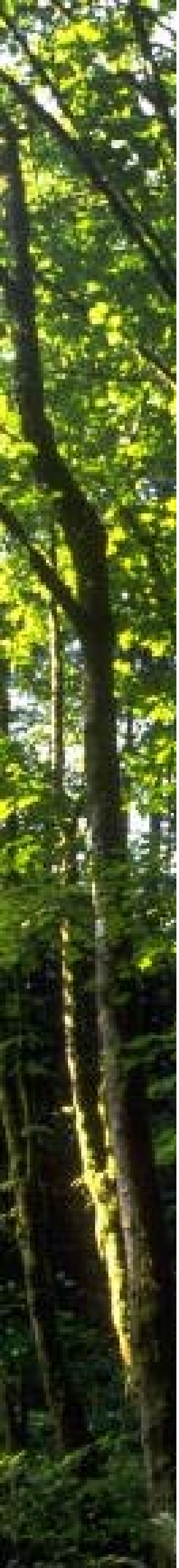


RAIN FOREST TEACHING CURRICULUM

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.

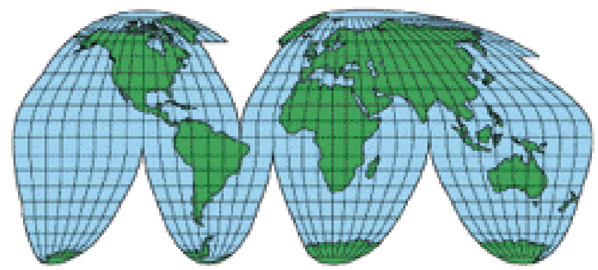
This workbook is brought to you through a partnership between:

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.

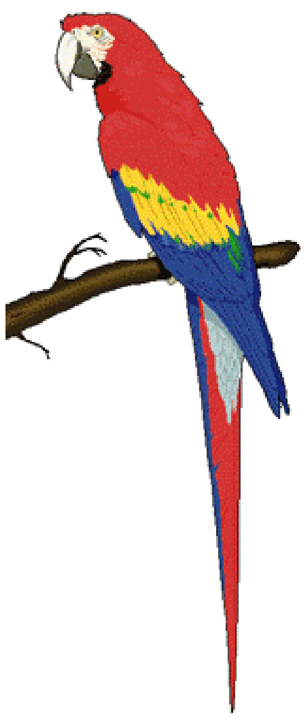
Where are tropical rain forests located?

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 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.

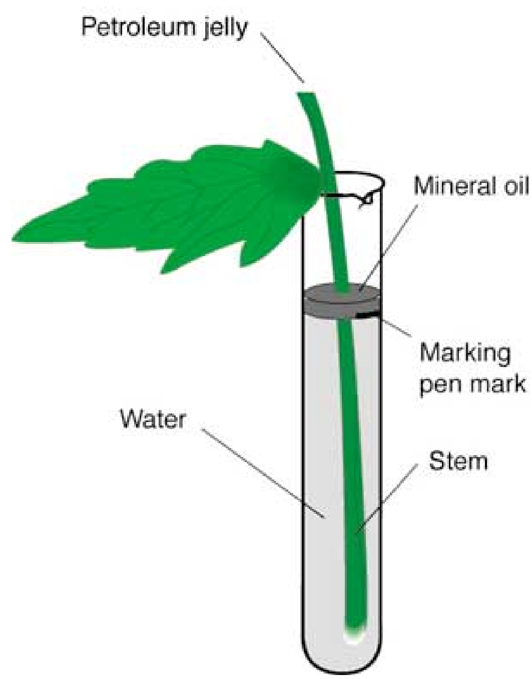
Grades 9-12 Activity: Transpiration in Plants

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.

