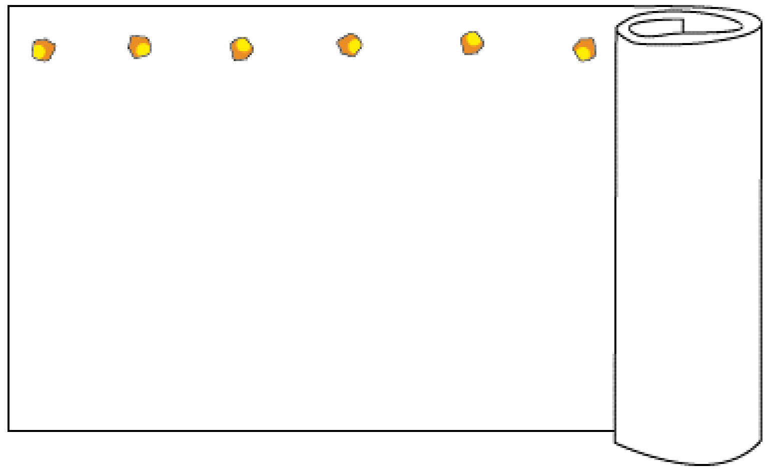
1. Soak the radish seeds in water for about an hour.

2. Fold a paper towel or piece of notebook paper lengthwise and float it in a shallow pan of water. Remove it and gently wring out the excess water (each pair of students needs to do this with two pieces of paper).

3. Give each pair of students twelve soaked radish seeds.

4. Lay six of the soaked seeds along the folded edge of the moist paper towel or piece of notebook paper. Roll the paper with the seeds into a cylinder, as in the diagram.

5. Repeat with the other six seeds on the second piece of paper.



6. Place the rolled paper cylinders in separate plastic beverage cups and add water to each cup to a depth of 2-3 cm.

7. Label one of the cups as a control and label the other as the experimental cup.

8. Provide nutrients to the experimental cup by adding a couple of drops of liquid fertilizer to the water.

9. Place a piece of aluminum foil loosely over both cups and allow the cups to remain undisturbed until the seeds germinate.

10. Once the seeds have germinated, remove the foil and place the cups in a location that provides them with light.

11. Have students measure the roots and the shoots of the growing plants and chart the growth of their seedlings every day or two.

12. Have students describe the effect of additional nutrients on the growth of the seedlings.

Questions for Students:

1. Why did you need two cups to perform this experiment? What conclusion could you draw if you had performed the experiment with only one cup?

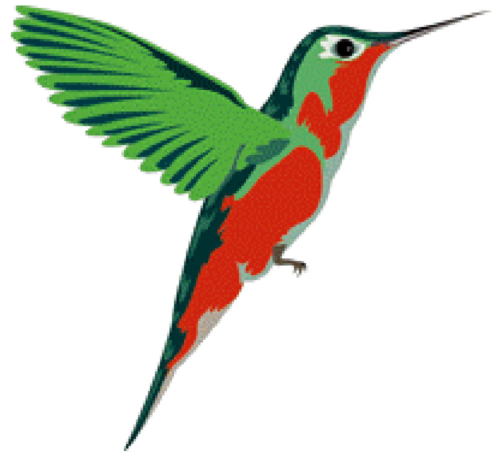
2. What effect did the fertilizer have on the plant growth?

3. If you put in twice as much fertilizer, what effect would this have on the plant growth? How could you find out?

4. How does this experiment relate to human nutrition?

As mentioned in the introduction, this experimental procedure can be used to test the effects of any difference on plant growth. For effects of acidity, add a couple of tablespoons of vinegar to the water. For effects of alkalinity, add a couple of pinches of baking soda to the water.

Grades 1-2 Outdoor Activity: Attracting Hummingbirds



Many species of hummingbirds inhabit the rain forests of the world. Hummingbirds also inhabit other climate zones in the United States. Hummingbirds are attracted to red colored flowers, and flowers are a source of nectar for the birds to eat. When purchasing commercial hummingbird food and feeders, one notices that both the food and the feeders are red. In this experiment, we will determine if this red color is important in attracting the hummingbirds.

Materials:

Three hummingbird feeders, commercially prepared liquid hummingbird food (to ensure that it is proper food for the hummingbirds, as opposed to making your own solution), blue and yellow construction paper, blue and yellow paint

Procedure:

1. Paste blue construction paper over the bottle of one feeder, and yellow construction paper over the bottle of another. Leave the third bottle uncovered.

2. Paint the tips of the feeder tubes the same color as the construction paper.

3. Hang the feeders outdoors where they can be easily watched.

4. Observe the behavior of hummingbirds and note if they prefer the red feeder.

5. Once the feeders have been hanging for a week or more, check to see how much nectar was consumed by the hummingbirds from each of the feeders

Questions for Students:

1. Was there a difference in the amount of food consumed in the different feeders?

2. Why is commercial hummingbird food colored red?

Grades 1-2 In-Class Demonstration: Light Absorption

Rain forests are located close to the equator, where there is much sunshine, and the temperature is high. In this demonstration, the effect of the color of an object on the absorption of light is investigated.

Materials:

Black and white socks, socks of varying colors, thermometers.

Procedure:

1. Label the thermometers with a number so that you can identify each one.

2. After the thermometers have been placed on a table in the classroom for several minutes, record the temperature on each thermometer, along with the thermometer number.

3. Place one thermometer in each of the socks of different colors. Carry the socks outside, and place them in a location where each sock will receive the same amount of sunshine.

4. After ten minutes, record the temperature on each thermometer, along with the thermometer number.

Questions for Students:

1. Before you record the final temperatures, which sock would you predict to have the highest temperature difference?

2. Which sock had the highest temperature difference? Which sock had the lowest temperature difference?

3. Can you rank the colors of the socks in order of increasing temperature difference?

4. Can you explain the ordering in Question 3?

Grades 2-3 Activities At a Glance

- Science Through Art: Flower Construction
- Interactive Science Activity: Making an Elastic Material
- Outdoor Activity: Flower Hunt and Dissection
- In-Class Demonstration: Reflection of Light

Grades 2-3 Science Through Art Activity: Flower Construction

In this activity the students learn the structures of the flower by constructing a flower model.

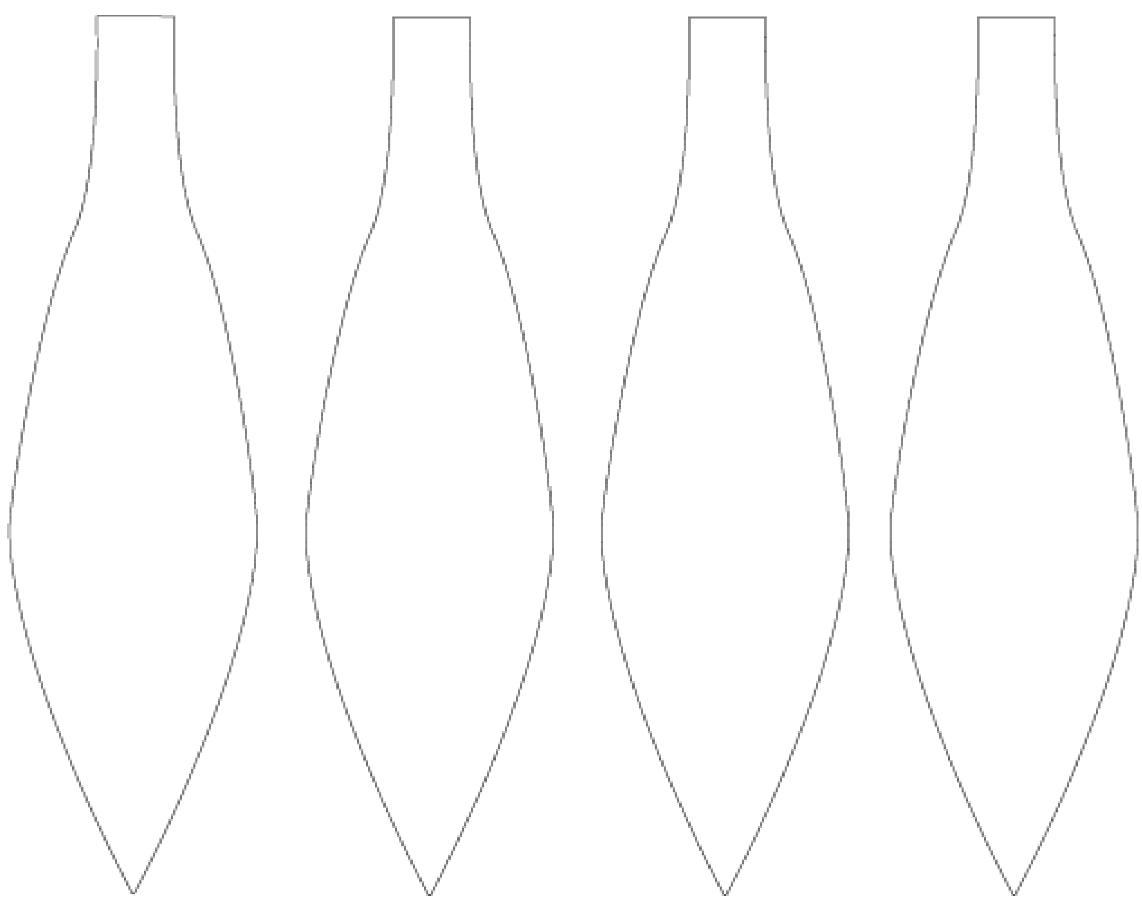
Materials:

Flower pattern from this workbook, bendable soda straws (5 per flower), colorful construction paper, glue, clear tape, and Styrofoam packing peanuts (5 per flower).

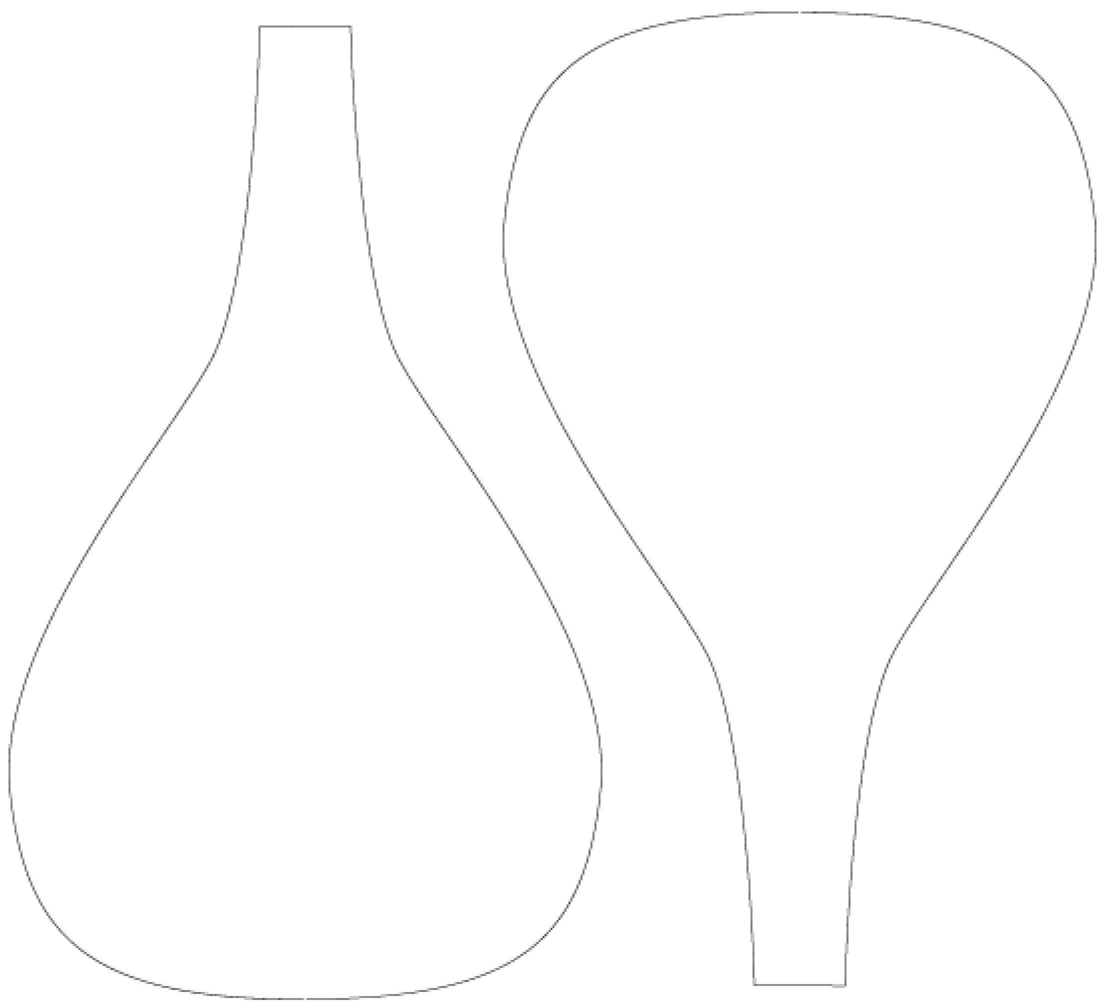
Procedure:

1. Print the flower pattern (below) and reproduce a copy for each student.

Sepals:



Petals (print two copies for a total of four petals per flower)



2. Have students trace around the pattern onto a piece of colored paper, being certain to print the sepals on green paper. (As an alternative, photocopy the pattern on colored paper. Students can then simply cut out the components without the need for tracing.)

3. Begin construction by securing 4 of the straws around a central fifth straw with tape. The straw in the middle should have the bendable end down while the other 4 are positioned with the bendable end up. The five straws together will constitute the stamens and pistil structures of the flower.

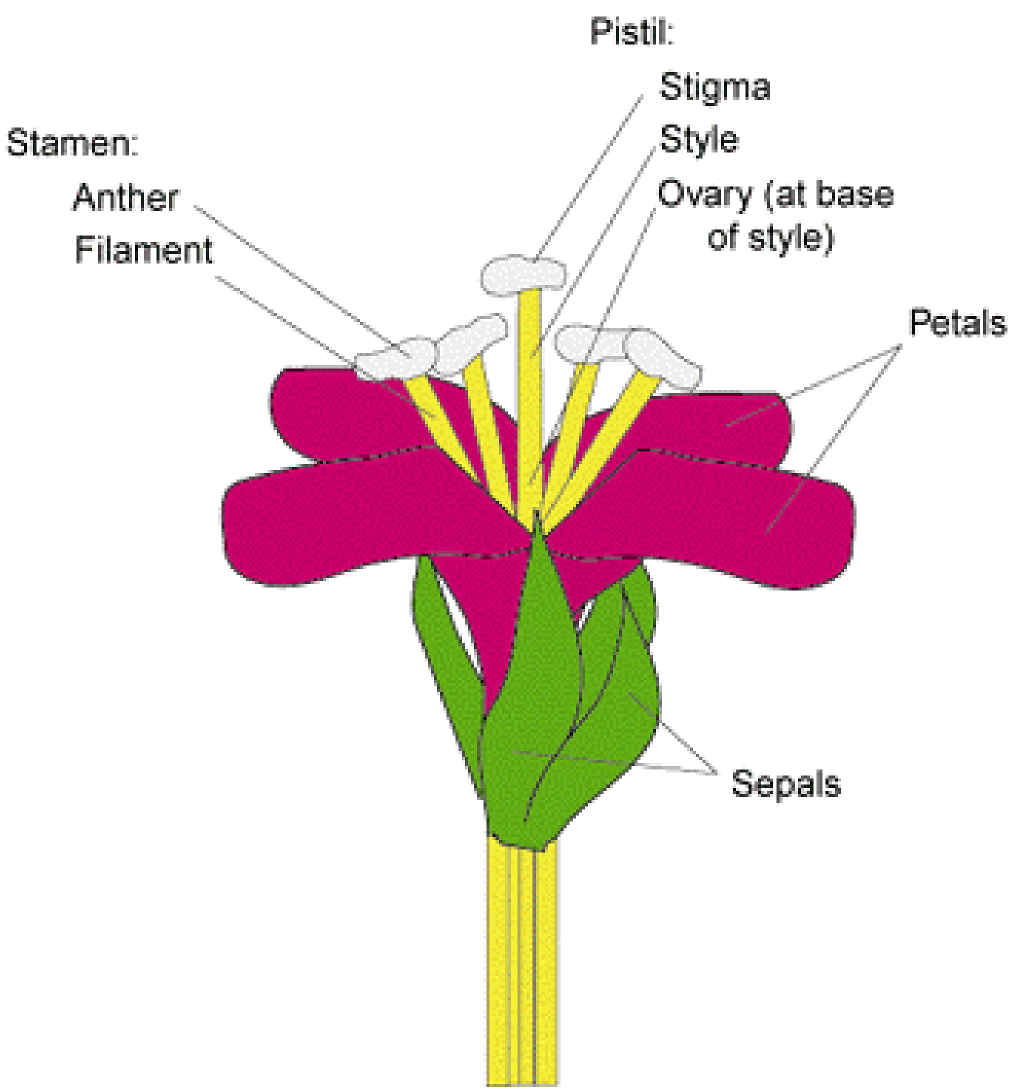
4. Attach a packing peanut to each of the four stamens, by simply pushing the peanut onto the end of each stamen. Bend each stamen away from the central straw.

5. Attach the fifth packing peanut, which will serve as the stigma, by gluing it on the top of the center straw, which represents the pistil.

6. Using a pencil, gently roll each petal around the pencil to give the petals a curve.

7. Place the petals (curving outward) evenly around the straws and secure with tape.

8. Place the sepals evenly around the petals and secure with tape.



Grades 2-3 Interactive Science Activity: Making an Elastic Material

Several species of plants and trees in the rain forests yield a milky white substance when the stems or trunks are cut. Historically, the native peoples of the rain forests found ways to use this substance, called latex or rubber, to waterproof bags, to make chewing gum, and make medicinal chewing gums by adding other plant ingredients. In this activity, white glue (a chemical polymer), water, and boraxo soap powder are used to model the making of a rubbery product.

Making an elastic type of material is an excellent way to introduce the topic of polymers. This is a very inexpensive way to allow students to experiment with the ratio and proportion of the ingredients that make this compound. They will learn quickly that accurate measurement results in a better quality product.

Materials:

Tap water, Elmer's Glue, all white glue, 4% borax solution (sodium borate, $Na_2B_40_7$ 10 H_20; 20 Mule Team Boraxo powdered hand soap is available at the grocery store), stirring rod (coffee stirrers work well), paper towels, plastic drinking cups (4 oz size is fine), plastic sandwich bag to store completed putty, some type of metric measuring device, such as a graduated cylinder, or kitchen measuring cup.

(A 4% borax solution is made by adding 4g of borax to 96g of water. If there is not a balance and a graduated cylinder available, place 1 level tablespoon of borax in 1 cup of water. Two batches will be plenty for a class of students.)

Procedure:

1. Measure 25 ml of Elmer's glue into a plastic drinking cup.

2. Add 20 ml of tap water to the glue. (In the event that you have nothing with which to measure liquids, this is roughly a 50/50 mixture of glue and water.) Five drops of food coloring can be added if desired. Stir very well until the ingredients are completely mixed.

3. Add 5 ml of the 4% borax solution. Again, if you have nothing with which to measure liquids, add 50 drops since 10 drops is roughly 1ml. Stir well.

4. A solid material will begin to collect on the stirrer. Remove the solid material and place it on a paper towel. Knead the material with your fingers. The material will be

sticky for about a minute or two. It will become more puttylike as the substance loses excess water.

Questions for Students:

1. Does the material stretch? Does it go back to its original shape when you release it after stretching?

2. What happens when the material is pulled rapidly? What happens when it is pulled slowly?

3. If you roll a piece of the material into a ball, does it bounce?

Grades 2-3 Outdoor Activity: Flower Hunt and Dissection

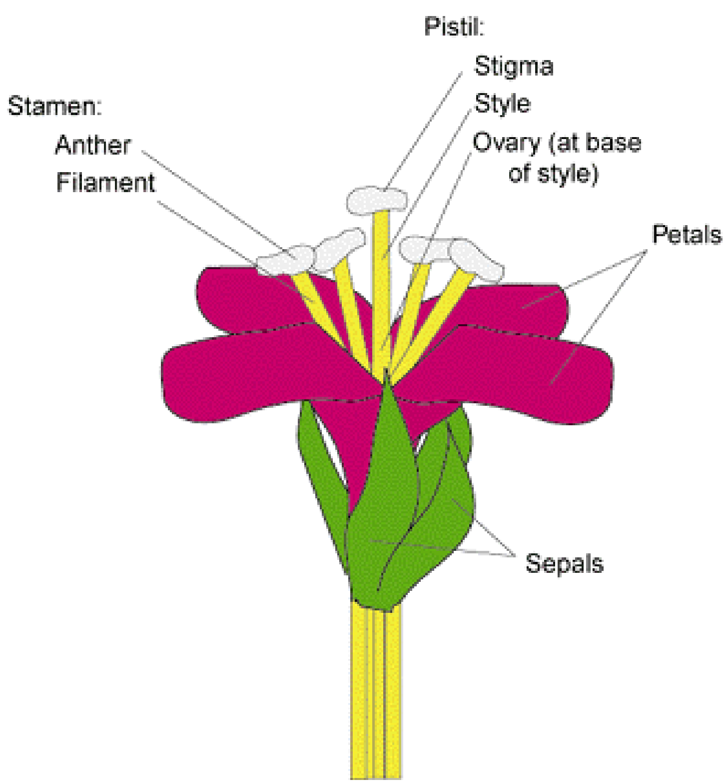
As a follow-up to the flower construction in the 1-2 activity section, students collect flowers and bring them inside the classroom for dissection and identification of the structures in this activity.

Materials:

Flowers brought in by students, forceps, tape, and construction paper.

Procedure:

1. Using forceps, have the students dissect the flower completely and lay out the structures on a piece of paper.
2. Have students secure the flower structures to the paper with clear tape, then label the structures.
3. Have students identify the structures by comparing to the diagram.



Grades 2-3 In-Class Demonstration: Reflection of Light

When sunlight enters the trees of the rain forest, there are a number of possibilities for what happens to the light. It can reflect off leaves, bark, ground, or water droplets. It can also be absorbed by any of these surfaces. In the 1-2 Light Absorption demonstration, light was absorbed in varying amounts by the different colored socks. In this demonstration, we will investigate reflection of light from different surfaces.

Materials:

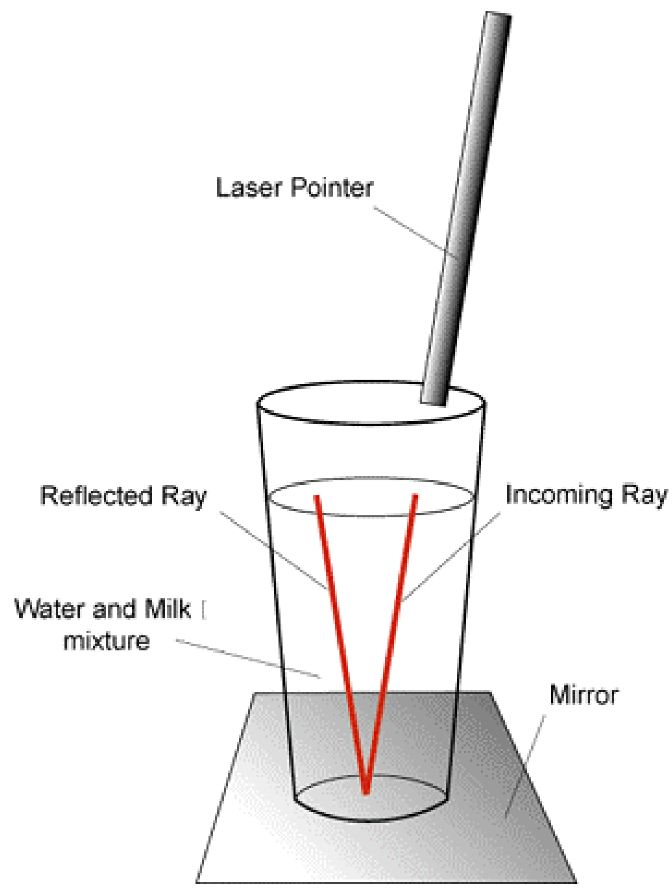
Laser pointer, clear drinking glass, pocket mirror, water, milk, leaves brought in by students, white paper.

Procedure #1:

1. Place the drinking glass on top of the mirror, with the reflecting side of the mirror facing upward.

2. Fill the glass with water, and add a few drops of milk to the water. Stir the water, so that it appears slightly cloudy.

3. Shine the laser pointer into the surface of the water so that it reflects from the mirror below the glass and you can see the reflected ray of light moving upward in the water.



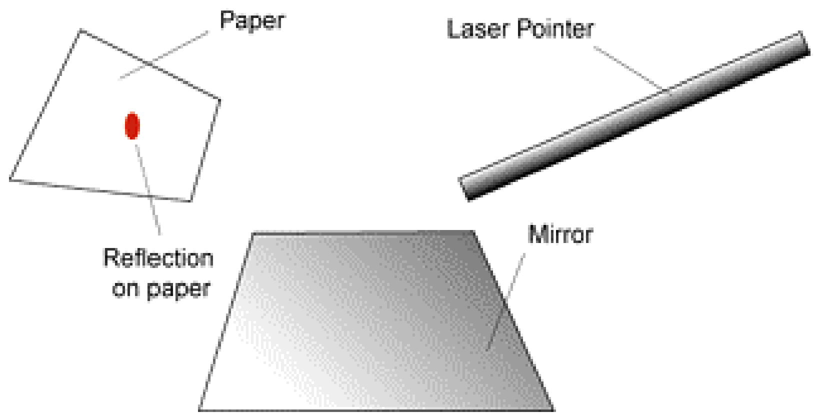
Questions for Students:

1. Can you see the light from the laser pointer in the air between the pointer and the water? Why not?

2. Why can you see the light from the laser pointer in the water?

3. Why is the light going upward from the bottom of the glass?

Procedure #2:



1. Remove the drinking glass. Shine the laser pointer onto the mirror. Hold a piece of paper near the mirror and move the paper and/or the laser pointer until the reflected light is seen on the paper. The diagram shows a typical arrangement of the laser pointer, mirror, and paper. Point out that the light is reflecting from the mirror and up onto the paper. The path is similar to that in Part I, but the path of the light cannot be seen as it was in Part I.

2. Now, replace the mirror with various leaves brought in by students. Using the same technique as with the mirror, see if you can observe light from the laser pointer reflected from a leaf onto the paper. The reflected light will be darker than for reflection from the mirror, and will be more spread out into a larger circle on the paper, but should be visible for some leaves.

3. Have students categorize the leaves into two groups - those that reflect light and those that do not. The leaves that reflect light should appear shiny, while those that do not should appear dull, in response to Question 2 below.

Questions for Students:

1. How would you describe where you have to hold the paper and the laser pointer to see the reflection of the light from the mirror?

2. Look at the leaves in the two groups. Can you describe how the leaves in the two groups look different from each other?

3. If you were able to measure the temperature of the leaves in sunlight, which group of leaves do you think would become warmer?

4. For the group of leaves that do not reflect light, what happens to the light when it hits the leaf?

Grades 3-4 Activities At a Glance

- Science Through Art: Sachet Jar
- Interactive Science Activity: Roots Grown from Different Parts of the Same Plant
- Outdoor Activity: Drying Flower Petals for Use in a Sachet
- In-Class Demonstration: Cloud in a Bottle

Grades 3-4 Science Through Art Activity: Making a Sachet Jar

This project allows students to use some products (renewable ones!) from the tropical rain forests to create an aromatic sachet jar. A component of this project is tied to the outdoor activity at this grade level.

Materials:

1/2 teaspoon of ground cloves, 1/2 teaspoon of all-spice, 1/2 teaspoon of cinnamon (powdered), 1/2 teaspoon of vanilla extract, about a quart of dried flower petals (such as rose), mixing container (bowl or small bucket), small glass jar with lid or cork top.

Procedure:

1. Place all of the powdered spices and the liquid vanilla extract in a container and mix thoroughly.

2. Add this mixture to the dried flower petals and mix again (gently), then place the spice and flower mixture in a glass container and replace the lid. When the lid is removed, the fragrance emerges.

Resource Information:

See the outdoor activity for the collection of the flower petals. The students can bring a container from home in which to place their sachet. Reusing an old container is a great way to recycle! The amount of sachet created in this activity is enough for at least 2 sachet jars and this activity lends itself well to working in pairs.

The lids of the jars can be painted, covered with colorful cloth and ribbon or decorated in any fashion desired. This makes a great take-home gift for holidays such as Valentines' Day and Mother's Day.

The primary scientific phenomenon that can be observed in this project is diffusion. The students should notice that the fragrance of the sachet is stronger the closer they are to it, as they move away from it, the fragrance becomes more faint. This is due to diffusion, the mixing of the sachet molecules with air molecules. As this mixing occurs, the fragrance becomes more and more dilute. They may also notice that as the temperature of the air in the room rises, the sachet fragrance becomes more intense. This is due to the faster-moving molecules in the warm air increasing the diffusion process.

It is important to note that diffusion is the movement of molecules of a substance from an area of high concentration (the sachet jar) to an area of low concentration (the space surrounding the sachet jar). Many students confuse diffusion with osmosis. Osmosis is the movement of water molecules from a higher to a lower concentration. A good example of osmosis is in the produce department of the grocery store. The produce is sprayed with water periodically to make it "plump up". This occurs because the water is in a higher concentration on the outside of the produce than it is on the inside. This causes the water to move into the produce and the fruits and vegetables appear fresher!

Grades 3-4 Interactive Science Activity: Roots Grown From Different Parts of the Same Plant

Plants have evolved many specialized mechanisms to ensure their survival. They have adapted to their environments in many ways, such as surviving wet or dry weather, soil conditions, and attracting bird, insect, or other animal pollinators. One other way many plants ensure the survival of their species is by being able to generate roots from various parts of themselves if they are broken apart by severe weather conditions, damaged by a falling boulder or neighboring tree, or trampled by animals.

In the crowded, dense conditions of the tropical rain forests, the ability to readily sprout roots and continue growth is very important. Some species, like the rubber tree plant, even send down roots from higher up on the stem to reach the nutrients of the soil below.

The nutrient layer of the soil in the tropical rain forests is not very deep, as the dead plants and animals which decompose to yield rich soil are used up very quickly by the abundance of organisms of all types, including bacteria and fungus. Therefore, soil nutrients are not available deep in the ground, so sending more root growth into the lower soil levels is not efficient. Also, due to the high amount of rainfall in this environment, roots are not needed deep in the ground to search for water, as they are in drier environments.

In this activity, students have the opportunity to model this special adaptation of plants.

Materials:

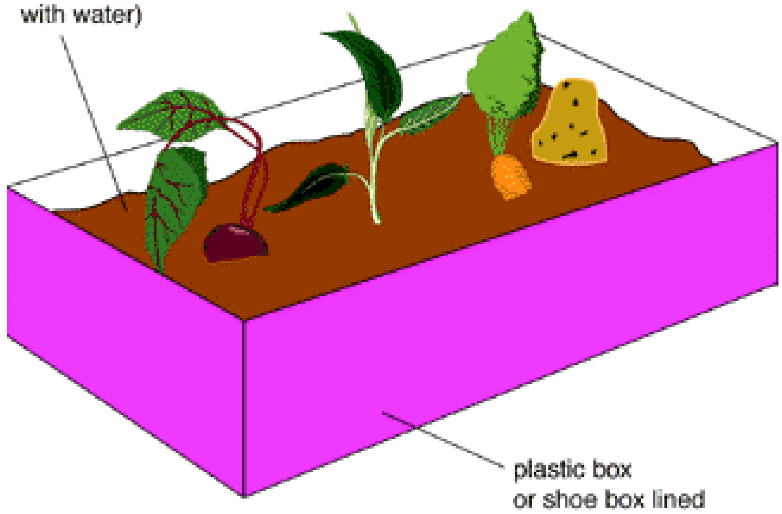
Box (shoe box lined with plastic wrap or aluminum foil, or plastic box), sand, water, a hand lens if available, and a variety of any of the following:

- Bulbs (tulip, daffodil, etc.)
- Sections of potato with eyes
- Onion
- Cutting of plants such as begonias or geraniums
- Beet, radish, or carrot tops with a little of the root still attached
- Sugar cane or bamboo (cut with a joint near the end)
- Stem of an iris

Procedure:

1. Place sand in a box (line the box first with plastic wrap or aluminum foil if the box is made from cardboard) to a depth of 7-8 cm.

2. Moisten the sand well with water, and plant a variety of specimens.



3. Keep the experimental setup out of direct sunlight.

4. Check on the specimens over a period of one week.

Questions for Students:

1. Sketch the root development of each of your specimens. Make certain to label each specimen in each sketch.

2. Use a hand lens if available and closely examine the roots of each specimen and sketch what you see. Write down similarities and differences.

3. Count the number of roots of each specimen. Which specimen had the most root growth?

4. Which specimen had the least root growth?

5. How is the ability to sprout roots from different parts of the plant a survival advantage?

Grades 3-4 Outdoor Activity: Drying Flower Petals for Use in a Sachet

Go out of doors either at home or at school and collect flowers. These will be used to make the sachet in the Science through Art activity. Supermarkets and florists are also often willing to give away old flowers for school projects. This project does not require that the flowers be at their freshest! For this project, rose petals are best, as they retain some fragrance. Other petals can be incorporated for color.

By taking the flowers apart to remove the petals, students can observe the different structures of the flowers and note their similarities and differences. Materials and information located on this website at the 2-3 grade level under "Flower Construction" in the Science through Art section would be helpful and a good review of the flowering structures of plants.

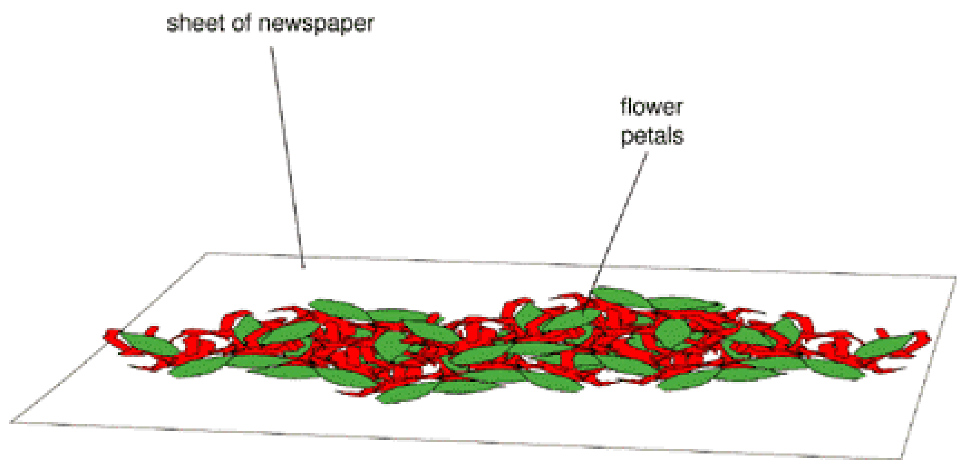
Materials:

Plastic or paper sack, newspaper, dry environment, flower petals.

Procedure:

1. Collect flower petals in a sack (or obtain from supermarket or florist discards).

2. Spread flower petals out in a thin layer over newspaper in a dry environment.



3. Depending on the humidity in the room and the type of flowers, the flower petals will dry in 1 to 4 days. They are now ready to be made into the sachet.

4. Ask the students why the petals appear darker in color when they are dry. They should be able to conclude that the loss of water during the drying process causes the color (pigment) of the petals to be darker because the pigment is now more concentrated without the water. Oxidation from the air has also occurred, however, one would not expect students at this grade level to have this knowledge!

Grades 3-4 In-Class Demonstration: Cloud in a Bottle

The tropical rain forest is a cloudy place, as much rain must fall to maintain this steamy environment, which is teeming with life. Have you ever wondered how clouds form? This demonstration allows us to witness cloud formation before our very eyes!

Materials:

One liter, clear plastic bottle with cap, water, and a match.

Procedure:

1. Place a small amount of water in the bottle (just a splash is sufficient).
2. Light a match and drop it in the bottle and quickly cap the bottle.
3. Squeeze the bottle 6 or 7 times (more squeezing may be necessary) and watch the cloud form!

Resource Information:

In order for water droplets to form and make a cloud, they need particulate matter (small particles) around which to form. This is the purpose of the smoke from the smoldering match. The cloud forms when the air cools as it expands, thereby reducing the temperature in the bottle below the dew point. The moisture then condenses as a cloud. Clouds on Earth form when warm air rises and its pressure is reduced. The air expands and cools, and clouds form as the temperature drops below the dew point.

In this demonstration you were able to make the air in the bottle compress and expand simply by squeezing the sides of the bottle and increasing and decreasing the air pressure.

Grades 4-5 Activities At a Glance

- Science Through Art: Crystal Flower Garden
- Interactive Science Activity: Light Affects the Growth of Plants
- Outdoor Activity: Ultraviolet (UV) Light
- In-Class Demonstration: Magnetic Fields and Bees

Grades 4-5 Science Through Art Activity: Crystal Flower Garden

In this project students get to learn a little chemistry (the formation of a precipitate) while growing a Crystal Flower Garden.

Materials:

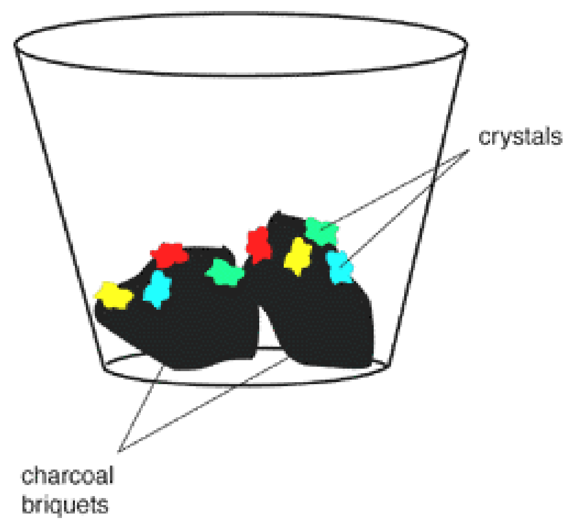
2 charcoal briquettes, 2 teaspoons of household ammonia, 4 teaspoons of water, 2 teaspoons of table salt, 4 teaspoons of laundry bluing, 2 plastic or glass containers.

Procedure:

1. Place 2 charcoal briquettes in the plastic or glass container.

2. In another container, mix a solution of ammonia, water, salt, and laundry bluing. Pour this solution over the briquettes.

3. Drop several drops of different food colors over the briquettes. Crystals will appear in several hours.



Resource Information:

If you are unfamiliar with laundry bluing, it is available at the grocery store in the laundry detergent section. Small, clear plastic drinking cups work well for this project. Students may also select a small, clear glass container from home in which to grow these attractive crystal formations. The crystals, if left undisturbed, will last for a long time.

As the liquid evaporates, a layer of crystals forms on the surface of the briquettes. The process continues as the liquid evaporates and additional layers of crystals form. The appearance of the salt crystals is very "flower-like", especially with the final addition of the food coloring.

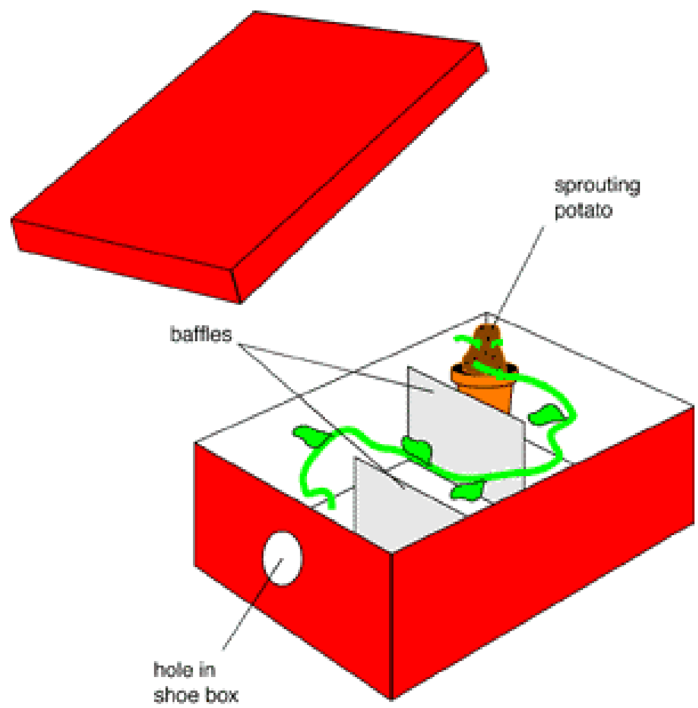
Grades 4-5 Interactive Science Activity: Light Affects the Growth of Plants

The tropical rain forests are very lush and dense with foliage. All of the plants that make up this dense foliage need adequate amounts of light to grow. This activity mirrors what happens in the tropical rain forest as plants compete for light in order to grow.

Materials:

Shoe box, a sprouting potato, small flower pot or plastic cup (large enough to hold the potato), potting soil, water, 2 pieces of poster board or large index cards to fit inside the shoe box (see diagram below), tape (clear or masking), scissors or blade, space near a window or other source of light.

Procedure:



1. Obtain a shoe box (with lid) and cut a hole (caution students to be careful, or do it for them), about 6 cm across in one end of the box.

2. Inside, place 2 cardboard or index card baffles (see diagram below).

3. Place a sprouting potato in a small cup or pot with a little potting soil and water and place it behind the baffle, farthest from the light source.

4. Place the lid on the box and place near source of light.

5. Lastly, have one sprouting potato out of a box and in the light for comparison.

Students can do this activity individually, in pairs, or in groups.

Questions for Students:

1. Sketch your plant and the plant that was grown outside of a box. Describe the differences.

2. Which plant looks healthier? Support your opinion.

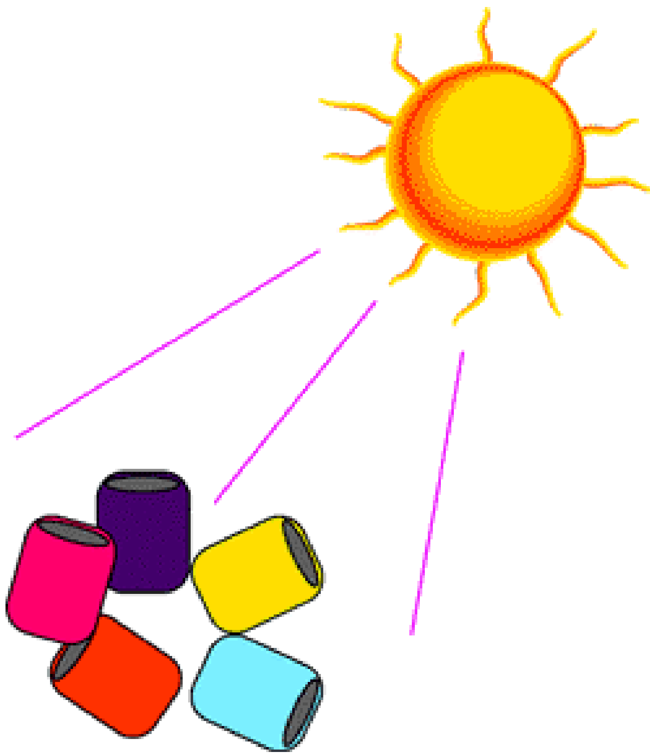
3. In crowded living conditions, such as the plants experience in the tropical rain forests, do you think that some plants have adapted to survival with different amounts of light? Or do you think that all plants thrive on the same amount of light? Support your opinion.

4. Try to be very patient and leave your experiment set up long enough to see if the potato plant can grow all of the way out of the hole in the end of the shoe box. If you do this, sketch and describe what occurs. Offer your best explanation of what happens when the stem reaches the outside of the box.

Grades 4-5 Outdoor Activity: Ultraviolet (UV) Light

There are many wavelengths of light, some of them visible to us and others not. Those wavelengths of light that are visible to us are not necessarily visible to all life forms capable of sight. At the same time, there are life forms other than ourselves that are capable of seeing wavelengths of light that we cannot. Ultraviolet light is an example of a type of light that humans cannot see but is important in the vision of other species.

Many flowers have markings on them that we cannot see without special equipment. These are markings that reflect ultraviolet light wavelengths. Bees can see this wavelength of light and these special markings on some flowers aid bees in locating the sweet nectar of the flower on which they feed. Bees, however, cannot see the wavelength of light that we identify as red!