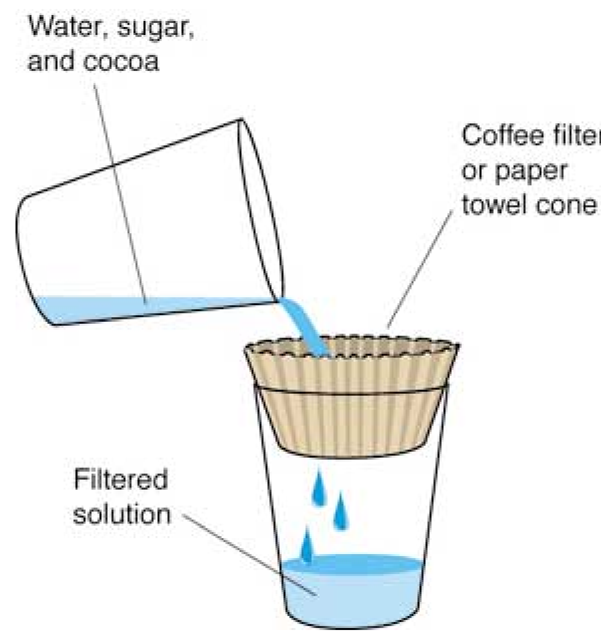
Grades 9-12 Activity: Filtering Mechanisms in Nature

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.

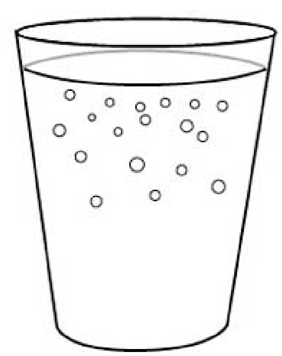
Materials:

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

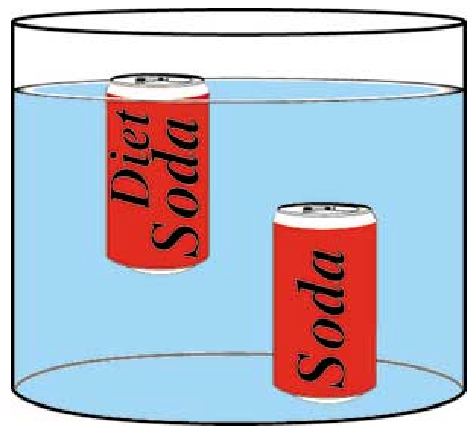
This demonstration can be performed in connection with the previous activity on raisins and carbon dioxide. It also addresses the concept of floating and sinking.

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

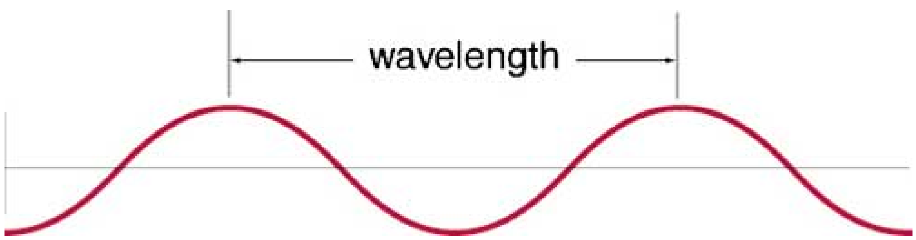
1. Prepare two plastic bottles beforehand.
2. Fill one with water and screw on the top.
3. Fill the other with rubbing alcohol and screw on the top.
4. Before presenting to the class, make sure that the water bottle sinks and the alcohol bottle floats.
5. Present the two bottles to the class. They will 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}

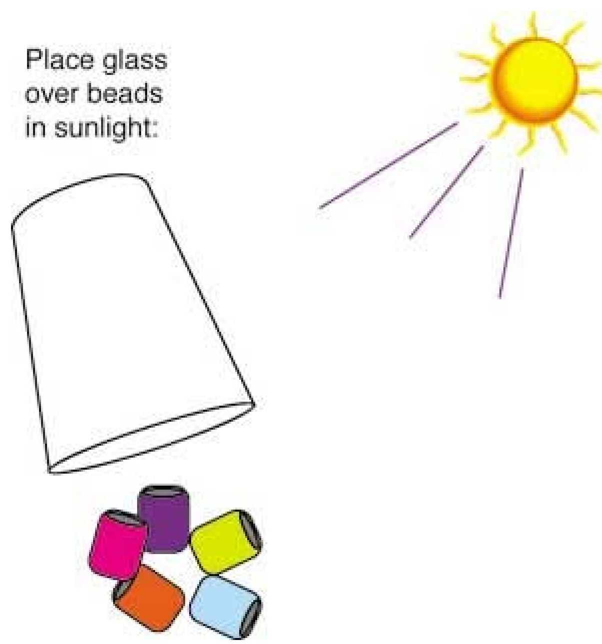
Grades 9-12 Activity: Ultraviolet Radiation

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?