In the tropical rain forests, as in other areas around the globe, plants have evolved elaborate mechanisms to entice the pollinators. Bees are one such type of pollinator needed to carry the pollen from one flower to another flower of the same species. It is the pollination process that eventually leads to the production of viable seed to ensure the survival of the species.

Another important aspect of ultraviolet light is the great hazard it presents in terms of the health of our skin. Aside from painful sunburns from overexposure to the sun, ultraviolet light ages our skin prematurely and can cause many types of skin cancer.

The following activity uses some very inexpensive, plastic beads that are treated with a special pigment that is sensitive to ultraviolet light. When exposed to this wavelength, they change color.

Materials:

Ultraviolet detecting beads available from Educational Innovations, 203/629-6049 (phone), e-mail info@teachersource.com, or at www.teachersource.com (Allow about a week for delivery).

All of the beads are white in color, but when exposed to ultraviolet light, they turn red, yellow, orange, purple, or blue (depending on which ones you select). There are 240 beads, each about 1/4 of an inch in diameter, per package at a cost of $6.95 per package. This is more fun if you have at least 2 colors of beads.

The only other element you need is a sunny day!

Procedure:

1. While still indoors, give each student as many beads as you wish. Tell them to hold them in their hands with their hands tightly closed until everyone is outdoors.

2. Once outdoors in full sunlight, ask the students to open their hands and observe the beads. Do not tell them that the beads turn color in ultraviolet light—see if they make the connection between sunlight and the change in the color of the beads.

3. Once the connection between the sunlight and the color change is made, have the students check the effectiveness of sunglasses and sunscreen lotions that claim to block ultraviolet light. This can be done by simply holding the glasses over the beads and noting if the beads remain white or change color. The sunscreen lotion can be rubbed on the beads and the same observation can be made.

4. Students can then use the beads as their personal UV detectors by making a bracelet or by stringing then on the ties of a jacket. As the beads turn color and become brighter, they will know its time to apply an effective sun screen lotion!

Grades 4-5 In-Class Demonstration: Magnetic Fields and Bees

Bees live in almost all parts of the world, including the tropical rain forests. In addition to producing honey and beeswax, bees provide an important service to plants by carrying pollen from one flower to another, which is an important link in the reproductive cycle.

Bees are able to navigate over surprisingly large distances. Many experimental studies have shown that bees have magnetic material in their bodies and that their navigation is based partly on the interactions of these magnetic materials with the magnetic field of the Earth.

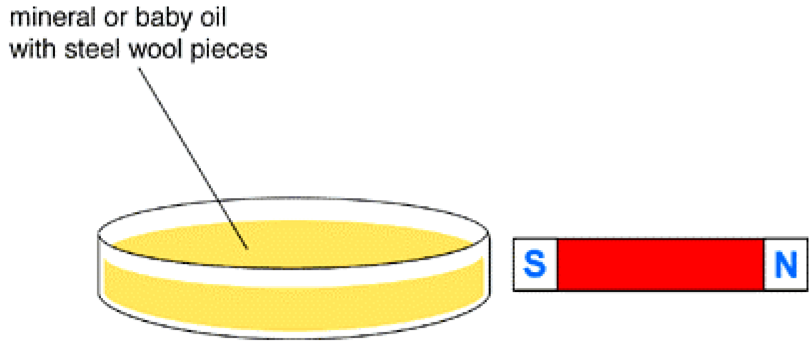
This demonstration allows an image of a magnetic field to be presented to the class on an overhead projector.

Materials:

Petri dish, mineral oil or baby oil, fine steel wool, strong magnet.

Procedure:

1. Cut the fine steel wool in very small pieces and separate the individual filaments so that they are no longer connected with each other.
2. Fill the petri dish two-thirds full with mineral oil or baby oil. Place the steel wool pieces in the oil and mix them in.
3. Place the petri dish on the stage of the overhead projector and turn on the lamp.
4. Place the magnet at the side of the petri dish and watch the steel wool pieces line up along the magnetic field lines.



Questions for Students:

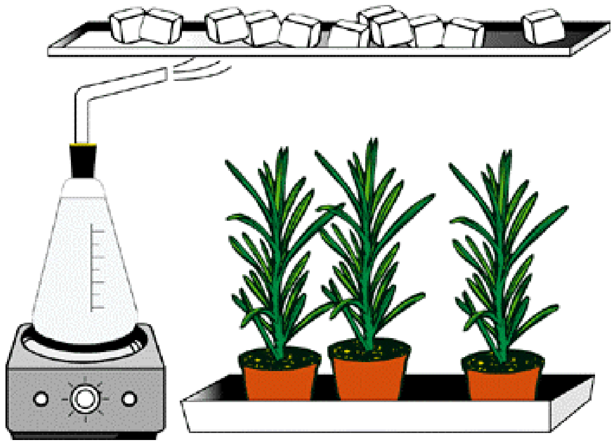
1. What will happen to the steel wool pieces if the magnet is turned over and brought near the petri dish again?
2. From your observation of the magnetic field pattern, can you determine if a north pole or a south pole is closest to the petri dish?
3. Where is the magnetic north pole of the Earth?
4. How could the lining up of a piece of magnetic material help bees in the rain forest to navigate?

Grades 6-8 Activities Overview

The tropical rain forest is a wonderful environment to learn not only about natural history, ecology, and biology, but also physics and chemistry. So much goes on in the rain forest and so many plants and animals live there (approximately 50% of the plant and animal life on the planet) that exclusive existence on the ground is impossible for the abundance of species. That is why the rain forest exhibits a layering of habitats, or canopy. There are many plants and animals, including insects, which never spend any part of their lives on the ground. These plants and animals have developed very specialized adaptations that allow them to compete successfully for all of the resources they require to thrive.

As we look at our planet, we can observe that the closer we move to the equator, the greater the abundance of life. The tropical rain forests, which exist in the narrow band around our Earth called the equator, are environments that require all plant and animal species to become very specialized in their strategies for acquiring food, water, reproduction opportunities, and all aspects of survival, because the competition for these resources is so great. This is very different from other areas of our planet, farther north and south from the equator, where the concentration of life is less dense. In those areas, it is more advantages to have very general adaptations and to be able to utilize many different strategies and resources. In other words, survival depends on being a generalist. Indeed, the rain forest can be a study in economics—supply and demand.

It is interesting to note that many of the species living in the tropical rain forest have yet to be discovered. In this portion of the Rain Bird Rain Forest Curriculum, we will be making our own discoveries, as we explore the sciences in the context of the highly specialized adaptations that all life forms exhibit in this fascinating environment. At each grade level, there are three activities for students and one in-class demonstration to be presented by the teacher.



Grade 6 Activities At a Glance

- Activity: Using Plants as a Natural Source of Dyes
- Activity: Making Rain
- Activity: The Impact of a Raindrop on Soil
- Demonstration: Energy in the Rain Forest

Grade 6 Activity: Using Plants as a Natural Source of Dyes

As we learn about the varied species in the rain forest, it is essential to remember that native peoples have inhabited this environment for hundreds of thousands of years. They too have developed survival adaptations and, in addition, have made fascinating discoveries and developed countless methods for making the most of the resources available to them.

An area where they have excelled is the use of native plants for food, medicine, shelter, clothing, and the making of artifacts. Native, rural peoples in many regions around the globe are actually excellent scientists. They have finely honed abilities in observation, analysis, and drawing conclusions. In the use of plants, they have proven to be good chemists, as they developed highly effective methods for dying fibers.

In this section we will experiment with some formulas for dyes made from plants. We will also employ an energy saving alternative to boiling the dye over a flame—we will construct a solar reflector to accomplish the same job! This is an excellent activity for the integration of the social sciences and art.

Materials:

Variety of plant materials collected from the wild, home garden, school campus or purchased, large glass jars with lids, wax paper or plastic wrap, water, cardboard box (such as a sturdy photocopy paper box), aluminum foil, mirror, alum, clean, carded wool or commercial skeins of white wool yarn.

Procedure:

We will employ the most simplified "one pot" method here. Usually, there are at least 2 steps involved. The first step is the mordant process. This is where a chemical is used to break down the fiber to be dyed so that the pigment bonds more effectively with the wool (or cotton) fiber. The word mordant comes from the Latin word mordere—to bite. This process is generally done first and you may wish to take the extra step first. It can, however, be incorporated right into the dying process.

Not using a mordant will result in color that fades. The type of mordant used also influences the color obtained from the plant pigment. The most common mordants used are naturally occurring water-soluble metal salts, all of which are poisonous to varying degrees. THE SAFEST MORDANT TO USE IS ALUM—THE SAME ALUM (ammonium alum) FOUND IN THE DRUGSTORE AND USED AS AN ASTRINGENT. Other mordants include chrome, tin, copper, and iron. Native peoples found these elements in the soil. In early pioneer days in the United States, rusty nails and old horseshoes were added as the source of iron in a mordant. Also, using a copper or iron pot was useful (though it was impossible to determine how much of the metal was being added to the fiber).

The mordant process is as follows:

1. Tease the wool material apart a little.

2. Obtain a nonreactive pot with a lid. The size depends on the amount of material you will be placing in the pot (water must cover the wool). Here's a guide: a pound of wool requires 2 gallons of water to cover it . You will probably not be using that much wool. If so, you can divide it up and place it in smaller vessels.

3. Place the wool in a vessel of warm water to loosen it up a bit. Let it stay there for at least 10 minutes.

4. In the nonreactive pot, add 4 tablespoons (64 grams) of alum to 2 gallons of water—always add the chemical to the water, not the water to the chemical. Bring the mordant bath to a simmer (180-190°F or 64-70°C). Simmer for 15 minutes or until the alum is dissolved.

5. Add the soaked wool and simmer, covered, for an hour.

6. Remove the mordant bath from the heat and let it cool. Remove the wool for dying. The damp yarn can be retained for at least 3 weeks in a plastic bag in the refrigerator if you are not ready to dye it just yet.

The "one pot", energy saving method for dying the wool is described below:

1. For each student or lab group of 2, 3, or 4, obtain a glass jar with a lid.

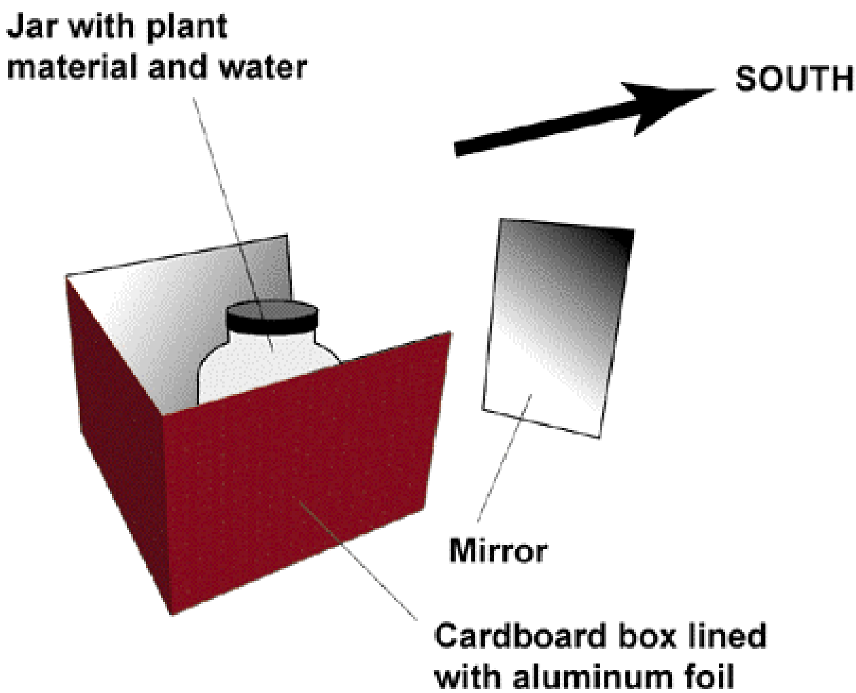
2. Place plant material (weeds are great—don't overlook them!) in the jar. Each student or group of students should try a different type of plant. Sunflower seeds, with hulls on, are also a good source of dye. Use flowers, leaves, stems, roots—experiment! Cover the plant material with water and place a piece of wax paper or plastic wrap over the mouth of the jar and secure the lid over that. This will create a lining for the metal lid and prevent a metal contamination of the dying process. Remember, the more plant material, the stronger the dye!

3. Construct a solar reflector by cutting the top and one side out of a cardboard box. Line the box with aluminum foil (shiny side of foil up). Place the box and the jar in the sun, with the open side of the box facing south. For extra energy, add a mirror to reflect light escaping from the open side back into the box. Surprisingly, the water will boil, producing an excellent dye bath.

4. Allow the plant material to simmer for an hour. (If you do not wish to use solar energy, this can also be done over a burner—but we're trying to save energy!) After an hour, allow the plant material solution to cool, then strain out the plant material. You now have a natural dye!

5. Place some wool yarn in the dye jar and add a level teaspoon of alum (unless you already put the yarn through the mordant process), replace the lining and lid, swirl the jar to mix in the alum in the solution and simmer for an hour in the solar reflector.

   An alternative is to simply chop up plant material, add the yarn (pre-mordanted), cover with water and allow the jar to sit out in the sun for 30 to 40 hours. This is how many Native American groups did their dying.



Questions for Students:

1. Which plants produced which colors of dyes?

2. Which plants produced the deepest colors? What could you do to ensure deep, rich colors?

3. Did you try more than one process for making the dyes (i.e. the regular boiling over a flame, the solar reflector, and 30-40 hours left out in the sun) and did the results vary or were they the same?

4. Did you try to dye yarn that was not mordanted? If so, compare to the yarn that went through the mordant process. Are the colors as deep? Did they fade?

5. If plants are not used, how do commercial companies make dyes? Check on the package of a commercial box of dye at the market.

Notes to the Teacher:

Be cautious not to use poisonous plants in this activity. If you are not sure about the safety of a plant, do not use it. Be very careful and direct students to be careful in handling hot liquids. You can also experiment with making dyes from asparagus and other vegetables and fruits. The amounts of plant material, water, mordant, and material to be died will vary depending on your needs. The rule of thumb is one pound of wool to 2 gallons of water to 4 tablespoons of alum (for the separate mordant process). For the dying, be certain that there is enough dye to cover the wool or yarn. You just need to experiment like the native, rural people of the rain forests did!

Grade 6 Activity: Making Rain

A rain forest by its very name indicates that much rainfall occurs there—up to 8 meters per year! This important process remains very overlooked and under-appreciated by many students. Often the depth of their investigation consists of merely copying a diagram of the water cycle. While this activity can be done as a teacher demonstration, it is much more engaging for the students to do it in lab groups or pairs.

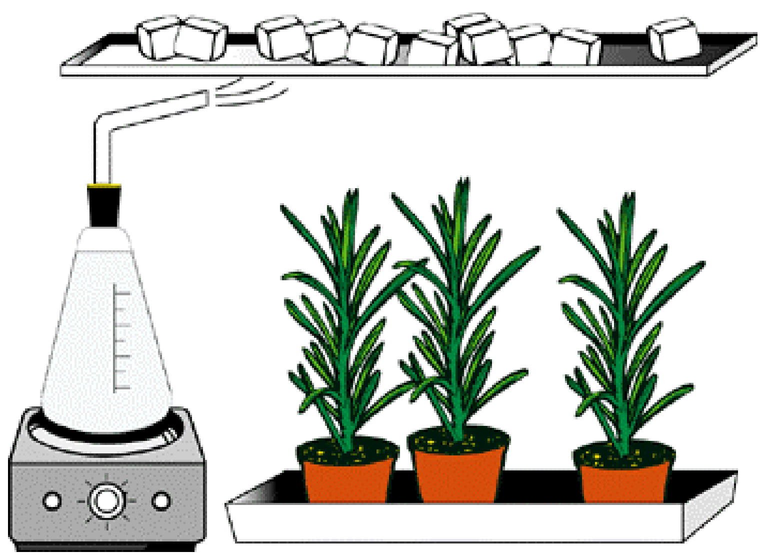
Materials (per group):

Ice, baking sheet, ring stand, hot plate, tea kettle (or lab glassware for boiling water and creating a stream of steam), a tray with a few potted small live plants.

Procedure:

1. About 40 cm from the tabletop, attach a baking sheet horizontally to a ring stand and cover the sheet with a layer of ice cubes.

2. Place water to boil on the hot plate adjacent to the baking sheet. A tea kettle works well, or use a flask with a one hole rubber stopper and a piece of glass tubing (a sturdy plastic flexible drinking straw can be used in place of the glass tubing). Direct the output of the kettle or tubing onto the bottom of the baking sheet.



3. In a tray, place a few small, potted plants and place this tray directly under the baking sheet (see diagram).

4. Wait for rain!

Questions for Students:

1. Describe the process you just observed. Make a list of what occurred in the order in which it occurred.

2. Where is the cool air in this set-up and what does it represent? Where is the hot air in this set-up and what does it represent? How does the warm air and the cool air come together?

3. Why did it rain?

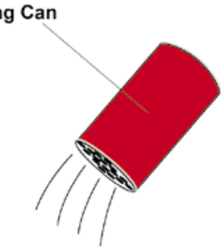
Notes to Teacher:

The tea kettle or the flask represents the source of water on Earth. As this evaporates and rises up to the ice-filled tray (the upper layers of Earth's atmosphere cooled by expansion), moisture condenses on the bottom of the tray and precipitation occurs. Rain falls on the small plants, which are used to model plant life on Earth.

Grade 6 Activity: The Impact of a Raindrop on Soil

When rain forest land is cleared and completely void of plant life a series of devastating events occur. One is the impact that clear cutting can have on the soil. This applies not only to the rain forest, but anywhere soil is left exposed.

Materials (per group):



Soil, 3 small flowerpots or food cans (e.g., tuna cans), one can (like a soup can) with holes punched in the bottom (this will act as a sprinkling can), 12 coins or bottle caps.

Procedure:

1. Fill 3 pots or cans with loose soil and press the soil so that it is even with the top on the container.

2. Place 4 coins or bottle caps on the soil of each container.

3. Place the cans or pots on several sheets of newspaper (or in a basin).

4. Use the "sprinkling can" to rain down on 2 of the 3 containers. Allow no water to fall on one container, moderate water to fall on the second container, and a heavy "rain" to fall on the soil of the third container.

Questions for Students:

1. What do the coins or the bottle caps represent in this activity?

2. What happed to the unprotected soil? Compare the results between your moderate and heavy rain to address this question.

3. Briefly describe the environmental impact of clearing land and exposing soil.

Notes to the Teacher:

Unprotected soil is splashed out and soil remains under the coins or bottle caps. You might want to make the "sprinkling cans" ahead of time for each group. This can be done simply by poking holes in the bottom of a soup can with a hammer and nail.

Grade 6 Demonstration: Energy in the Rain Forest

One of the most important concepts in biological, chemical, and physical processes is energy. In any natural process, energy is transferred or transformed. There are three types of energy that can be possessed by a system:

Kinetic Energy—the energy associated with the translational or rotational motion of the system

Potential Energy—the energy associated with interactions among members of the system (e.g., gravitational, electrical, tension in a spring, etc.)
Internal Energy—when considering a macroscopic system, this is the energy associated with the microscopic components of the system. It includes vibrational energy of atoms and molecules, bond energy between molecules, and nuclear energy in the nuclei of atoms.
There are several ways of transferring energy across the boundary of a system. The three most important energy transfer methods for studying the rain forest are the following:
Electromagnetic Radiation—the most familiar example of this is light, which is used in the process of photosynthesis. Other examples include radio transmissions and microwave cooking.

Heat—Energy will flow into or out of a system by heat if there is a temperature difference between the system and its surroundings. This process involves the collisions of molecules. If the temperature of the system is higher than the surroundings, molecules in the system will be moving randomly with a higher average kinetic energy than those in the surroundings. The higher energy molecules will collide with the lower energy molecules, transferring energy to them. As a result, there is a net energy flow from the system to the surroundings. There is significant energy flow by heat in the rain forest. For example, if the ground is warmer than the air, there will be a flow of energy by heat from the ground to the air.

Mass transfer—energy can be transferred by moving matter containing the energy from one location to another. A simple example of this is bowling—the energy you put into the bowling ball travels along with the mass of the ball (as kinetic energy of the ball) and is delivered to the pins. Another everyday example is filling your car with gasoline. The energy in the gasoline is transferred by moving matter—the gasoline—from the gas station holding tanks into your car. In the rain forest, the primary mass transfer mechanism is convection, in which energy in air is moved from one location to another. For example, the air that is warmed by heat from the ground, as discussed above, will rise upward and deliver the energy to higher regions of the canopy of the rain forest.

Part 1—Electromagnetic Radiation

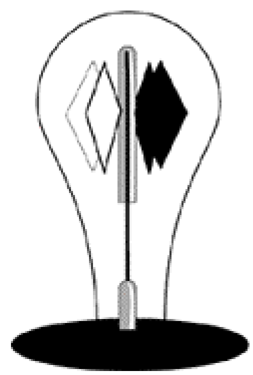
Materials:

Crooke's Radiometer, flashlight.

Procedure:

Shine a flashlight on a Crooke's radiometer. (Crooke's radiometers are available from scientific supply houses as well as many novelty gift stores.) The vanes should begin to turn, with the white sides leading.

Questions for Students:



1. How is energy entering the glass envelope of the Crooke's radiometer?

2. In what form does the energy appear inside the Crooke's radiometer?

3. How is energy carried from the Sun to the Earth?

4. What happens to the energy from the Sun when it is absorbed by a leaf in a rain forest plant?

Notes to the Teacher:

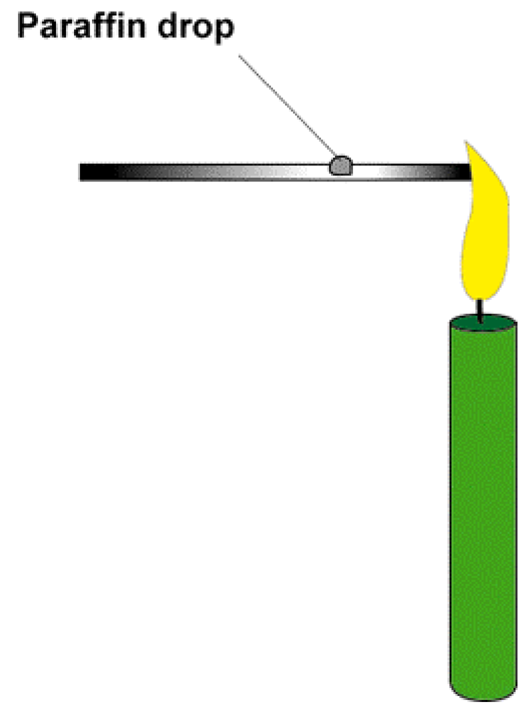
In the Crooke's radiometer, energy is transferred into the system by electromagnetic radiation, and appears in the system as kinetic energy—the rotation of the vanes. In a plant leaf, energy is transferred into the system by electromagnetic radiation, and is used in the process of photosynthesis. Be sure to point out this analogy for the students.