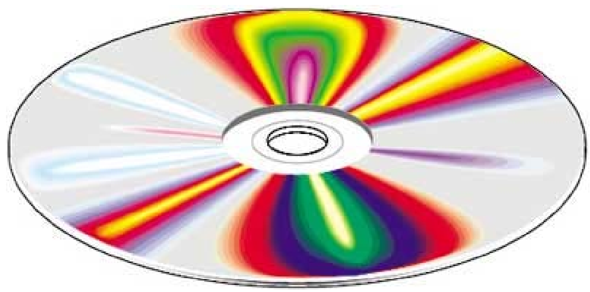
Notes to the Teacher:

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?

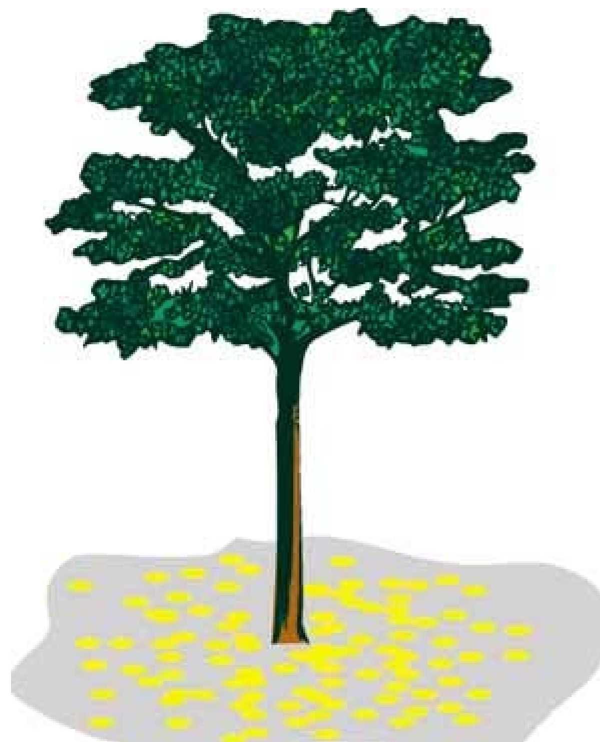
4. Knowing what you do about the structure of the blue feather, how do you suppose the water turned the feather dark?

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

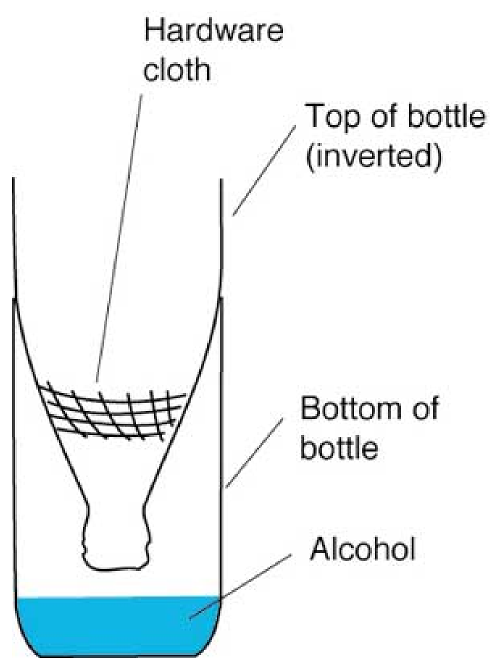
1. Cut a beverage bottle in half with a razor blade. Hint: put a rubber band or tape around the bottle as a cutting guide.

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.

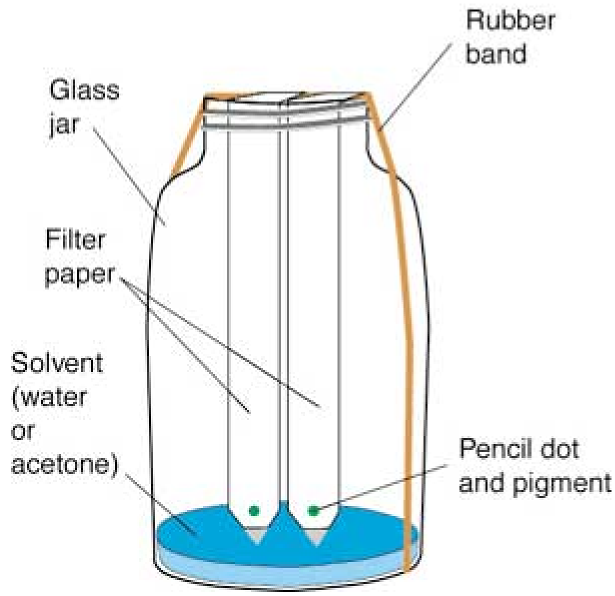


Figure 1. The experimental apparatus for analysis by chromatography.

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.

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.

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.

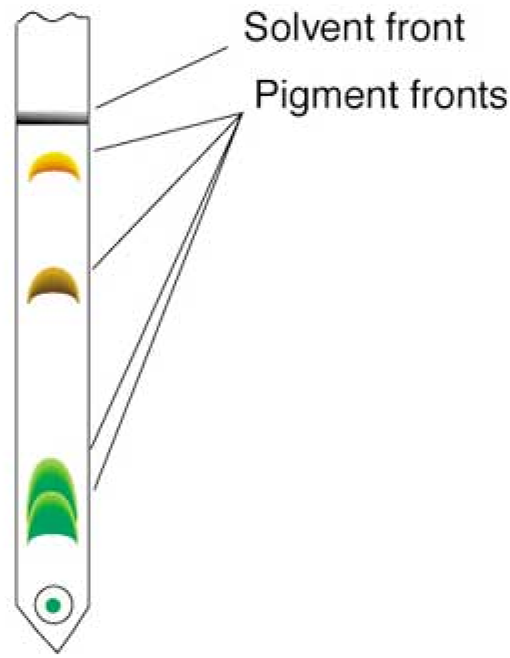


Figure 2. The appearance of the chromatogram.

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?

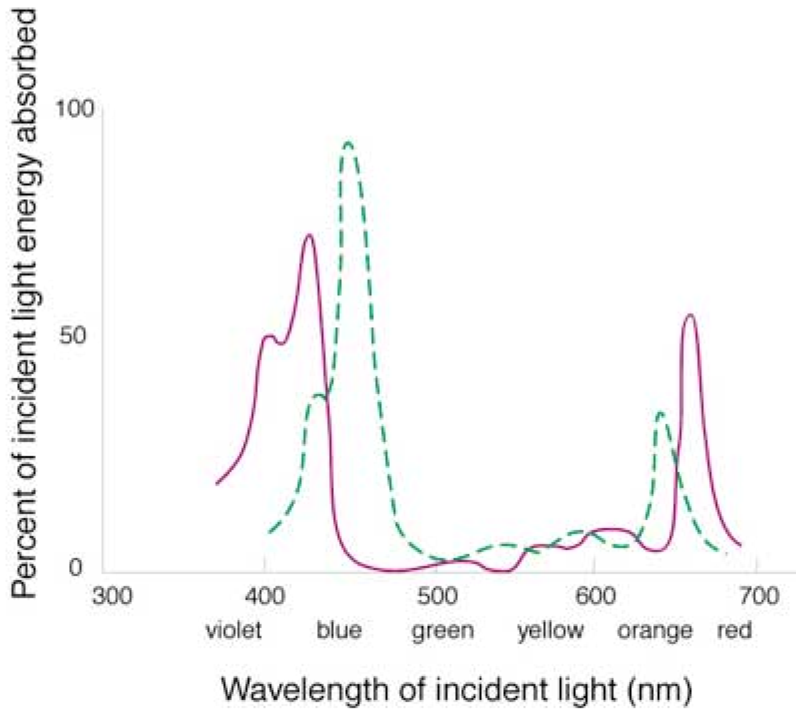


Figure 3. An absorption spectrum for chlorophyll from a spectrophotometer.