Part 2—Heat

Materials:

Metal rod, candle.

Procedure:



1. Light the candle and allow some wax to drip onto the metal rod and harden.
2. Secure the candle in an upright position and let it burn.
3. Place the metal rod in the flame so that the wax is two centimeters from the flame. After a few moments, the wax on the metal rod will melt.

Questions for Students:

1. What is happening inside the metal rod to allow the energy to move through the rod?
2. How would the demonstration be different if a glass rod were used?
3. At night in the rain forest, the water in a lake might be cooler than the air above the water. In which direction will energy be moving by heat?

Part 3—Mass Transfer

Materials:

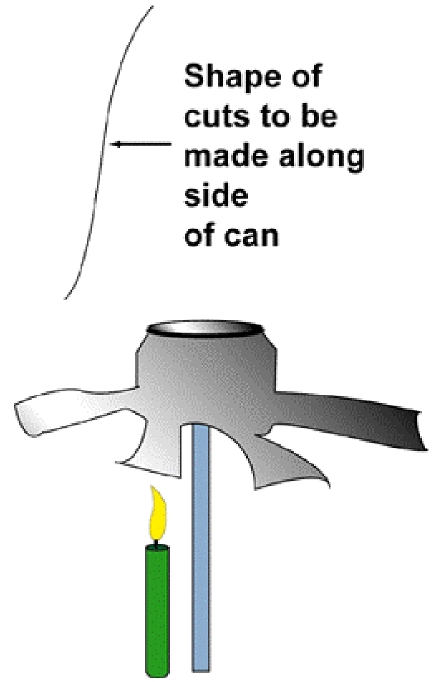
Soda can, tin snips or scissors, candle, thumb tack, pen, cork with hole, modeling clay.

Procedure:

1. Cut the top from a soda can and discard the top.
2. Along the length of the can, make several cuts of the shape shown in the diagram, stopping about two centimeters from the bottom of the can.
3. Bend the resulting strips of metal upward, and you will have a fan-shaped object.
4. Insert a thumbtack through the center of the bottom, from the inside of the can.
5. Rest the head of the thumbtack on the flat end of a vertical rod such as a pen, so as to provide a relatively low-friction support.

6. Secure the rod to the tabletop by inserting the end of the pen into the hole in a cork and fastening the cork to the table with modeling clay.

7. Place a candle under the fan, and watch the fan rotate.



Questions for Students:

1. What causes the fan to rotate?

   If the fan is moved to a new position under the blades, will the direction of rotation change?

   How would the rotation change if three or four candles were under the fan?

2. In the rain forest, are there different temperatures at different heights? Will this cause energy transfer by convection?

Notes to the Teacher:

The word "heat" is one of the most misused words in our language. Be sure to use this word correctly in your teaching. Heat is a process by which energy moves from one location to another. It is also the amount of energy that is transferred by this process. It is not, however, a form of energy and it is not energy in motion, two concepts that are often presented as heat. Thus, the following phrases represent incorrect uses of the word:

"The water has a lot of heat in it..."

"The heat moved from one object to another..."

"Heat transfer occurred..."

As a test, substitute the word "transfer" for "heat" in a phrase. If it sounds awkward, the word heat is likely being used incorrectly. For example, the phrases above become,

"The water has a lot of transfer in it..."

"The transfer moved from one object to another..."

"Transfer occurred..."

These clearly sound awkward, so the word "heat" has been used incorrectly.

Grade 7 Activities At a Glance

- Activity: Determining the Gas Released by Germinating Seeds
- Activity: Culturing and Studying Molds
- Activity: Making a Smoke Print of Leaves to Study External Morphology Characteristics
- Demonstration: The Colors in White Light

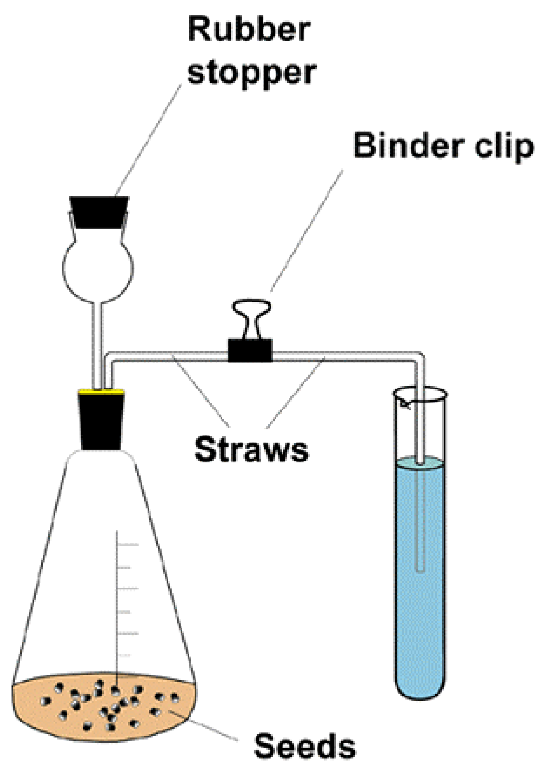
Grade 7 Activity: Determining the Gas Released by Germinating Seeds

We know that all living things share certain characteristics in common. Even plants and animals share certain common qualities, such as the gases they give off. Or do they? In this activity we will use limewater indicator to discover if germinating seeds give off the same gas we do when we breathe.

Materials (per group):

Radish seeds, lime water (see "Notes to the teacher" below for the recipe), paper toweling, 250 ml flask, rubber with 2 holes to fit flask (or substitute plumber's putty), test tube (glass or plastic), test tube rack or holder (inverted Styrofoam cup works well), binder clamp (the kind used to hold a stack of papers together), thistle funnel with stopper (or substitute apparatus explained below), 2 flexible drinking straws.

Procedure:



1. Soak some radish seeds for 30 minutes prior to lab (each group will need about 10).

2. Moisten some paper toweling (it should be wet but not so wet that water puddles in the bottom of the flask) and place it in the bottom of the flask (you may need to use a pencil to move it into place and flatten it out). Drop the seeds into the flask.

3. Place the rubber stopper on the flask. Place the thistle funnel in one hole and one of the flexible drinking straws in the other hole (use the end closest to the pleating of the straw to insert into the rubber stopper). Bend the straw so that the part exiting the stopper is horizontal to the tabletop and cut at a position 10 cm from the bend in the straw. Attach the other straw to the end you just cut and bend this straw down into the test tube (see diagram). Hint: Cut a couple of slits in the end of one straw so that the other straw slips on easily, then secure with a piece of tape. Blow through the 2 straw apparatus to make certain there are no obstructions.

4. Fill the test tube with limewater.

5. Clamp the straws at the point where you joined them.

6. Allow the seeds to germinate for a few days (at least 3 days).

7. Fill a second test tube with limewater and using a drinking straw, bubble your breath through it. It will turn cloudy indicating the presence of carbon dioxide.

8. After several days, remove the stopper from the thistle funnel and gently pour water down the funnel. Open the clamp. The water will displace the air and force it through the straws and into the limewater. Record the reaction.

Questions for Students:

1. What occurred when the gas from the flask containing the germinating seeds was forced into the limewater? Was this the same reaction that occurred when you bubbled your breath through the limewater?

2. What can you conclude about the gas given off by germinating seeds?

Notes to the Teacher:

The bubbling of human breath through the limewater indicator can be done as a demonstration in front of the entire class prior to setting up the activity, or by the students themselves. Limewater can be made by purchasing pickling lime at the market. Add 1 tablespoon of pickling lime to a quart of water. Use a glass quart jar for this. Secure the jar lid. Let this solution stand over night. The next day, decant (pour off) the clear liquid on the top, leaving the cloudy precipitate at the bottom. Store what you decant in another glass jar with a lid—this is your limewater. This clear solution becomes cloudy in the presence of carbon dioxide.

Grade 7 Activity: Culturing and Studying Molds

Molds play a very important role in the decomposition of organic materials. In the rain forest, which is teeming with life, dead plant and animal material would accumulate very quickly if it were not for animals that feed on dead organisms, bacteria that break down organic materials, and molds, which also break down organic materials. Molds have a variety of uses in our everyday lives as well, aside from being decomposers. They are important to the process of making bleu or Roquefort cheese and other food products, and probably the most famous of all uses, the antibiotic drug penicillin. In this activity you will culture several types of molds to examine.

Materials:

Mold cultures (see below), 4 or 5 potato slices, hand lens (or dissection microscope if available, but not necessary), dissecting needle or toothpick.

Procedure for Culturing Molds:

1. Obtain an orange with green mold on it, place in a jar and keep it in a dark, warm place for a few days.

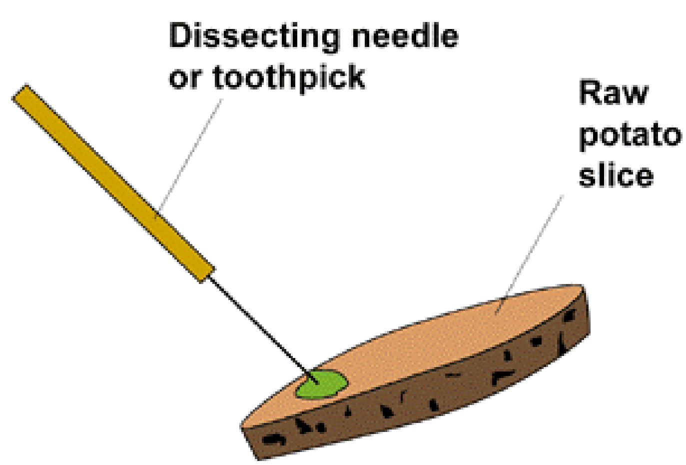
2. Place a piece of moist bread in a sandwich bag and keep it in a dark, warm place for a few days.

3. Take a piece of bleu or Roquefort cheese and put it in a jar in a dark, warm place for a few days.

4. Put a few dead flies in some stagnant water and keep them in a dark, warm place for a few days.

5. Leave a cup of coffee out for several days.

6. In each of the above cases, you should see mold growing. Transfer a little of each mold to a potato slice. Place the potato slices in a dark, warm place and after several days, each slice will have grown a pure culture of the respective molds.



Procedure for Examining Molds:

1. Using a hand lens or dissection microscope, examine each of the mold cultures.

2. Make sketches of what you see. Look for web-like structures (rhizomes) and stalks with ball-like structures (spore cases containing thousands of spores from which new molds can grow under the right conditions).

Questions for Students:

1. What primary purpose do molds serve?

2. If you go to your refrigerator and want to snack on some cheddar cheese, but you see some dark mold on it, will cutting off the dark mold you see ensure that all of the mold is gone? Why or why not?

3. What conditions are best for growing mold?

4. How does refrigeration help to keep our food free of mold?

5. Why do foods get moldy over time even in the refrigerator?

Notes to the Teacher:

It is probably best to do the culturing of the molds for the students. This will save time and ensure pure cultures. Be certain to show them the process, however.

Grade 7 Activity: Making a Smoke Print of Leaves to Study External Morphology Characteristics

In the rain forest an overwhelming number of plant species grow. The variety of adaptations and specialized characteristics is astounding. In this simple activity, one can gain a special appreciation for the characteristics of plant leaves by making smoke prints. Often what is revealed in a process like this helps us to discover subtle characteristics we might otherwise have overlooked.

Materials:

A variety of leaves from different plant and tree species, petroleum jelly, 2 smooth glass bottles with caps or corks, water, white paper, newspaper, candle.

Procedure:

1. Cover one side of the outside surface of a bottle with a layer of petroleum jelly, fill the bottle with cold water, and cap or cork it tightly.

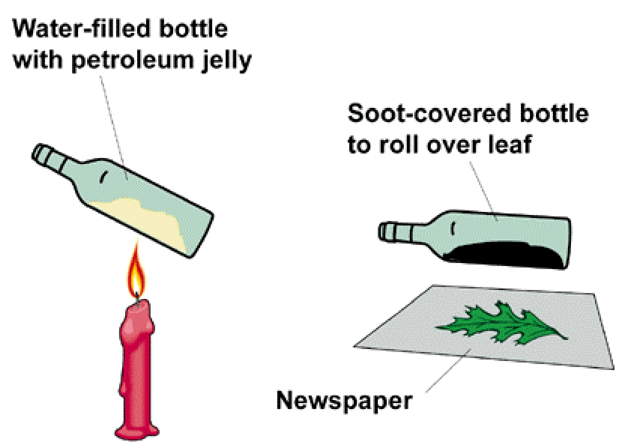
2. Hold the bottle over the candle flame, with the petroleum jelly side toward the flame, until it is covered evenly with soot.

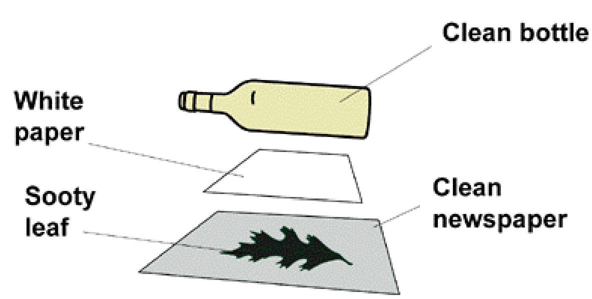
3. Place a leaf, veins up, on a newspaper and roll the sooty bottle over the leaf.

4. Remove the sooty leaf from the newspaper and place it, again with veins up, on a clean newspaper, and place a piece of white paper over the leaf.

5. Roll a clean bottle over the paper that is over the sooty leaf. You now have a smoke print of the leaf.

6. Do this with several species of leaves.





Questions for Students:

1. Compare the characteristics of the leaves. Examine the edges and the veining as well as the thickness of the leaves.

2. Describe the plant survival advantages of the characteristics you have examined.

Notes to the Teacher:

You may want to soot the bottles for the students, depending on their level of maturity and sophistication working with flames. In any case, make certain that long sleeves are rolled up and long hair is tied back. This activity is excellent for integration with art.

Grade 7 Demonstration: The Colors in White Light

Light is a critical aspect of plant life in the rain forest. There is a constant fight for light, with the tallest trees receiving the most light and blocking light from smaller plants. In this demonstration, we will look at the spectral components of light and its interaction with plants.

Part 1—Separating the Colors in White Light

The goal of this demonstration is to demonstrate to students that white light can be separated into spectral colors. In addition, colored filters allow only certain colors of light through and colored objects reflect only certain colors of light.

Materials:

Overhead projector, paper or cardboard, holographic diffraction grating material (available from numerous scientific supply houses, e.g., Fisher Scientific, 1-800-955-1177), colored filters, colored objects, "neon" Post-It notes.

Procedure:

To protect the holographic diffraction grating material from fingerprints and scratches, mount it in cardboard with an opening about the size of the lens on your overhead projector. Mount the grating on the front of the lens, with the slits in the grating oriented vertically.

Place pieces of cardboard or paper on the stage of the overhead projector, with a 1-2 cm gap between them. Turn on the overhead. You should see a white line representing the gap between the paper or cardboard pieces. Turn the overhead so that this white line is off the screen, and you should see a bright spectrum of colors on the screen.

Place different colored filters along the gap between the paper or cardboard pieces and have students notice which colors pass through the various filters. Discuss the behavior of a colored filter as allowing the color of the filter to pass through and absorbing all other colors. Be aware of a common student preconception that filters add the appropriate color to white light, rather than subtracting the other colors.

Remove all the filters and select a colored object. "Neon"-colored Post-It notes work very well because of their high reflectivity. Place the object on the screen, to the left of the display of colors. Start sliding the object into the display of colors and have students tell you when the appearance of the color of the object best matches the color on the screen at the location of the object. For example, an orange object will appear to match the orange part of the display, but will look very different from the screen in the blue part of the display. Discuss the colored appearance of objects as due to reflection of certain colors of light and absorption of other colors.

With this series of demonstrations, you can assist students deeply in their understanding of the concepts of selective transmission of colors (filters) and selective reflection of colors (objects).

Questions for Students:

1. What filters could be placed on top of each other to completely block any light from passing through?
2. Are there any pairs of different-colored filters that could be placed on top of each other such that some light still passes through?
3. Purple is a combination of red and blue. If a purple object were slid across the color display, how would its appearance change at various locations?
4. What would you see if a red object were placed on the screen in the display from a blue filter? How about a red filter?

Part 2—Light Reflected from Leaves

Materials:

Overhead projector, paper or cardboard, holographic diffraction grating material (available from numerous scientific supply houses), green leaves.

Procedure:

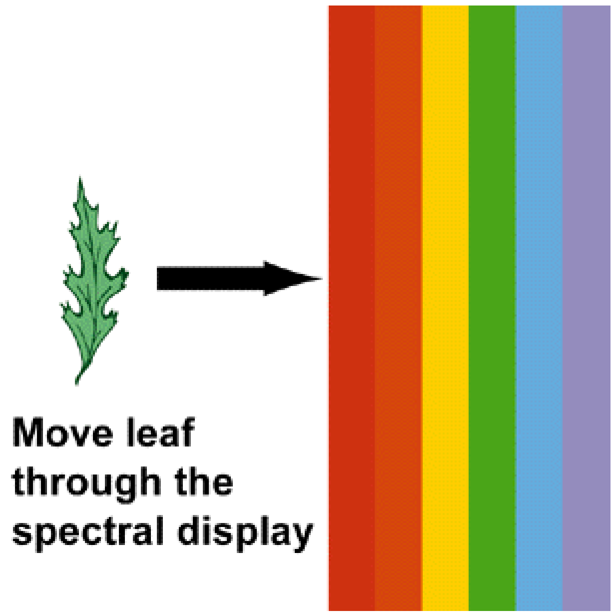
Using the apparatus set up in Part 1, slide a leaf into the color display on the screen and have students notice when it appears most similar to the display on the screen.

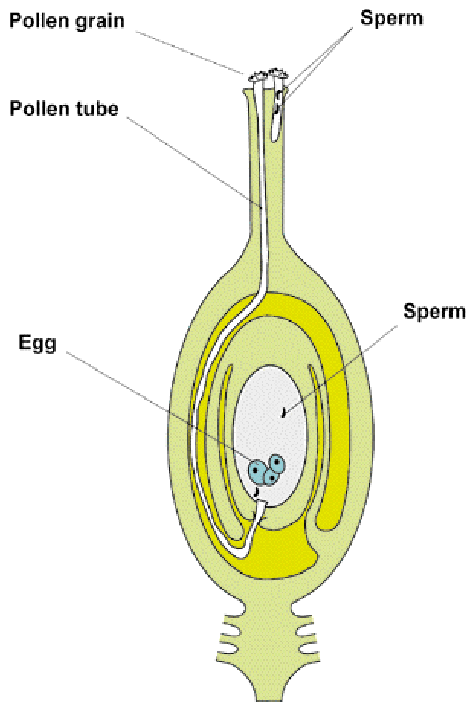
Questions for Students:

1. Why do leaves appear green?

2. Is green light important for the survival of plants? Would a plant grow well if it were grown in a room with only a light source covered with a green filter?

3. Suppose you were to grow a plant with one leaf wrapped in a green plastic filter, one in a red filter, and one in a blue filter. (The filters are perforated to allow the leaves to transpire.) How would the growth of the three wrapped leaves compare?





Grade 8 Activities At a Glance

- Activity: Growing Pollen Tubes and Pollen Examination Under the Microscope
- Activity: DNA Extraction from Strawberries and Bananas
- Activity: Making a Fish Print to Study External Morphology Characteristics
- Demonstration: Buoyant Forces and Stratification in Rain Forest Lakes

Grade 8 Activity: Growing Pollen Tubes, Pollen Examination Under the Microscope

Plants have evolved elaborate flowers to enhance their chances of attracting pollinators to vector pollen from one flower to the next in order for fertilization to occur. All flowers, no matter how beautiful we find them or how great we think they smell, exist for one purpose and one purpose only, to set viable seed for reproduction of the species. This is a fascinating area of study and we will focus on one small part of it—pollen.

We will not only collect and examine pollen, but we will also grow pollen tubes, the tiny structures that must grow once the pollen reaches the stigma on the top of the pistil of the female reproductive parts of the flower. Pollen is produced in the anthers, which are the male reproductive structures of the flower. When the pollen is vectored by the wind, insects, birds, or even bats, and deposited on the stigma of the same species, a chemical signal triggers the growth of a pollen tube. It is down this tube that the sperm travels in an effort to reach the ovules and fertilize the eggs inside. Once the egg is fertilized, a viable seed develops and a new plant life begins.

Materials:

Glass microscope slides, petroleum jelly, flowers, microscope, sugar, water, shallow dish with glass cover or plastic wrap, hand lens or dissection microscope.

Procedure:

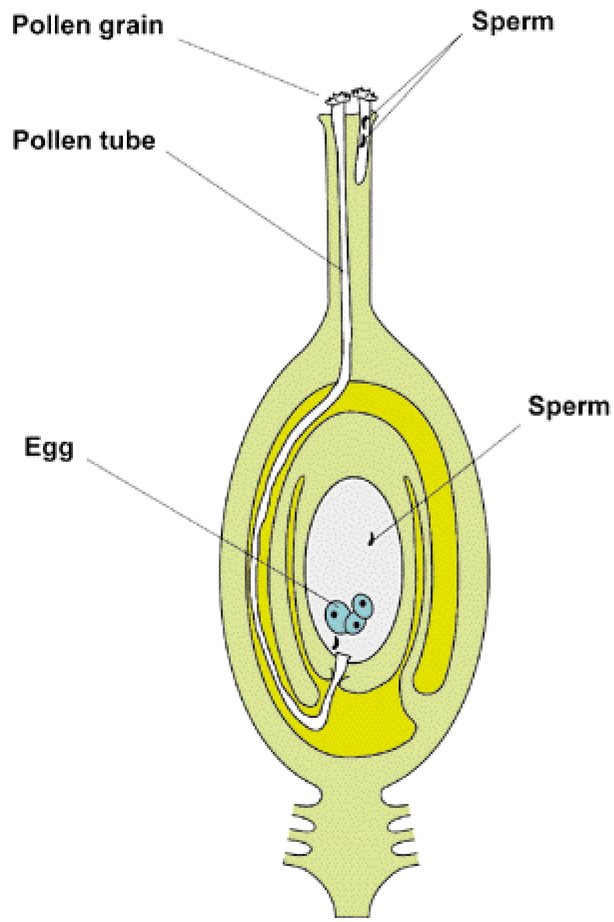
1. Make a strong sugar solution and place it in a petri dish or other shallow dish (like a saucer), cover with lid or plastic wrap.

2. Shake pollen from flowers (select several kinds to ensure success) onto the surface of the sugar water. Cover with a glass lid or plastic wrap and let stand in a warm place for several hours. Pollen tubes will appear.

3. Examine some pollen by smearing a little petroleum jelly on a glass microscope slide and shaking the pollen onto the jelly.

4. Focus on several pollen grains and make sketches.

Questions for Students:



1. How would you describe the pollen grain?
2. Does your description give you any clues as to why people suffer from pollen allergies? Why or why not?
3. Describe the pollen tube and a make a sketch.
4. Do a little extra research and create a labeled diagram of the flower, identifying the male and female reproductive parts.
5. If a flower is long and tubular, what type of organism would most likely pollinate it?
6. When bees, birds, or other organisms pollinate flowers they are unaware that they are providing this "service". So why do they go from flower to flower? What attracts them?

Notes to the Teacher:

You may want to grow the pollen tubes a day ahead of time to make certain that you have them available when you need them. In the K-3 section of the Rain Bird Rain Forest Curriculum there is an activity for building a flower model that you may want to incorporate here. It is an activity that is adaptable to any grade level.

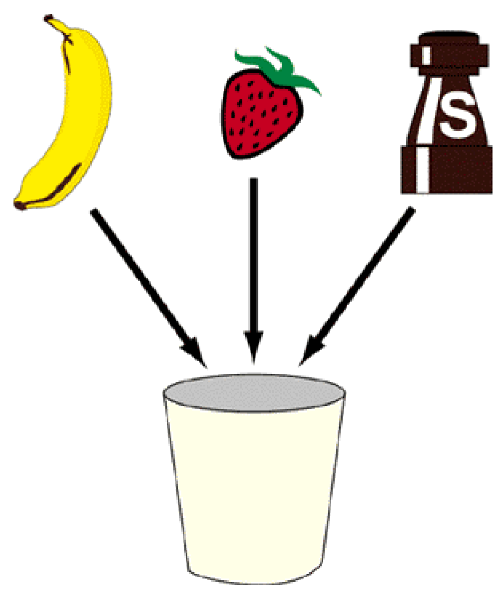
Grade 8 Activity: DNA Extraction from Strawberries and Bananas

All living things contain DNA (deoxyribonucleic acid—the genetic code material of cells). It is the DNA that determines all of the unique characteristics of species and accounts for the great biological diversity of organisms on Earth. Any research into the study of recombinant DNA (genetic research) requires the first step of isolating this molecule. Extracting DNA can be a complex and lengthy process, even when working with plants. However, Dr. Kristin Bozak in the Biological Sciences Department at California State Polytechnic University, Pomona has developed the following simple but effective way of isolating and extracting DNA.

Materials:

Plastic cup with a mashing rod or a spoon, or a mortar and pestle, funnel, plastic cup for catching liquid, glass rod or plastic "swizzle stick", one third of a banana and/or 3 to 6 strawberries, water, tablespoon of salt, a few drops of liquid dish washing detergent (Dawn works well), several layers of cheese cloth, about 200 ml of 91% rubbing alcohol (available from the drug store).

Procedure:



1. Place 1/3 of a banana and 3 to 6 strawberries in a cup and mash into a pulp. The back of a spoon against the side of the cup works well if you go not have a mortar and pestle handy. This mashing process separates the cells and breaks up the cell walls.

2. Add an equal amount of water to the volume of the mashed fruit so that you have a rough 50/50 mixture of fruit and water.

3. Add 50 grams (one tablespoon) of salt to make the solution of fruit and water about one molar. Continue to mix and mash to further break down the cell walls, cell membranes and nuclear membranes in order to release the DNA from the nuclei of the cells.

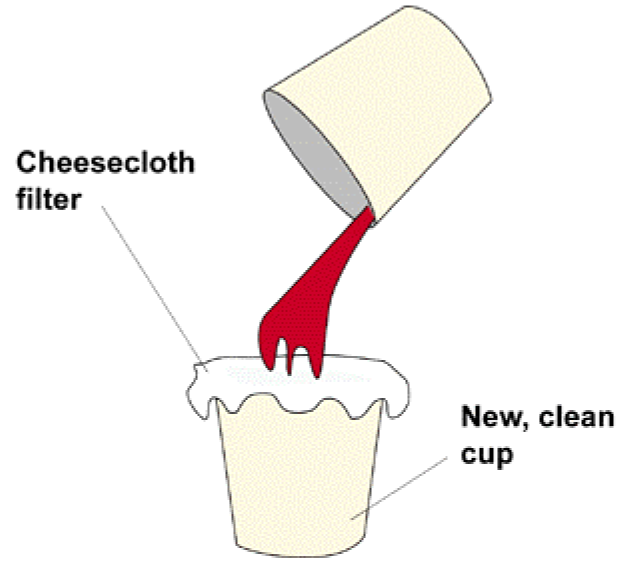
4. Add a few drops of liquid dish washing detergent—this will aid in the breaking down of the cell membranes, along with the salt. The salt also helps to bring the DNA together in order to precipitate out of solution.

5. Filter this mixture through several layers of cheesecloth into a plastic cup.

6. Measure the liquid (use a graduated cylinder or a measuring cup) and double the volume by adding the 91% isopropyl rubbing alcohol.

7. Spool the DNA on the glass rod or "swizzle stick". It will spool as you slowly stir the solution.

8. Remember, this is a very simple process and any cellular components that are not alcohol soluble are still included. To further purify this extract would require hazardous chemicals that are not necessary for our purposes here.



Questions for Students:

1. Do textbook or Internet research and determine the "building blocks" of the DNA molecule.

2. Draw a diagram of the DNA molecule and label its components (you will need your text book or the Internet as a resource).

3. Describe the chemical reaction you observed (that is, describe what you saw occurring) when you began to spool the DNA.

4. If time permits, try this experiment again with a different type of plant material and work on refining your lab skills to produce the best possible extraction of the DNA.

Notes to the Teacher:

Goggles should be worn while working with the isopropyl alcohol. This activity is a great way to introduce the topic of protein synthesis.

Grade 8 Activity: Making a Fish Print to Study External Morphology Characteristics

Numerous species of fish exist in the tropical rain forests. Fish, like all of the rain forest species, are a vital link in the complex ecological web of this threatened biome.

This activity is designed to be done prior to a standard laboratory fish dissection. It could also be done as an integration with art. The object is to gain an appreciation and understanding of the external characteristics of the fish (whatever species you decide to dissect—perch is the most commonly used in the lab). This activity also serves the purpose of creating a permanent record of the fish's external morphology.

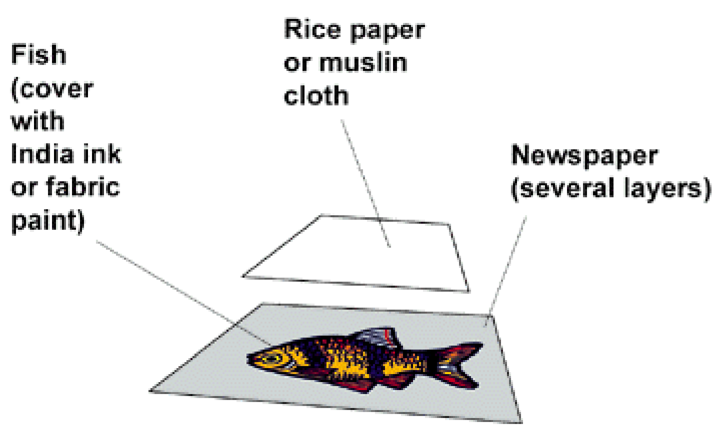
Materials:

Fish (from scientific supply house or supermarket seafood counter), rice paper or muslin cloth (cut in 8 ´ 10 inch squares, or large enough to accommodate the fish being printed), India ink, or fabric paint, paint brush. All of these materials are available from the craft store, with the exception of the muslin cloth, which can be purchased from a fabric store.

Procedure:

1. Lay the freshly rinsed fish on several sheets of newspaper and pat it dry with paper toweling.

2. You can choose to do the following procedure by using rice paper and India ink or muslin fabric and fabric paint. Paint the fish with either ink or fabric paint (most craft paints work well). Apply a sheet of rice paper (if you are using ink, fabric paint if you are using muslin cloth) to the fish and gently press, without smearing.



3. Gently pull the rice paper or fabric away from the fish and let dry.

Questions for Students:

1. How many fins does your fish have? What do suppose the function of each fin is in terms of aiding the fish to maneuver efficiently in the water?

2. Do the scales of the fish appear to grow from the head toward the tail, or from the tail toward the head? Why do the scales grow in the direction you described?

3. Make a simple sketch of your fish. Measure the length, the width (at the widest point), and the distance from the mouth opening to the dorsal, pectoral, and side fins. Now calculate the percentages of these distances compared to the total length of the fish. Example: If the fish is 24 cm long and the dorsal fin begins at 10 cm from the mouth opening, the dorsal fin begins at 42% of the fish's total length.

Notes to the Teacher:

Remind students to wash their hands well after handling the fish. If you are using preserved fish from a scientific supply house, make the certain that the room is well ventilated due to the odor of the formalin preservative.

Grade 8 Demonstration: Buoyant Forces and Stratification in Rain Forest Lakes

One of the most puzzling events of recent years was the sudden release of carbon dioxide gas from Lake Manoun in 1984 and Lake Nyos in 1986. Both lakes are located in the rain forest country of Cameroon, Africa. Over 1700 Cameroonians died in these events. Several questions can be addressed for scientific investigation of the cause of these events:

- No such other event has been recorded, yet two different lakes exhibited this event only two years apart—Why?
- Both events occurred in August—Why?
- Death from the event occurred up to 26 km away from the lakes—What was the mechanism for these deaths?
- Why did the lakes hold large amounts of carbon dioxide?
- Could this happen in other lakes?

One of the most important concepts for understanding the Cameroon disasters is that of the buoyant force, which we will investigate in this group of demonstrations.

Part 1—Observing the Buoyant Force

This first demonstration will show students direct evidence of the buoyant force. As a mass hanging from a spring scale is dipped into water, the reading on the scale decreases. The upward buoyant force from the water on the mass results in a smaller force from the spring. Be sure to stress the importance of the relative density of the object and the water in a discussion of floating and sinking.

Materials:

Hanging spring scale, metal object with hook, transparent glass or cup, water.

Procedure:

1. Fill the cup with water to a level such that it will not overflow when the metal object is immersed in the water.

2. Hang the metal object from the spring scale.

3. Face the spring scale toward students, and slowly dip the object into the water.

4. Have the students watch the spring scale reading as the object sinks deeper into the water.

Questions for Students:

1. Imagine that the cup is sitting on a second spring scale while the object is lowered into the water. What would happen to the reading on this spring scale?

2. Does the object become completely submerged? Why? Explain what would happen in this demonstration if the object were made of wood.

3. Suppose the demonstration were repeated with an object of a different metal. Which would be the same for the two metals—the difference between the initial and final scale readings, or the ratio of the initial and final scale readings?

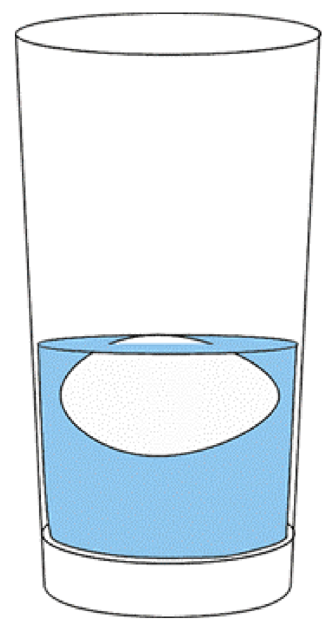
Part 2—Stratification in Water

One of the major contributions to the Cameroon disasters was the steady-state stratification of water in the lakes. This demonstration shows one result of stratification in water.

Materials:

Egg, distilled water, salt, clear drinking glass.

Procedure:



1. Fill the glass half full with distilled water. Add salt to the water and stir. Keep adding salt until no more salt will be dissolved, and salt begins collecting on the bottom of the glass.

2. Lower the egg into the salt water. It should float.

3. Gently add some fresh water on top of the salt water until the glass is full. You might want to pour the fresh water over the back of a spoon so that the fresh water sprinkles down gently onto the salt water. The important consideration is that the fresh and salt water mix as little as possible. You should be able to create a layer of salt water and a layer of fresh water above it, with the egg floating at the interface between the two layers. You can add a drop or two of food color to the fresh water before adding it to the cup in order to make the appearance of the stratification more dramatic.

Questions for Students:

1. What physical quantity is different in the water above and below the egg?
2. Would it make a difference if the egg were boiled?
3. What would happen if the glass were allowed to sit for a long time? Why?

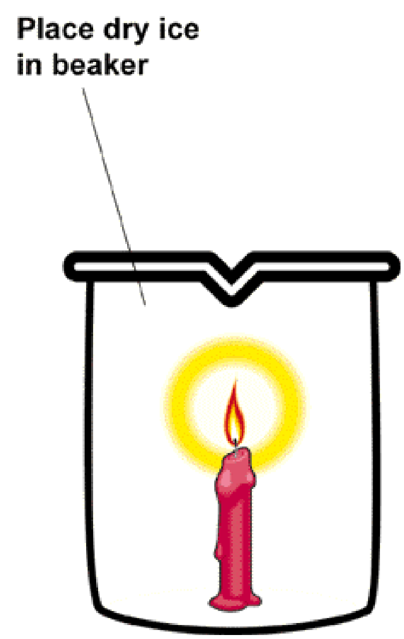
Part 3—Does Carbon Dioxide Float on Air?

Once the carbon dioxide was released from the lakes in Cameroon, it stayed close to the ground rather than rising into the atmosphere. This is what killed the individuals and animals near the lakes—they suffocated from lack of oxygen. This demonstration shows this effect, which is due to the fact that carbon dioxide is denser than air. It stresses the fact that the buoyant force is a consideration for gases as well as solids and liquids.

Materials:

Beaker, candle, dry ice.

Procedure:



1. Fasten a candle to the bottom of a beaker and light the candle.
2. Drop a few pieces of dry ice into the bottom of the beaker. The candle will go out in a few moments.

Questions for Students:

1. Why did the candle go out? Is this because of the drop in temperature?
2. How tall would the candle have to be relative to the beaker for it not to be extinguished?
3. What if a helium balloon were allowed to leak into the beaker—would the candle go out?
4. Why is the air warmer near the ceiling of a room than near the floor? Why are ceiling fans operated in the winter if you are trying to warm up the air?
5. How does this demonstration explain why so many Cameroonians died in the Lake Manoun and Lake Nyos disasters?

With the understanding from these demonstrations, we can now answer some of the questions about the Cameroon disasters. In a lake located in a temperate zone such as the United States, there are significant temperature variations during the day and during the entire year. For example, imagine the sun going down in the evening. As the temperature of the surface water drops, because of the absence of sunlight, the water contracts and becomes denser. This denser water sinks, and the warmer, less dense water below rises to the top. Thus, there is a process, based on the buoyant force, which tends to mix the upper and lower layers of water.

Lakes Monoun and Nyos have two characteristics that contributed significantly to the disasters. First, they are very deep, so that it is difficult to mix the various layers of water over such a large vertical distance. This factor also results in a very large pressure at the bottom of the lake so that a large amount of carbon dioxide can be dissolved into the water from local rocks and deep springs. Second, both lakes are located in an equatorial rain forest region where the temperature variation is much smaller than in the temperate zones. This results in little driving force to mix the layers of waters in the lakes. The result is major stratification of the water. The water that is near the bottom of the lake stays there for a long time and collects a large amount of dissolved carbon dioxide. Without a mixing process, this carbon dioxide cannot be brought to the surface with the water and released safely. It simply continues to increase in concentration.

The situation described is explosive. If the carbon-dioxide-laden water were to be brought to the surface where the pressure is much lower, the gas will expand and come out of solution rapidly. This is what happened in 1984 and 1986, although the exact cause of the breakdown in the stratification is not known. The stability of the situation is weak. Once there is any small breakdown in the stratification and carbon dioxide comes out of solution, the bubbles will rise through the water and cause more mixing of layers.

If there were a temperature decrease of the surface water, this water would become denser and will sink, possibly triggering the release of carbon dioxide and the beginning of the explosive situation described above. The monsoon season in Cameroon is in August. Monsoon clouds block the sunlight, resulting in lower surface water temperatures—this may be the reason that the disasters occurred in August. Climate data for Cameroon show lower than normal temperatures and higher than normal rainfall in the mid-1980s. The resulting decrease in surface temperature could explain why these events occurred in 1984 and 1986. The exact reasons for the sudden release are not known and remain an area of active research.

Finally, once the carbon dioxide was released from the lakes, it stayed near the ground because it is denser than air, as seen in the third part of the demonstration. Thus, a layer of carbon dioxide gas spread out over the land around the lake, representing a deadly suffocating gas for all organisms requiring oxygen in its path.

Grades 9-12 Activities At a Glance

For the grades 9-12 level of activities related to the rain forest, we do not assign specific activities to specific grade levels. This is due to the variety of possibilities for the timing of a particular science (chemistry, biology, physics) in a student's high school career.

The 9-12 rain forest curriculum is divided into four topic areas, as listed below:

- **The Rain Forest and Weather**
  - Activity: Transpiration in Plants
  - Activity: Filtering Mechanisms in Nature
  - Activity: Raisins and Carbon Dioxide
  - Demonstration: Soda Float

- **Light in the Rain Forest**
  - Activity: Ultraviolet Radiation
  - Activity: Interference of Light
  - Activity: Structural Versus Pigment Color
  - Demonstration: Sunballs

- **Ecology and Diversity**
  - Activity: Leaf Litter Ecosystem
  - Activity: Plant Pigment Chromatography and the Absorption Spectrum for Chlorophyll
  - Activity: Extracting DNA from Wheat Germ
  - Demonstration: Light and Diversity

- **The Rain Forest as an Economical Resource**
  - Activity: What is an Antioxidant?
  - Activity: Natural Antibiotics
  - Activity: Chemical Indicators from Plants
  - Demonstration: Products from the Rain Forest

Grades 9-12 Activities Overview – Part I: The Rain Forest and Weather

While the tropical rain forests of the world comprise only about 2% of the Earth's ground cover, they have a significant impact on the climate of our planet. A biome of this type is multi-layered and reaches many meters above the surface of the ground. For this reason, there is a tremendous amount of plant material in a relatively small amount of space.

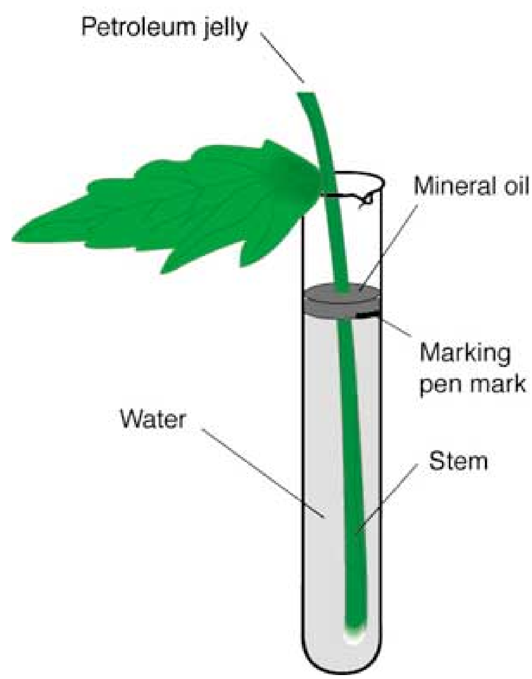
Plant material has an effect on the weather. It takes in water and releases water to the atmosphere through the process of transpiration. When tropical rain forest land is cleared for purposes such as grazing cattle, much less water is transpired though the grazing grasses to the atmosphere compared to that of the natural rain forest vegetation. Less water in the atmosphere results in higher air temperature and less rainfall.

Grades 9-12 Activity: Transpiration in Plants

Plant tissue is composed mainly of water. Most plants, however, retain very little water and lose most of it to the atmosphere in a process called transpiration. This process occurs through the leaves, specifically through small openings called stomata. The transpiration rates of plants vary greatly from species to species, from those that replace their entire water volume daily to those such as cacti that have evolved to retain water during long periods of drought. Transpiration is an important factor as agricultural demands increase with the rapid increase in the human population.

Where the tropical rain forests of the world are concerned, clearing 27 million acres per year to create grazing land for cattle to meet food supply needs has a serious impact on the worldwide weather pattern. The vegetation of the tropical rain forests is a mix of a wide variety of leafy plants. Therefore, when these plants are removed, the amount of water they release to the atmosphere also is removed. What is put in there in its place is plant material suitable for grazing cattle-all small leafed gassy plants (monocotyledonous species).

Materials:



Three standard test tubes, mineral oil, petroleum jelly, plant material (preferably bean, ivy, or any leafy plant with a large leaf surface and a monocot leaf; any grassy plant will suffice), test tube rack, metric ruler, razor blade (or scissors), graduated cylinder, 1 cm square graph paper, water, glass marking pen.

Procedure:

Part 1: Determining Leaf Surface Area

1. Remove all but one leaf from the stem of a plant using a blade or scissors.

2. Prepare both a dicotyledonous leaf and a monocotyledenous leaf.

3. Trace around the entire leaf on a sheet of 1 cm graph paper. Count the squares within the tracing, estimating with portions of squares, and then multiply by 2 because leaves transpire from both sides. This is your surface area in square centimeters. Be certain to do this for both the dicotyledonous leaf and the monocotyledenous leaf.

Part 2: Setting Up the Transpiration Experiment

1. Once you have a complete outline of both leaves, cover all places where leaves were removed from the stems with petroleum jelly and place the stem end of the dicotyledenous leaf in one test tube and the moncotyledenous leaf in another test tube. The test tubes should be filled with water (about 2 cm from the top of the tube).