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.*

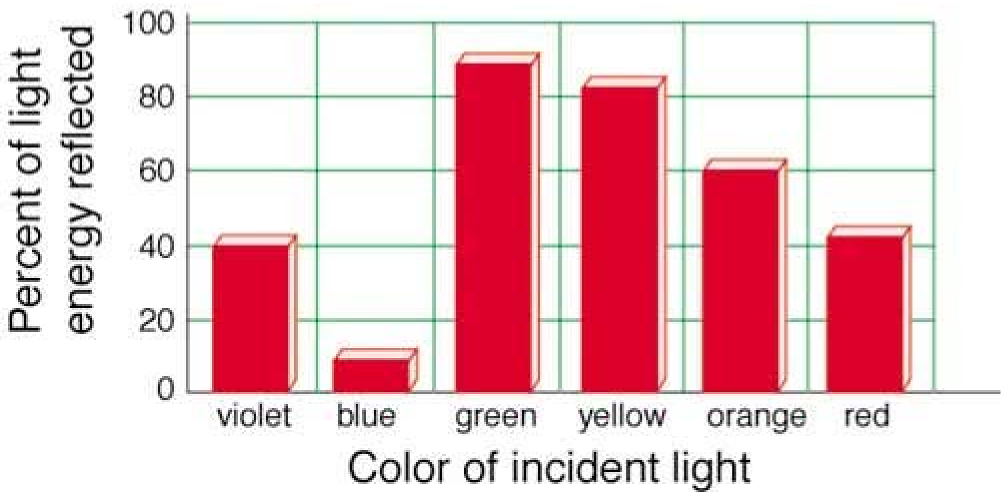


Figure 4. Percentage of light reflected for visible colors incident on chlorophyll.

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.**

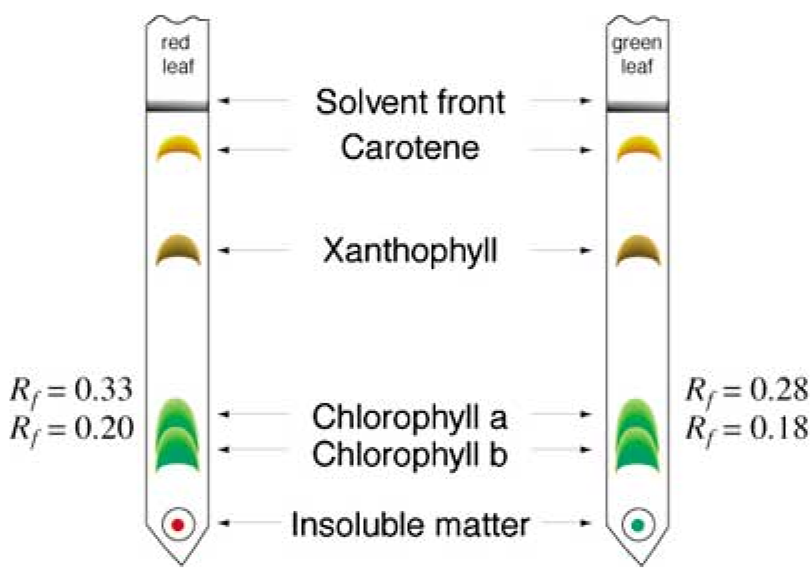


Figure 5. Chromatograms for red and green leaf samples in acetone.

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.