2. Pour about 3 mL (20-40 drops) of mineral oil (or vegetable oil) on top of the water in both tubes.

3. Make a control for the experiment using just the water and oil in a test tube.

4. On each test tube, including the control, use a wax pencil or waterproof marker to mark the water level (mark where the water and oil meet).

5. On days 2-4 of the experiment, take measurements in cm of the drop in water level. Create a data table on which to record the data.

6. On the fourth day of the experiment, calculate the total volume of water lost using the following equation for the volume of a cylinder:

$$V = \pi r^2 h$$

7. Graph your results in units of mL of water lost per cm2 of leaf area over the four days of the experiment.

Questions for Students:

1. How does the rate of transpiration compare between the moncotyledenous leaf and the dicotyledenous leaf?

2. What conclusions can you draw about the impact of clearing tropical rain forest vegetation and replacing it with grazing grasses for cattle?

Notes to the Teacher:

Students should generate data that illustrates greater transpiration rate in large leafy plants as opposed to narrow leaf grasses. They should understand that the weather pattern of the Earth is influenced by the amount of water brought into the atmosphere that in part comes from the water transpiration of plants.

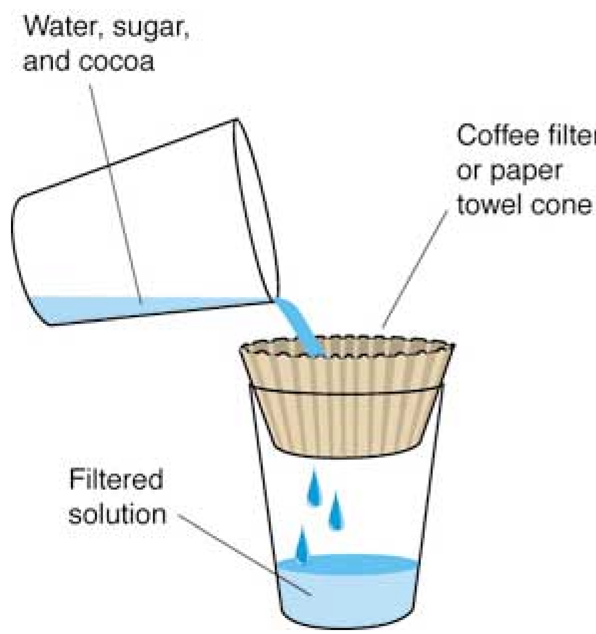
Grades 9-12 Activity: Filtering Mechanisms in Nature

As indicated by the name, the rain forest receives a large amount of water in the form of rain. The natural filtering of this water is one process by which wildlife and native peoples living in the rain forests receive fresh drinking water.

Materials:

Sugar, pure powdered cocoa, plastic cups, water, paper toweling or coffee filters, teaspoon.

Procedure:



Part 1: Preparing the Filtration Solution

1. Place a teaspoon of sugar and a teaspoon of cocoa in the cup.
2. Fill the cup about one-fourth full of water.
3. Mix very well with a spoon.

Part 2: Filtering

1. Place a coffee filter (cone or basket type) in the second cup. Or you may substitute the coffee filter with a paper towel folded into a cone shape. To do this, fold the paper towel in fourths and then pull one of the open points away from the other three, creating a cone.
2. Pour the solution you just mixed through your filter and into the second cup. Be patient; this will take a few minutes.
3. Take a sip of the filtered solution.

Questions for Students:

1. How does the filtered solution compare in color to the unfiltered solution?
2. How does the filtered solution taste?

3. Of the three items in your original solution, water, cocoa, and sugar, which one(s) passed through the filter?

4. How do you know which one(s) passed through the filter?

5. What makes the difference as to why some substances can pass through the filter and some cannot?

Notes to the Teacher:

The students should realize that it is molecular size which determines which substances can pass through the filter and which cannot. In this activity the sugar, combined in solution with the water, was able to pass through the filter due to its small molecular size. The molecular size of the cocoa prevented its passage. The students can determine from the sweet taste of the filtered solution that the sugar passed through the filter.

Grades 9-12 Activity: Raisins and Carbon Dioxide

An important consideration for rain forest climate is the floating and sinking behavior of fluids with different densities. This is true both for the air in the rain forest as well as for water in rain forest lakes. When air increases in temperature, it expands and becomes less dense than surrounding cooler air. As a result, the warmer is pushed upward by a buoyant force. This contributes to vertical currents of air that keep the air circulating among different vertical elevations in the rain forest.

A similar situation occurs with water in lakes. As surface water cools at night, it becomes more dense and sinks, setting up vertical currents in the water. The absence of these vertical currents is what led to the disaster in Cameroon studied in an earlier activity in this curriculum (see Grade 8 Activity: *Buoyant Forces and Stratification in Rain Forest Lakes*).

In this activity, we will study the floating and sinking behavior in a simple system of raisins in a carbonated beverage.

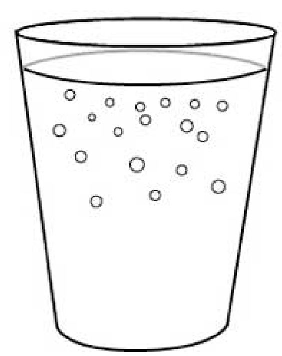
Materials:

Clear plastic cup, raisins, clear carbonated beverage (e.g., 7up, Sprite, etc.) .

Procedure:

In this activity, you will be observing raisins in a carbonated beverage. As carbon dioxide comes out of solution in the beverage, bubbles of the gas will collect on raisins. The overall density of the raisin-bubbles combination will become less than that of water and the raisin will float to the surface. At the surface, the carbon dioxide will escape into the air and the raisin will sink again.

Your goal in this experiment is to study the time behavior of the carbon dioxide as it comes out of solution. Before performing the experiment, discuss with your group which of the following two experiments you will perform to study this behavior:



1. A single raisin will be dropped into the beverage and the time between trips to the surface will be recorded.

2. Several raisins will be dropped into the beverage and the number arriving at the surface in a ten-second interval every minute will be recorded.

After selecting your experiment, but before performing the experiment, *predict* the shape of a graphical representation of the data for your experiment. Draw this prediction on graph paper. Now, perform your experiment and record the data.

Questions for Students:

1. Which experiment did you perform? Why did you choose this experiment? What are the advantages of this experiment over the one you did not choose? What are the disadvantages?

2. How closely did the graphical representation of your data match your prediction? Account for any differences.

3. How could the accuracy of your experiment be improved?

Notes for the Teacher:

An important objective of this experiment is to provide students with an opportunity to think about graphical representations of data before performing the experiment, based on what they expect to happen to the concentration of carbon dioxide as time progresses. The experiment is not as much about raisins and carbon dioxide as it is about critical thinking. You might need to suggest various shapes for the experimental curve. Will the number of raisins (experiment b) in-crease rapidly to a plateau and then stay approximately constant until it de-creases at some later time? Does the number of raisins in-crease slowly and then de-crease slowly? Does the number of raisins start off very high and gradually become smaller? Does the number of raisins oscillate with some period?

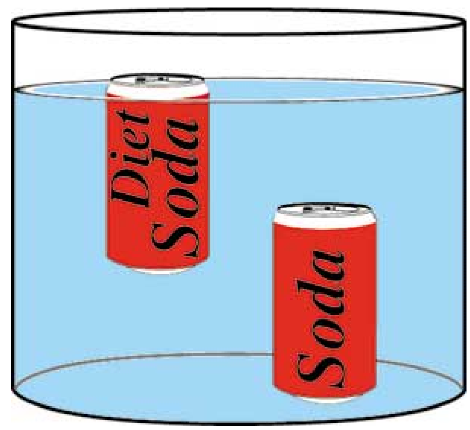
Grades 9-12 Demonstration: Soda Float

This demonstration can be performed in connection with the previous activity on raisins and carbon dioxide. It also addresses the concept of floating and sinking.

Materials:

Large transparent container, such as an aquarium, water, cans of diet and regular soda, two identical plastic bottles with screw-on tops, rubbing alcohol.

Procedure:



Part 1: Cans of Soda

1. Fill the large container with water to a depth of about 20 cm.
2. Ask students to predict what will happen when cans of diet and regular soda are placed in the water.
3. Place the cans in the water and notice that the diet soda floats while the regular soda sinks.
4. Repeat with other pairs of cans (different brands of cola, cola versus lemon-lime).
5. Discuss with students the role of the density of sugar compared to the density of artificial sweetener in the observed behavior.

Part 2: Bottles of Water

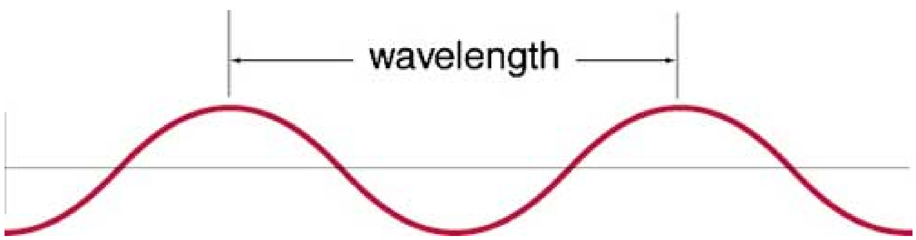
1. Prepare two plastic bottles beforehand.
2. Fill one with water and screw on the top.
3. Fill the other with rubbing alcohol and screw on the top.
4. Before presenting to the class, make sure that the water bottle sinks and the alcohol bottle floats.
5. Present the two bottles to the class. They will appear identical.
6. Show the class the different behavior of the two bottles when placed in the water and ask them to explain the difference.

Grades 9-12 Activities Overview – Part 2: Light in the Rain Forest

In these activities and demonstrations, we will investigate some of the complexity of light coming from the sky and entering the rain forest. Visible light is one example of an *electromagnetic wave*. A single electromagnetic wave has a *frequency* f and a *wavelength* λ associated with it. The wavelength λ is the distance in space between two crests of a wave, as shown in the diagram. The frequency f is a measure of how many oscillations per second the wave makes. For visible light, wavelengths are measured in hundreds of nanometers and the frequency is on the order of 10^{14} Hz, where a *hertz* (Hz) is an oscillation per second.

The frequency and wavelength are related as $\mathbf{c = \lambda f}$

where c is the speed of light. In a vacuum, $c = 3.00 \times 10^8$ m/s, and this value is valid for light passing through air also. For light passing through solids and liquids, the speed deviates in the downward direction from this value.



Various ranges of frequencies of electromagnetic radiation are given different names:

Name	Frequency Range	Wavelength Range
Radio	10^4 - 10^9	0.1 - 10^4
Microwaves	10^9 - 10^{12}	10^{-4}- 0.3
Infrared	10^{11}- 4 x 10^{14}	7 x 10^{-7} - 10^{-3}
Visible Light	4 x 10^{14} - 8 x 10^{14}	4 x 10^{-7} - 7 x 10^{-7}
Ultraviolet	8 x 10^{14} - 10^{18}	10-^{10}- 4 x 10^{-7}
X-rays	10^{16}- 10^{20}	10-^{12} - 10^{-8}
Gamma Rays	10^{18}- 10^{22}	10^{-14} - 10^{-10}

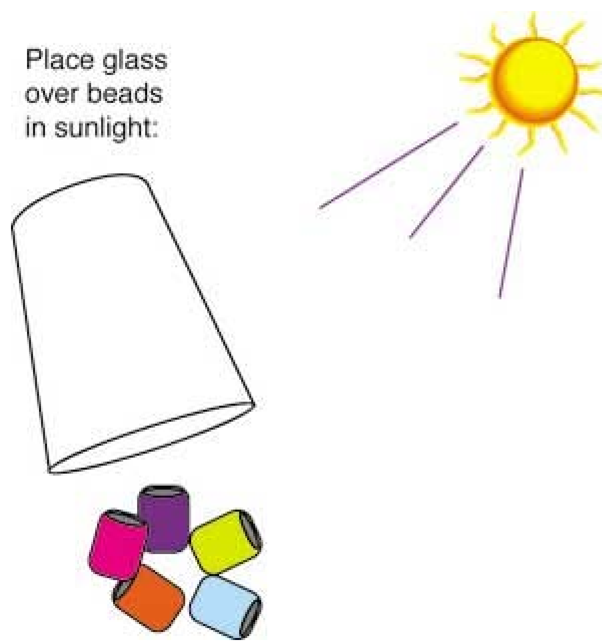
Grades 9-12 Activity: Ultraviolet Radiation

One component of radiation from the Sun that is absorbed by the vegetation of the rain forest is ultraviolet radiation. We are shielded from this type of radiation by the ozone layer. The ozone layer is becoming thinner, due to human interactions with the environment, resulting in increased danger from higher levels of ultraviolet radiation. The beads listed below in the materials list are sensitive to ultraviolet radiation, and will turn from white to a color when they absorb ultraviolet radiation.

Materials:

Ultraviolet detecting beads (available from Educational Innovations, 203/629-6049 (phone), e-mail info@teachersource.com, or at www.teachersource.com), clear, colorless drinking glasses (glass and plastic), plastic and glass sheets, water.

Procedure:



1. Place your ultraviolet detecting beads in the sunlight and notice the color change.
2. *Predict* whether the beads will appear colored or white when placed in the Sun under a drinking glass made of glass and one made of plastic. (Be sure to predict before you do the experiment.) Discuss your prediction with other members of your group.
3. Once you have discussed and finalized your prediction, test it with the beads under a drinking glass.
4. *Predict* whether the beads will appear colored or white when placed in the Sun in a drinking glass made of glass and plastic and filled with water. Discuss your prediction with other group members.
5. Once you have discussed and finalized your prediction, test it with the beads in a drinking glass filled with water.
6. *Predict* whether the beads will appear colored or white when a plastic or glass plate is held between your beads and the Sun. Discuss your prediction with other members of your group.

7. Once you have discussed and finalized your prediction, test it with the plates between the beads and the Sun.

Questions for Students:

1. With the beads in the water, how can you determine if the appearance is due to the glass or the water?

2. If the beads turned color when a plastic or glass plate was between them and the Sun, from where was the ultraviolet light coming?

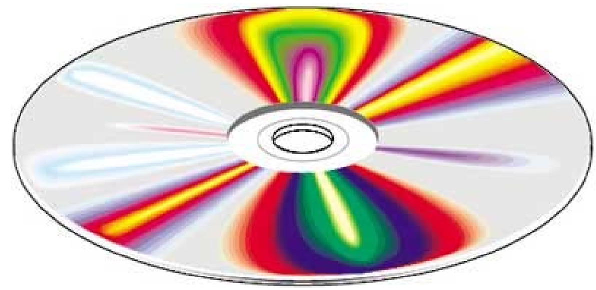
3. Will the beads turn color when placed inside your car, with sunlight shining on them through the windows?

Notes to the Teacher:

Lead a discussion of whether the beads will turn from white to a color on a cloudy day. If a cloudy day is available, test it. Relate the discussion to sunburns on cloudy days and to the dangers of the loss of the protective ozone layer in the atmosphere.

Grades 9-12 Activity: Interference of Light

This activity allows you to explore the interference of light using simple materials. This activity culminates in the connection to the rain forest-the origin of colors and iridescence in some organisms.



Materials:

Compact disc, laser pointer, flat mirror, peacock feather.

Procedure:

Part 1: Laser Beam Reflection

1. Place the mirror on the table, reflecting side up.
2. Shine the laser pointer onto the mirror while your partner holds a piece of paper at the expected location of the reflection. ***Do not allow the laser beam to strike anyone in the eye.***
3. Move a second piece of paper around the area above the mirror and verify that there are no additional reflections beyond the one you have already observed.
4. Replace the mirror with a compact disc, placed on the table with the playing side upward.
5. Shine the laser pointer onto the disc while your partner holds a piece of paper at the expected location of the reflection. ***Do not allow the laser beam to strike anyone in the eye.***
6. Move a second piece of paper around the area above the disc and look for additional reflections.

Questions for Students:

1. Does the disc act just like a mirror? In particular, is there only one reflection from the disc, as there is from the mirror? Explain any difference.
2. Based on the locations of the additional reflections, can you estimate the distance between tracks of information on the disc?

Part 2: White Light Reflection

Hold the compact disc in your hand and view light from a window or light bulb that is reflected in the surface of the disc. Although the light source is sending white light toward the disc, you see colored light reflected from the disc.

Questions for Students:

1. Why do you see colors from the surface of the disc?
2. Why do the colors change as you alter the orientation of the disc?

Part 3: Peacock Feather

1. Hold a peacock feather in white light and observe the colors closely.
2. Rotate the feather and observe any changes in the colors of the feather.
3. In a dark room, shine the laser beam on various parts of the feather and observe the result.

Questions for Students:

1. Is the color of a peacock feather due to pigmentation? Explain.
2. Explain the results of the experiment with the laser beam and the peacock feather.

Notes to the Teacher:

You can choose to discuss interference of light either before beginning the experiment, or after Part 1, depending on your style. The additional reflections from the compact disc are higher-order interference maxima in the interference pattern formed by light reflecting from the surface of the disc. The parallel tracks of pits on the disc act as a reflection diffraction grating.

The next activity allows students to explore further into the origin of color in feathers. If available, show students other examples of biological colors from interference such as the throat area of hummingbirds, Morpho butterflies, iridescent beetles, etc.

Grades 9-12 Activity: Structural Versus Pigment Color

This activity is an investigation into color, specifically the color of birds. The tropical rain forests of the world are famous for the numerous species of brightly colored birds. The bird shown below is the red-crested touraco (photo from Aves International on-line catalog) and is native to east Africa.

This bird displays a rare green pigment and a water-soluble red pigment. If the red pigment of this bird is water soluble, how can this species maintain its color in the rain forest without having its red pigment wash away? You will discover this answer shortly.

Procedure:

We will now examine our three samples of feathers (red, blue and white) to learn something about the origin of their colors.

Part 1: Feather Observation

Obtain the red, blue, and white bird feather samples and observe them closely under a dissection microscope or with a good hand lens. Try to observe all three samples at once for the best comparison. (This will require cutting a small piece of each feather so that they can be grouped closely together.) Sketch each as it appears under magnification, using colored pencils.

The blue feather is an example of Tyndall blue found in many different types of animal tissues. The blue is not due to pigment, but to tissue structures that cause constructive interference for the blue rays. Blue feathers are the most abundant and often the most impressive example of Tyndall blue in animals. Other examples include blue eye color and the blue bare-skin patches of certain mammals.

The hard, mid-rib portion of the white feather appears as if it is made of ice crystals or cut glass. The color of the hard matter of the feather results from very much the same principle as ice crystals or cut glass in that it exhibits diffuse reflection. There are many tiny air spaces inside the feather branches that reflect the incoming light in all directions, and the feather looks white.

In the red feather, the hard mid-rib portion is quite colorless and transparent. The hollows of the small branches are filled with red pigment (red, because it absorbs all of the light rays except red and, therefore, reflects red). The interesting point here is that red and yellow pigments (carotinoids) can only be produced by plants (you may recall learning about these pigments from experiments you have done in plant pigment chromatography). These pigments can only be found in birds due to the foods they consume.

Red bird feathers can come about in one of two ways. For some bird species it is a matter of consuming yellow carotinoids and having the physiologic ability to turn the yellow into red color matter. Other species must directly consume the red pigment.

The touracos of Africa (related to cuckoos) mentioned earlier are a good example of unusual pigmentation in birds. They display actual green pigment. Well over ninety percent of green birds are actually blue birds with some amount of yellow pigment or yellow birds with some amount of blue structure. This accounts for the incredible variety of green shades seen in birds throughout the world.

The touraco actually has a green pigment called turacoverdin. This green color is not a mix of blue structure and yellow pigment. The red feathers of these birds are due to a pigment called turacin. This red pigment is a copper salt and it is soluble in water.

Part 2: Color Investigation

1. Place a portion of your red feather sample in water. Leave the feather in water overnight and compare to the dry red feather the next day.

2. Using the blue feather you can verify that the blue color is due to structure by altering the physical structure of the feather. To do this, snip a portion of the blue feather into small pieces and then crush it with a mortar and pestle. The feather will immediately turn dark because all that is left after the blue producing structure is destroyed is the melanin understructure, which is now visible.

3. Dip a portion of the blue feather into water. Observe and note.

4. Use an eyedropper to drop some water on several locations of any of your feather samples. Does the water soak in or bead up and stay on the surface?

Questions for Students:

1. After the red feather sample was soaked in water, what color did it become?

2. Because your investigation has proven that the red pigment in bird feather is water soluble, you might begin to wonder why the red color of bird feathers does not wash out in the tropical rain forests they inhabit. Explain why this does not happen by recalling what occurred when you dropped water on the feather's surface.

3. What do you suppose is on the surface of a bird feather that might cause the water to act as it does when placed on the feather?

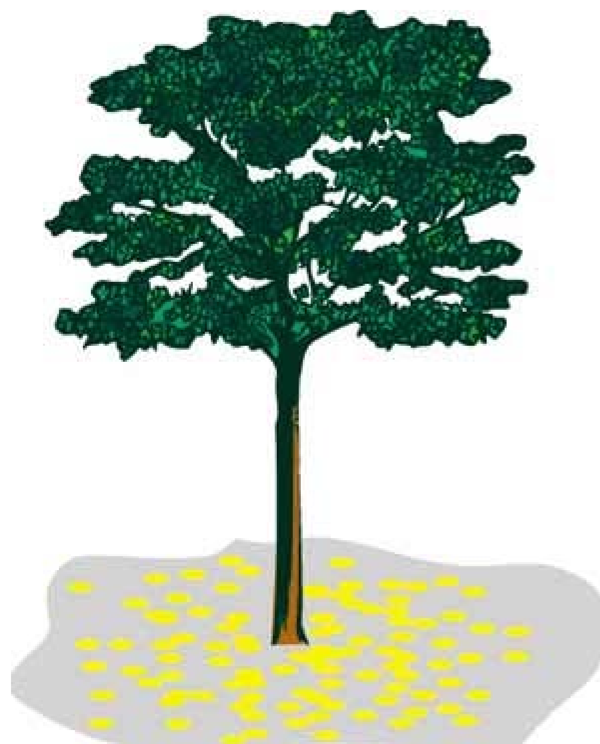
4. Knowing what you do about the structure of the blue feather, how do you suppose the water turned the feather dark?

Notes to the Teacher:

The students may figure out that the reason the water soluble red pigment of tropical rain forest birds does not wash out in the rain is due to several factors. First, the color is deeply impregnated into the feather. Second, since the bird gets its red pigment from the foods it eats, it maintains its color through its diet. Third, they should realize that water beads up on feathers-they were able to demonstrate this property of the feather to themselves. They may conclude that this is from natural oils that birds produce. What they may not know is that birds have an oil gland at the base of their tails and use their beaks to collect the oil and then, in their preening, spread it around to all the feathers of the body. This is why all birds are frequently seen reaching around to the base of their tails and then preening - they are spreading natural oils.

Grades 9-12 Demonstration: Sun Balls

This demonstration shows the principles of a pinhole camera without the necessity for film and the difficulties of developing. The leaves in the high canopy of the rain forest form small openings through which light can pass. These openings act as pinholes, projecting many images of the Sun onto the ground. If you wish, you can combine this demonstration with a pinhole camera activity, forming images on film or on a piece of wax paper at the end of a shoebox.



Materials:

White paper, lamp with incandescent light bulb, black paper, flashlight.

Procedure:

Part 1: Outdoors

1. Find an outdoor location with trees having leaves far off the ground. Make sure that there are spots of light on the ground caused by sunlight passing through the leaves.

2. Place white paper on the ground and observe the spots of light. While the spots of light will look as if they have random shapes on the rough ground, they will be circular on the flat paper. These circles of light are called sun balls. They are caused by the sunlight passing through small opening between leaves. The openings act like pinholes in a pinhole camera, such that they cause an image of the Sun to be projected onto the ground. (If you do this during a partial solar eclipse, you will see hundreds of images of the eclipse on the flat ground. This is a safe way to observe an eclipse.)

Part 2: Indoors

1. Reproduce the sun balls in the classroom by punching small holes in a piece of paper with a hole punch or other device. Make sure that you have both circular holes and holes of arbitrary shape.

2. Allow light from an incandescent light bulb to pass through the holes in the paper and be projected onto a wall. Demonstrate how the shape of the spot of light on the

wall changes as the paper with the holes is moved from a point near the wall to a point near the light bulb.

3. Punch a pinhole in a piece of black paper and wrap the paper over the end of a flashlight.

4. Project the light passing through the pinhole onto a wall in a darkened room. You will see an image of the filament of the flashlight light bulb on the wall.

Questions for Students:

1. The sun balls are produced by light passing through small openings between leaves. Why are the sun balls round regardless of the actual shape of the opening between the leaves?

2. In the classroom demonstration, the shape of the spot of light changes as the paper is moved between the wall and the light bulb. Why does this happen?

3. When you are in an airplane and it takes off in daylight, you can see the shadow of the airplane on the ground. The shadow has sharp edges. As the airplane climbs higher, the shadow becomes fuzzier on the edges. At some point, the shadow is very indistinct and appears to be a faintly dark circle moving across the ground that you may see only in your peripheral vision. As the airplane continues to climb, the shadow eventually disappears completely. Why does the shadow of the airplane behave in this way? Can you reproduce this behavior in your classroom?

Grades 9-12 Activities Overview – Part 3: Ecology and Diversity

As we consider the abundance and diversity of all species on our planet, we find that there is a dramatic increase in the diversity of species as we move farther from the poles and closer to the equator. Because the climate of the equatorial region is so conducive to the proliferation of living organisms, it is necessary for survival that a species evolve to compete by being very specific in its food and habitat requirements.

Where there are fewer life forms, species can survive better by being more general in their life requirements. Let us look at an example of this phenomenon. If a bee in search of nectar is living in a temperate region it is to the bee's advantage to be very general and accept the nectar from as many different flowers as it can locate. It is also to the flowering plant's advantage to accept many pollinators, such as bees, other insects, birds, etc. to ensure the likelihood of fertilization and the production of viable seed.

Toward the tropical regions of the world, where over 50% of the plant and animal species exist, the mere abundance of life places a selective force on the evolution of species yielding the exact opposite of this example. A bee in a tropical region must compete with many other bees for nectar and the flowering plants must compete with many other flowering plants for pollinators.

It therefore makes good survival sense to develop very specific life requirements to overcome the competing forces. We know of course, that it is the genetic code that yields to the constraints of the environment, allowing certain species and members of species to survive and therefore pass on their DNA to another generation. This results in the incredible diversity of species found in the tropical rain forest ecology.

Grades 9-12 Activity: Leaf Litter Ecosystem

In this activity you will construct a simple device known as a Berlese funnel. It is used to collect organisms living in leaf litter. An identification book will assist in the identification of the organisms found in the litter. This apparatus demonstrates the leaf dwelling organisms' requirement of a dark, moist place to live as they move away from the light and eventually fall into the alcohol and are preserved. More than insects (class Insecta) will be found in this litter. There may be spiders (class Arachnida), millipedes (class Diplopoda) and centipedes (class Chilopoda).

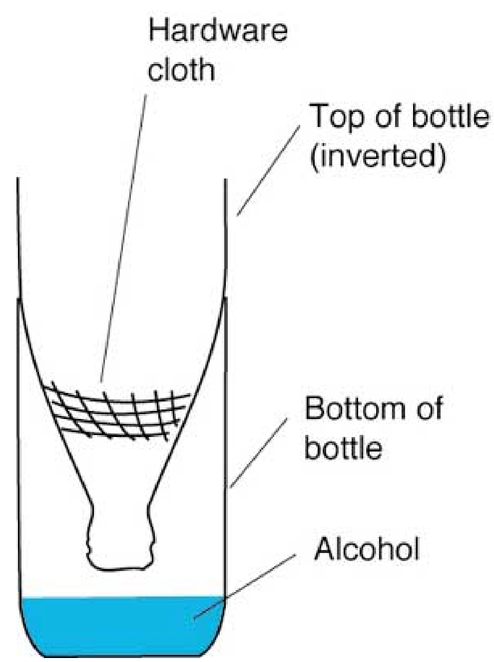
Materials:

Plastic beverage bottle (1 - 2 liter), razor blade, hardware cloth (from hardware store), isopropyl alcohol (from drug store or grocery store), leaf litter (from a vacant lot, school grounds or home garden), metal cutters (from hardware store), light source, such as a desk lamp, identification book for organisms in the phylum Arthropoda, sieve.

Procedure:

Part 1: Preparing the Berlese Funnel

1. Cut a beverage bottle in half with a razor blade. Hint: put a rubber band or tape around the bottle as a cutting guide.
2. Cut a piece of hardware cloth in the shape of a circle and bend the edge so that it fits snugly into the "shoulders" of the top of the bottle.
3. Place isopropyl alcohol in the bottom of the bottle to a depth of about one inch.
4. Place leaf litter on the hardware cloth and place the top of the bottle in the bottom of the bottle.
5. Place the apparatus under a light source. Organisms will collect over the next several days.



Part 2: Observing the Organisms

1. After a day or two, pour the contents of the bottom of the Berlese apparatus through a sieve to collect the organisms for identification.

2. List and sketch each of the organisms found in your Berlese funnel apparatus.

Questions for Students:

1. From where did you collect your leaf litter?

2. Compare the organism inventory you have to that of others in your class who collected from locations other than yours.

3. What vital role do these organisms play in the ecosystem as a whole?

Notes to the Teacher:

The students should understand that in order for organic materials to biodegrade, there must be organisms available to feed upon it and break it down to smaller and smaller components. They should realize that within the ecosystem there are many smaller ecosystems contributing to the balance of nature. The leaf litter ecosystem is such as example.

Changing the mesh size of the hardware cloth used will necessarily change the collection results in this experiment.

Grades 9-12 Activity: Plant Pigment Chromatography and the Absorption Spectrum for Chlorophyll

In this activity, you will be experimenting with a technique called chromatography, which will allow you to visually demonstrate that the pigment in leaves is a combination of several different colored pigments. This technique is useful in that it can separate and identify the various components of mixtures, such as those contained in plant pigments.

A pigment is a substance that absorbs light at specific wavelengths-chlorophyll in the leaf of a plant is one of these pigments. Its green-yellow color is due to the strong absorption of red, orange, blue, and violet wavelengths and the strong reflection of the green and yellow wavelengths. When white light (containing all of the light wavelengths, or the entire spectrum of colors) shines on the leaf surface, all of the wavelengths are absorbed except for the ones you see, the green and the yellow, which are those portions of the spectrum that are reflected.

Later in this activity, once you have extracted and identified various plant pigments using the chromatography method, you will examine data from an instrument called a spectrophotometer. This instrument can be used to measure the amount of light absorbed by a pigment. This is another method of identifying a substance-much like chromatography is used to identify substances by their physical separation on chromatography paper, the spectrophotometer identifies substances by the amount of light absorbed.

Materials:

Cone-type (size 4) coffee filter paper (or Whatman #1 chromatography paper), large glass jars (quart size), acetone (available from the paint department at a home supply store), distilled water, capillary tubes, fresh spinach, red Swiss chard (or red leaf lettuce; however, chard produces the better result), ivy leaves grown in direct sunlight, ivy leaves grown in shaded area, mortar and pestle, clean sand (available from a home supply store), a spectrophotometer (if you have one; however, it is not necessary, as printed data is provided).

Procedure:

Part 1: Plant Pigment Chromatography

Chromatography depends on the movement of liquid materials upward on a piece of absorptive paper. Figure 1 (below) shows the experimental apparatus. Liquid materials from the pool of liquid at the bottom of the jar will move upward on the absorptive paper strips hanging from the top of the jar.

In this first part of your investigation of plant pigments, you will observe an effect of solubility as materials move upward on your developing chromatogram. There are several forces at work on the liquid as it moves up-the paper in this experiment.

There are propelling forces, due to solubility and solvent flow, and retarding forces, due to cohesion between the water absorbed in the paper and water moving up-ward past it. In addition, gravity pulls downward on the water.

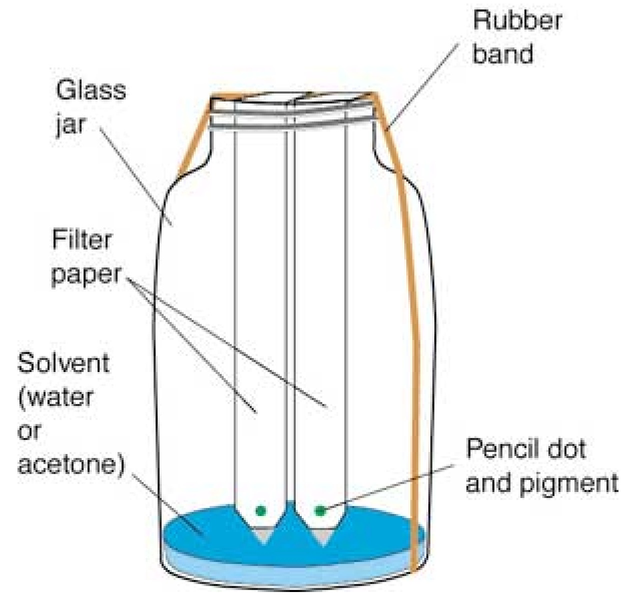


Figure 1. The experimental apparatus for analysis by chromatography.

If the conditions are identical, the relative distance moved on the paper by a particular compound is the same from one mixture to another. This is why chromatography can be used to identify a compound. The actual identification requires a simple calculation of a variable, Rf, called a reference front, as shown below:

$$R_f = \frac{\text{distance moved by compound from original spot}}{\text{distance moved by solvent from original spot}}$$

It is important to remember that several factors can influence the reliability of the Rf value. These include humidity, temperature, solvent, pigment extract preparation, and the amounts of the material present. Values are comparable only when the extracts are prepared in the same way and the chromatograms are prepared identically and developed together in the same jar.

Precautions: Acetone is flammable-keep it away from sparks or open flames. Wear eye protection.

Preparation of plant pigment extract:

1. Each lab group (or individual if not working in groups) will need four strips of filter paper, approximately 15 cm long and 2.5 cm wide, two large glass jars, acetone (enough to cover the bottom of one of the jars about 1 cm deep), distilled water (enough to cover the bottom of one of the jars about 1 cm deep), a couple of leaves of spinach, and a leaf of red Swiss chard. Place the acetone and the water in the

2. respective jars and label the jars according to the solvent.

3. Place the spinach leaves in a petri dish or other glass container and pour some acetone over the leaves. Stir and let stand for a few minutes until the acetone is darkly colored. Decant the extract into a small glass container.

4. Repeat the above procedure with the Swiss chard.

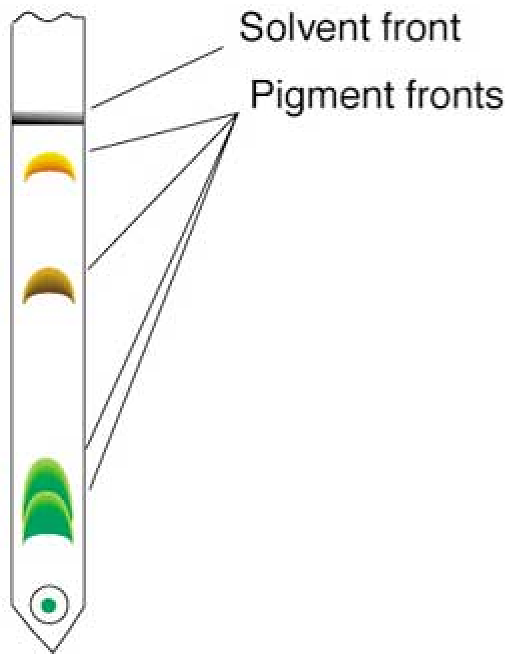


Figure 2. The appearance of the chromatogram.

Preparation of chromatograms:

1. Cut each piece of filter paper into a point, using a pencil, make a dot on each strip of filter paper and write "green leaf" on two strips and "red leaf" on the other two strips.

2. Using a capillary tube, dab spinach extract on the pencil dots of two of the strips of filter paper. Several applications will be required and a little drying time is required between each application. A toothpick will work in place of a capillary tube.

3. Repeat the above process with the red Swiss chard.

4. Place a spinach and a chard chromatogram in each glass jar as in Figure 1.

5. Wait approximately 30 minutes as the chromatograms develop, then compare results with a sample chromatogram in Figure 2. Measure the movement of each pigment. Measurements should be made in mm. Calculate the value of Rf for each pigment.

Questions for Students:

1. Which pigments were soluble in water?

2. Which pigments were soluble in acetone?

3. Which pigments were found in both red and green leaves?

4. With what you have discovered about pigments, what conclusions can you make regarding the changing color of leaves in autumn?

Part 2: Comparison of Pigment Amounts Due to Light

In part 2 of this activity, you will have the opportunity to compare pigment amounts. To do this, it is necessary to prepare plant pigment extracts with equal amounts of plant material in equal amounts of acetone. Use 3 grams of ivy leaf material in 10 ml acetone. Because ivy leaves are tough, they need to be ground in a mortar with clean sand and acetone. Two chromatograms will be made this time.

1. Place 3 grams of full-sunlight ivy leaves in a mortar, sprinkle a little sand over the leaves and grind with a pestle while slowly adding the 10 mL acetone. Let the solution settle and remove any small particles.

2. Repeat the above process with the same amount of shade-grown ivy leaf material.

3. Write "light" on one strip of filter paper, and "shade" on the other.

4. Use the same technique for placing extract on the paper strips as you used in part 1 of this activity.

5. Place both chromatograms in a developing tank with acetone and allow to develop for about 30 minutes.

Questions for Students:

1. Do the leaves grown in different amounts of light have the same kinds of chlorophyll? How can you determine this?

2. Do the leaves grown in light and grown in shade have the same amounts of each pigment? How can you determine this?

Part 3: Absorption Spectrum for Chlorophyll

Now that you have identified plant pigments using the chromatography technique, we will consider another very common and equally useful laboratory technique to identify compounds. This technique involves the use of an instrument called a spectrophotometer. If your laboratory has a spectrophotometer, you can generate your own data by pouring your plant pigment extract in the cuvet and reading the absorption values. If you do not have access to a spectrophotometer, you may use the printed absorption data shown in Figure 3.

Questions for Students:

1. As you read the graph of the absorption spectrum for chlorophyll, which of the colors in the visible spectrum is seen the least when looking at reflected light from a green leaf?

2. What is the approximate wavelength of the color you identified in question 1?

3. What percent of light energy absorbed corresponds to the peak of the color you identified in question 1?

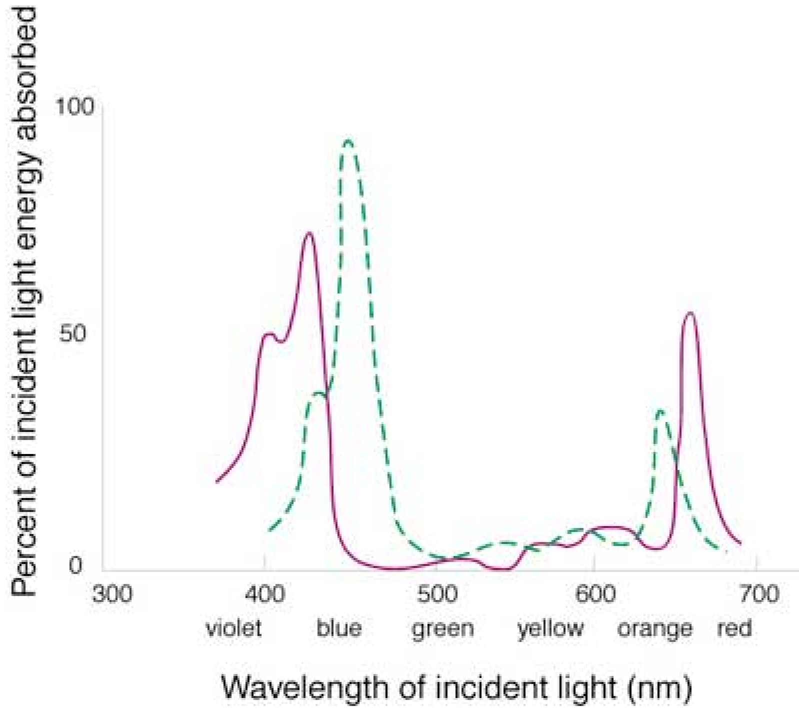


Figure 3. An absorption spectrum for chlorophyll from a spectrophotometer.

4. How much of the color you identified in question 1 is being reflected?

5. What percent of light energy absorbed by chlorophyll b does the orange spectrum peak represent?

6. Why are there no peaks in the range between 500 nm and 610 nm?

7. Are you able to see the light in the green-yellow portion of the spectrum? If so, how is this possible?

8. Arrange the colors in the absorption spectrum of chlorophyll a and b in order of their visibility. Place the most visible color first.

The bar graph in Figure 4 presents the opposite data compared to that presented in the previous graph. This graph shows the percentage of *reflection*, as opposed to *absorption.*

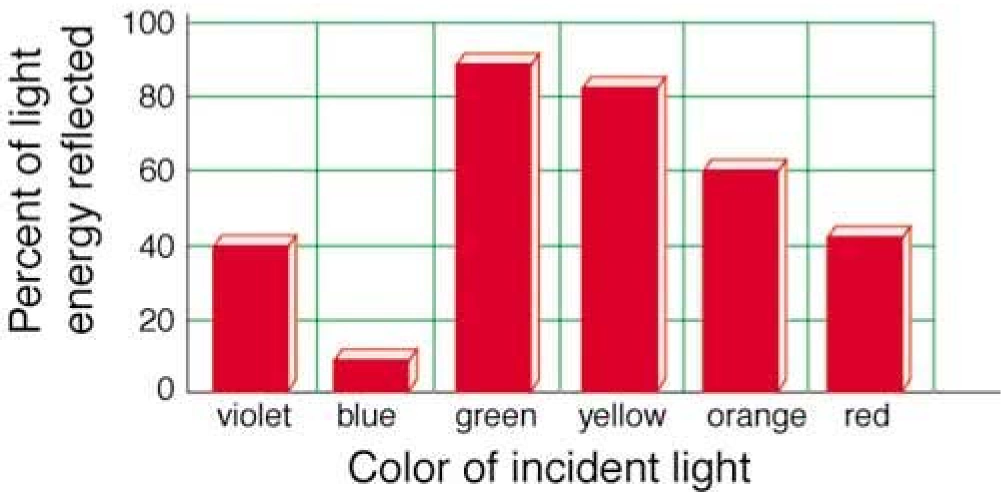


Figure 4. Percentage of light reflected for visible colors incident on chlorophyll.

1. Referring to Figure 4, which color in this spectrum is most visible in the light reflected from a green leaf?

2. What is the approximate percentage of the light energy reflected for the color you just named?

3. What percentage of light energy absorbed by the color you just named does this represent?

4. If everything above 50% of light energy reflected is visible to the human, is red light part of the mixture of colors seen in light reflected by chlorophyll?

Notes to the Teacher:

When using the acetone solvent, keep in mind the following precaution: **Acetone is flammable-keep it away from sparks or open flames. Wear eye protection.**

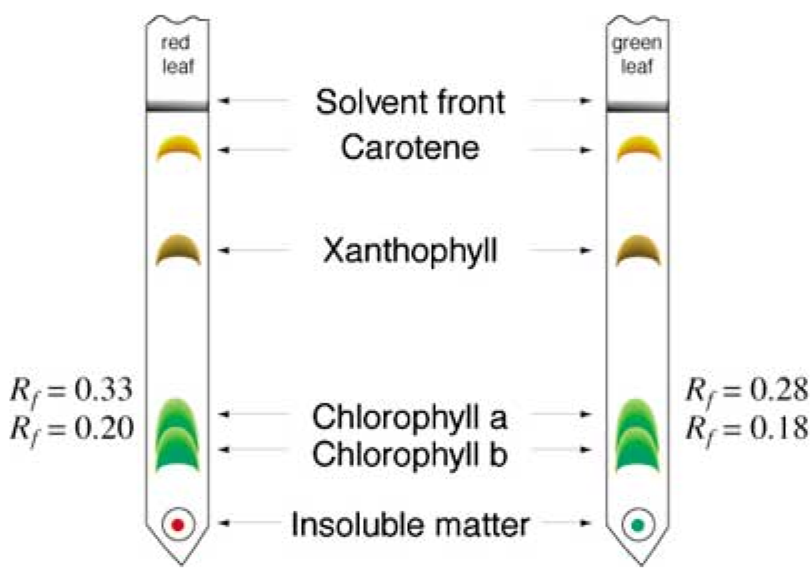


Figure 5. Chromatograms for red and green leaf samples in acetone.

In Part 1, the extracts can be made a day ahead of time, kept in the refrigerator, and then developed the next day.

In Part 1, the red and green leaf chromatograms in acetone should differ as shown in Figure 5.

The red and green leaf chromatograms in water should look like Figure 6.

The full-sunlight and shade-grown ivy chromatograms in acetone should look like Figure 7.

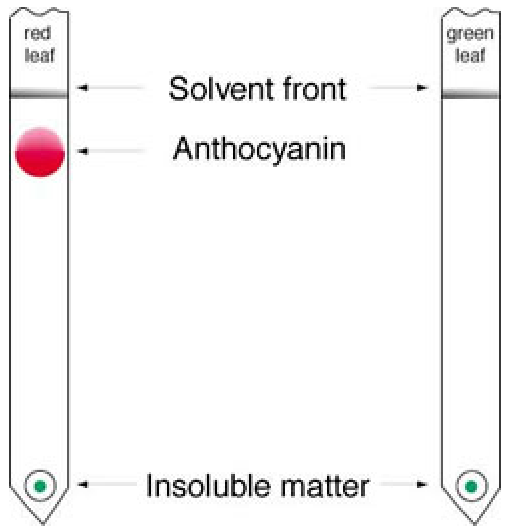


Figure 6. Chromatograms for red and green leaf samples in water.

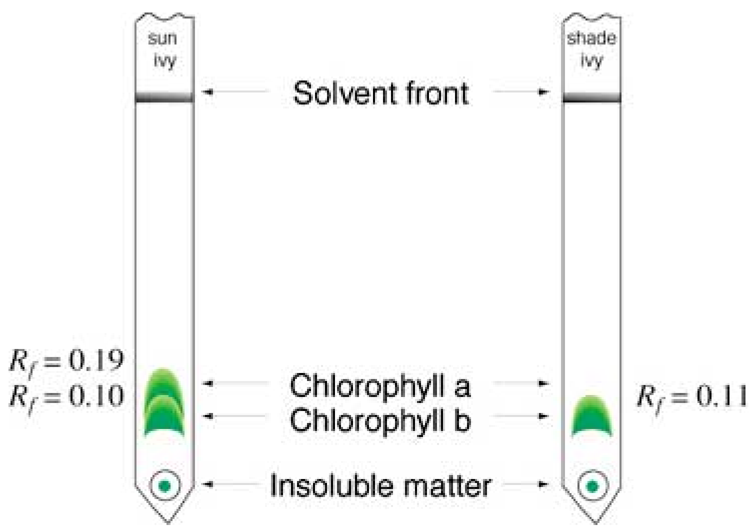


Figure 7. Chromatograms for full-sunlight and shade-grown ivy samples in acetone.

Grades 9-12 Activity: Extracting DNA from Wheat Germ

This activity will allow you to extract DNA (deoxyribonucleic acid) from the cells of wheat germ. While this method is not sophisticated enough to release the DNA from the nuclei of the cells, it will make it possible to extract the cytoplasmic DNA.

Materials:

Wheat germ, unseasoned powdered meat tenderizer, water, 91% isopropyl alcohol, glass flask or beaker (250 mL to 400 mL size), hot plate, teaspoon, glass stirring rod

Procedure:

Part 1: Preparing for Extraction

Place one heaping teaspoon of wheat germ in a glass container suitable for boiling water. Add 70 mL of water (tap water is adequate). Swirl or stir the wheat germ in the water until it is well mixed. Add a generous 1/4 to 1/3 teaspoon of powdered meat tenderizer and swirl until it is well incorporated into the solution.
Heat until the solution just begins to boil. Remove from the hot plate and allow to cool for 5 to 10 minutes.

Part 2: Extraction

Double the volume of your solution by adding 91% isopropyl alcohol. Let the solution stand undisturbed. After a few seconds you will see a white precipitate appear. As it begins to collect at the top of the solution it can be gently swirled onto a glass stirring rod. The precipitate is composed of long strands of cytoplasmic DNA.

Questions for Students:

1. What purpose does the heating serve in the extraction of the DNA from the cells of the wheat germ?

2. What was the purpose of using the meat tenderizer? Hint: think about what it means to "tenderize" meat and how that process works.

3. Describe what you observed as the DNA precipitated out of solution.

Notes to the Teacher:

Caution the students to be very careful working with the hot plate and the heated glassware. Allow the precipitate to begin to form before attempting to swirl in onto a glass stirring rod or the strands will easily break apart.

You may have to give the students some background information on meat tenderizers before they come to the conclusion that the tenderizer contains an enzyme that breaks down the cell wall. Students may also not know that wheat germ is the highly nutritious embryo of the wheat kernel.

Grades 9-12 Demonstration: Light and Diversity

Organisms have extremely diverse methods for detecting their environment and navigating through the environment. As humans, we are used to the advantages of complex sight organs (eyes) that allow us to study our environment in great detail. On the other hand, although we have well-developed sound organs also (ears), we cannot hear sounds as high in frequency as a dog can detect.

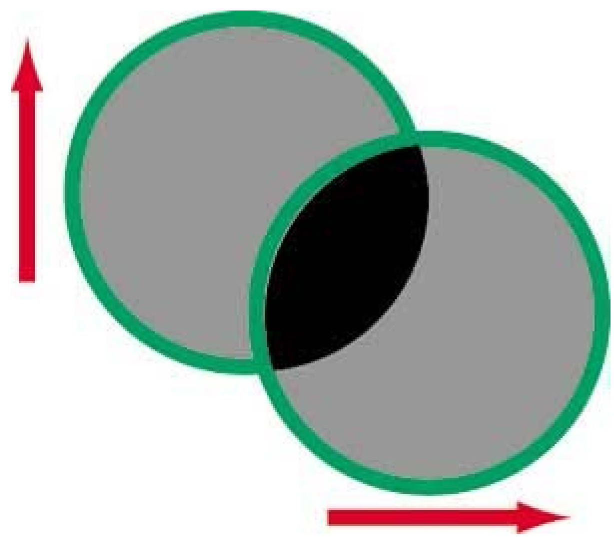
Some organisms can detect their environment using light in ways that humans cannot. In this demonstration, we will explore two of these ways.

Materials:

Two large polarizing filters (polarizers), overhead projector, Karo syrup, plastic glass, several small polarizers, glass plates.

Procedure:

Part 1: Polarization



1. Place the two polarizers on the stage of an overhead projector.
2. Rotate one polarizer with respect to the other and show students the results on the projection screen.
3. Place one polarizer on the stage of an overhead projector.
4. Place a plastic glass with Karo syrup on top of this polarizer.
5. Hold the second polarizer above the glass and observe the effect on the projection screen as the second polarizer is rotated. The Karo syrup will appear to change in color as the polarizer is rotated.
6. Discuss with students the optical activity of the sugar molecules, causing the polarization of light of different colors to rotate through different angles.
7. Take students outdoors and have them locate a point in the sky 90° from the direction to the Sun. Have them hold a polarizer between their eyes and this point.

As they rotate the polarizer, they will see this region of the sky change from bright to dark.

8. Discuss with students the origin of polarized light from the sky. Discuss with students the use of polarized light by bees for navigation.

Part 2: Infrared Radiation

1. Have students close their eyes and face toward the Sun. Be sure that they notice the sensation of warmth on their eyelids.

2. Now have them place a glass plate in front of their eyes, keeping their eyes closed. The sensation of warmth should reduce significantly, due to the filtering out of infrared radiation by the glass.

3. Inform students that they can do the same activity with radiation from a fire in a fireplace, using ordinary prescription glasses as the filter.

4. Discuss organisms that use infrared radiation for detection of the environment, such as the bushmaster, a pit viper found in the South American rain forest, and the American cockroach, found in our kitchens.

Grades 9-12 Activities Overview – Part 4: The Rain Forest as an Economical Resource

It is uncommon to think of a natural environment as an economic resource. We tend to view economics in terms of goods and services from urban areas or from agricultural regions-locations highly developed by mankind.

For this reason, natural areas are often seen as expendable and as having no real economic value. This type of thinking results in damage to the natural environment because habitat is destroyed to build structures or provide grazing land for livestock. If, however, regions such as the tropical rain forests of the world can be seen as having an economic value, without altering their natural state, the likelihood of preserving these regions is greatly enhanced.

To accomplish this, harvestable and renewable natural products need to be brought to the public's attention. Many products such as Brazil nuts, spices, and latex from rubber tree plants are good examples of renewable resources that come from the tropical rain forests and provide income for native peoples.

Grades 9-12 Activity: What is an Antioxidant?

This activity allows you to witness the action of some antioxidants. You are probably familiar with this term through the popular media and have heard that consuming foods rich in antioxidants can help to prevent cancer. As we know, many of the drugs we use to combat cancer come from the tropical rain forests. While we cannot experiment with these drugs in the classroom, we can learn about the contributions of certain compounds in preventing cancer. Many of the foods we enjoy that contain these compounds (those high in vitamins A, C, and E) come from the tropical regions of the world.

Materials:

Vitamin A, C, and E tablets (500 mg), water, plastic picnic plates, plastic cups, plastic sandwich bags, plastic spoons, any hard object suitable for crushing vitamin tablets, fresh, sliced fruit, such as peaches, apples, bananas.

Procedure:

Part 1: Preparing the Vitamin Tablets

1. Place a vitamin A tablet, a vitamin C tablet, and a vitamin E caplet in separate sandwich bags.

2. Crush each one with a hard object such as the bottom of a coffee mug or a hammer.

3. Place each of the crushed vitamins in a cup of water and stir until dissolved.

Part 2: Testing the Antioxidant Property

1. Place samples of freshly sliced fruit in separate plates; each type of fruit should be placed in two separate dishes.

2. Over one sample of each fruit, spoon regular tap water. Over the other samples of each fruit, spoon vitamin A, C, or E solution. If you have enough fruit slices available, separately subject each fruit sample to each vitamin solution.

3. Wait approximately 30 minutes.

Questions for Students:

1. How do the sliced fruits subjected to water compare to the sliced fruits subjected to the vitamin solutions?

2. How would you describe what oxidized fruit looks like?

3. Why do you suppose that cooks pour lemon juice over certain fruits such as apples when preparing a pie?

4. By performing Internet research or library research, determine the role antioxidants play in maintaining good health.

Notes to the Teacher:

To keep fruit from browning too soon, have the students carefully slice the fruit themselves (use plastic picnic knives). Students should see this browning of the fruit as cellular damage.

The result of the students' Internet or library research on antioxidants should contain information that includes much of the following:

- antioxidants are available to us in the foods we eat and are certain vitamins and minerals;
- antioxidants enable cells to combat "free radicals";
- the modern diet which is based on fast-foods and too few fresh fruits and vegetables, as well as grains grown in leached soil, means that most people do not consume enough antioxidants to fight off free radicals;
- free radicals are oxygen atoms that have been ionized and, therefore, chemically attack various parts of cells causing damage and the invasion of disease;
- free radicals are involved in over 200 diseases;
- antioxidants help cells defend themselves by creating a chemical barrier to the attack of free radicals.

Grades 9-12 Activity: Natural Antibiotics

The native peoples of the Earth's tropical rain forests have long made use of plants as a source of medicines. In this activity, you will compare the effectiveness of natural antibiotics with other types of antibiotics. It is interesting to note that the first medical schools always maintained a botanical garden as a source of plants suitable for making medicines. While it may be difficult for you to obtain plants from the tropical rain forest with which to experiment, you can obtain locally available products that are natural antibiotics.

Materials:

Commercially prepared or homemade agar media, petri dishes or clear plastic sandwich boxes, hot plate, flask suitable for boiling, natural antibiotics (cranberry, garlic, Echinacea purpurea), paper disks, forceps, Knox gelatin.

Procedure:

Part 1: Preparing to Culture Bacteria

1. Obtain a petri dish with agar. If you prefer, you can make your own agar as follows:
2. Boil some rice or potatoes in a dish until well cooked.
3. Drain and save the water.
4. Make a sample of Knox gelatin, replacing the water called for in the directions with your water from the boiling of rice or potatoes.
5. Add a pinch of salt and a little beef broth or a bouillon cube (if the beef broth or the bouillon cube contain salt, omit the pinch of salt) to the gelatin.
6. Use the petri dish or the plastic sandwich boxes as described below.
7. Pour enough of the hot gelatin mixture into each dish to cover the bottom to a depth of 3 or 4 mm.
8. Quickly replace the covers and let the dishes stand until the gelatin has hardened.

If you do not have petri dishes, try clear plastic sandwich boxes (used for take-out food) available at restaurant supply stores like Smart and Final or Costco. Once the agar is poured and solidified, the agar plates can be stored upside down in the refrigerator for several days until they are used.

Part 2: Obtaining Bacteria

1. Using a clean cotton swab (directly from the package), swab the inside cheek and tongue surfaces of your mouth.

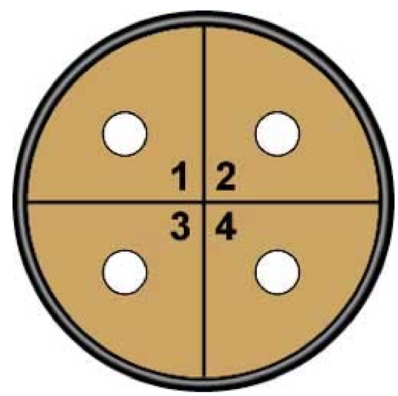
2. Slightly lift the lid of your petri dish (or substitute container) and gently, without piercing the agar, streak your plate by zigzagging back and forth on the agar with your swab.

3. Replace the lid of your dish.

4. Take a glass marker (such as a Sharpie pen) and on the outside bottom of your container with the agar, draw a line through the middle vertically and then horizontally so that you now have four equal quarter-circle sections.

5. Near where the lines intersect, number the sections, 1, 2, 3, and 4.

Part 3: Obtaining the Natural Antibiotic



1. Using a hole punch, make several punches of clean, white paper to form paper disks a few millimeters in diameter.

2. Obtain a garlic clove and mash it until liquid runs out of it.

3. Using forceps, soak a paper disk in the liquid.

4. Remove the disk with your forceps and wave it in the air to dry slightly.

5. Now place this disk on the surface of the agar at the center of one of your four spaces. (Do not break the surface of the agar with your disk.) Replace the lid.

6. Record the section number for the garlic.

7. Obtain a cranberry tablet or some pure cranberry juice (available at health food stores). If you have a tablet, crush it and combine with 25 mL of water. Do the same with an *Echinacea purpurea tablet* (also available from the health food store).

8. Soak a paper disk in each of these solutions and then place the cranberry disk in one of the four spaces on the agar and the *Echinacea purpurea disk* in another space.

9. Record the section number for each of these substances.

10. Place a disk with nothing on it on the remaining agar space.

11. Close the lid and place the dish in a warm location, out of direct sunlight for 48 hours to incubate.

Part 4: Comparing to Other Antibiotics

Repeat the process above with three disks pre-impregnated with different antibiotic drugs. Again, have one section of your agar reserved for a disk with no antibiotic on it.

Questions for Students:

1. What was the purpose of the paper disks with nothing on them?

2. Make a drawing of both dishes (the one with natural antibiotics and the one with the commercially prepared antibiotics). Use a colored pencil to show where the bacteria have grown.

3. Do you notice any clear zones surrounding any of the disks in either dish? If so these are called zones of inhibition. These zones are areas where the antibiotic was effective.

4. Summarize the results of the effectiveness of the natural and commercially prepared antibiotics.

5. How do tests like these help to protect the public health and the consumer?

Notes to the Teacher:

Pre-impregnated antibiotic disks are available from Carolina Biological Supply (800) 227-1150. Using strict sterile techniques is *not* absolutely necessary in this activity. It is, however, an opportunity for students to learn and practice these techniques if you have he equipment available. For instance: Keep a Bunsen burner on in the vicinity of each lab station (caution the students to be careful around the flame), flame the forceps, and autoclave the paper disks (wrap in aluminum foil). If you do not have an autoclave, use a pressure cooker (15 lbs for 15 minutes). Pre-poured agar plates, or petri dishes and commercial agar can be purchased from Carolina Biological Supply (800) 227-1150.

Stores such as Wal-Mart (if you do not have a health food store in your area) also carry natural antibiotic products like *Echinacea purpurea* (purple corn flower) and cranberry tablets.

Grades 9-12 Activity: Chemical Indicators from Plants

In this activity, you will make your own chemical indicator solutions and test papers using plant materials. Chemical indicators are useful for determining which chemical substances are acids or bases. They do this by changing color. When the chemical indicator mixes with the test solution, it undergoes a chemical reaction with the test solution and changes color. The indicator will change to one color in the presence of an acid and to another color in the presence of a basic solution.

Materials:

Violet blossoms, elderberries, red cabbage, goldenrod photocopy paper, water, glass jars, beakers or drinking glasses, strainer, commercially available pH paper (optional).

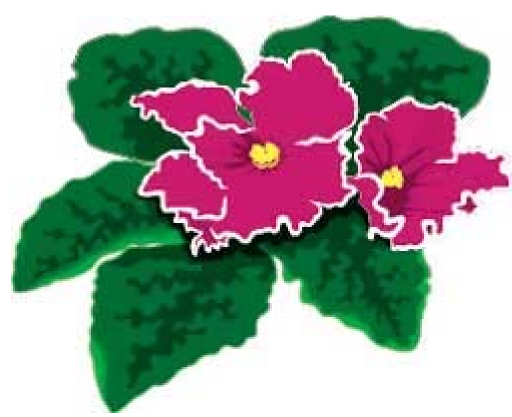
Procedure:

Part 1: Preparing Indicator Test Paper from Goldenrod Photocopy Paper

Cut small strips of this paper and dip in test solutions. When it comes in contact with basic solutions (or alkalies) it turns from a golden color to red.

Part 2: Preparing Indicator Test Solution from Red Cabbage

1. Place a few red cabbage leaves broken into small pieces in water in a glass container over night. The resulting solution will be a clear purple color.
2. Strain the cabbage leaf pieces out. The solution turns green in bases and red in acids.



Part 3: Preparing Indicator Test Solution from Elderberries

Crush a few elderberries and strain the juice. This juice turns greenish-blue when it comes in contact with a basic solution and red when it comes in contact with acids.

Part 4: Preparing Indicator Test Paper from Elderberry Solution

Soak small strips of white paper in elderberry juice and allow the paper to dry. You will have test paper that turns greenish-blue when it comes in contact with a basic solution and red when it comes in contact with acids.

Part 5: Preparing Indicator Test Solution from Violets

1. Cut two dozen violet blossoms into tiny pieces.

2. Place these pieces in a container of hot water. After a short while you will have a greenish-blue solution. This solution turns green in bases and red in acids.

Part 6: Preparing Indicator Test Paper from Violet Solution

Soak small strips of white paper in the violet solution and allow the paper to dry. You will have test paper which turns green when it comes in contact with a basic solution and red when it comes in contact with acids.

Under your instructor's direction, you will use one or more of the indicator papers or solutions to test various liquids to determine whether they are acids or bases. Carefully record your results.

1. Place a small amount of milk in a clear container and test to see if it is an acid or a base, using one of the indicator papers or solutions.

2. Record your result.

3. Now leave a sample of milk (a small amount will suffice) in an open container out on a counter until tomorrow.

4. Using one of the indicator papers or solutions, test to see whether the milk that was left out for 24 hours is a base or an acid.

5. Compare the results to the test you did on the milk 24 hours earlier. Did your results differ after 24 hours? If so, why? Smelling the milk that was left out for 24 hours may give you a clue.

6. If possible, obtain some commercially available pH paper. Use it to discover which test solutions are acids or bases.

7. Compare the accuracy of your "home made" indicators with the commercial pH paper.

Questions for Students:

1. If you had access to commercially prepared pH paper, how did the accuracy of your indicators compare?

2. What was your result when you tested the fresh milk?

3. What was your result when you tested the milk that was left out for 24 hours?

4. How can you account for the difference in your results between the fresh milk and the milk that was left out for 24 hours? Hint: smell the milk that was left out for 24 hours.

5. What industries would use tests concerning acids and bases?

Notes to the Teacher:

Making test strips from goldenrod photocopy paper is very simple, providing you have the correct paper that has actually been colored with goldenrod flower extract. The paper of this type is usually deeper in color than the brands of paper that do not use the actual flower extract. If the paper you normally have at your school site does not turn red when exposed to a base (such as a simple soap solution), obtain Wausau brand goldenrod paper that works well. You can obtain this paper through Nationwide Papers (800) 835-5469.

Grades 9-12 Demonstration: Products from the Rain Forest

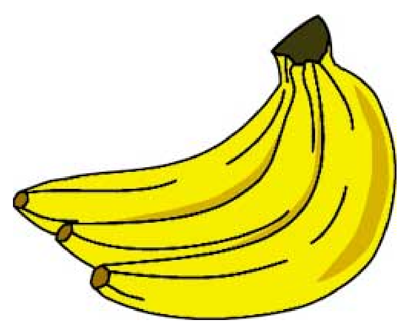
Gather examples of tropical rain forest products such as: Brazil nuts, vanilla beans, cinnamon, piece of teak wood (or something made from teak wood), coconut, coconut product (like a bag of shredded coconut), a can or bottle of tropical fruit drink, a piece of elephant ivory (like an old piece of jewelry or beads), a piece of sea turtle shell jewelry (or a plastic simulated example), tagua nut (or something carved from a tagua nut), potted or canned beef from Argentina, pictures of tropical iguanas and parrots (unless you have real specimens), cocoa powder or any chocolate product, and bananas.

There are many more examples, but these are a good start and most are readily available.

Discussion with Students:

Purchasing sustainable products that come from the tropical rain forests of the world helps to save these regions from destruction as it supports the local economy. Ask the students which products they think are renewable and non-renewable.

When showing them the teak wood, let them know that there are now managed forests for harvesting teak and that they should look for label or packaging information of that type when they buy such things as furniture to see if the wood was harvested from a managed forest where trees are replaced.



As for the tagua seed, it also called "green ivory". It is the very hard seed of the ivory nut palm (*phytelephas* which means "ivory plant") that grows in the tropical rain forests of Central and South America. The native people eat the fruit before it hardens and use the hard fruits to create beautiful carvings (a replacement for ivory).

There are several Internet sites that show these carvings and offer them for sale (search under tagua). The potted or canned beef from Argentina shows an example of clearing tropical rain forest vegetation to create grazing land for cattle to support the increasing demand for this product as people worldwide tend more and more toward meat-centered diets.