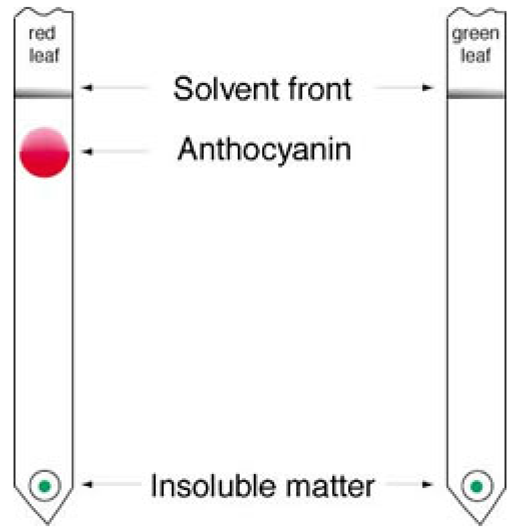


Figure 6. Chromatograms for red and green leaf samples in water.

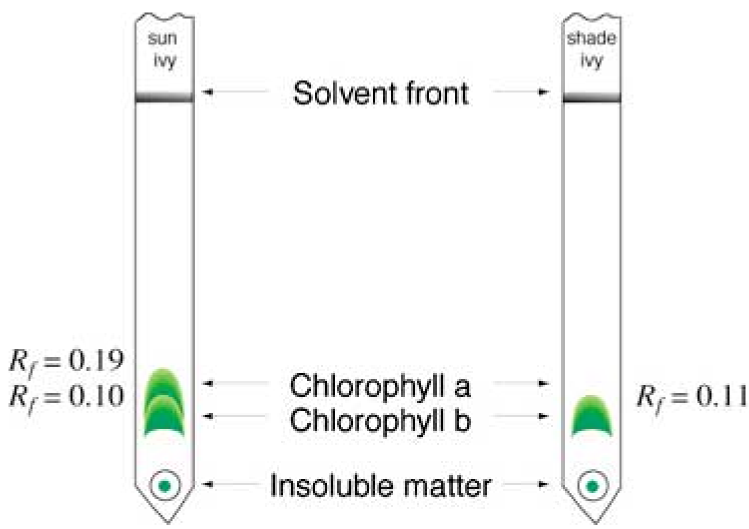


Figure 7. Chromatograms for full-sunlight and shade-grown ivy samples in acetone.

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.

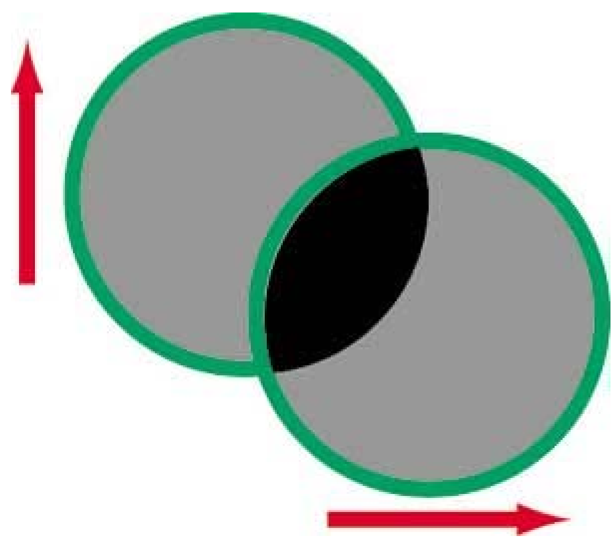
Some organisms can detect their environment using light in ways that humans cannot. In this demonstration, we will explore two of these ways.

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.

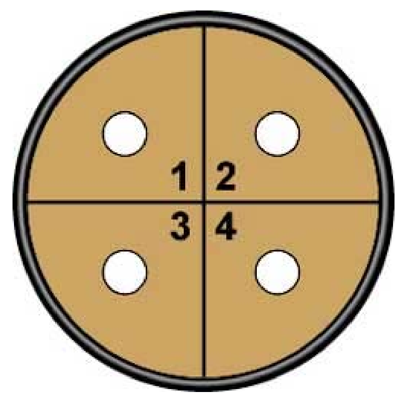
2. Slightly lift the lid of your petri dish (or substitute container) and gently, without piercing the agar, streak your plate by zigzagging back and forth on the agar with your swab.

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:

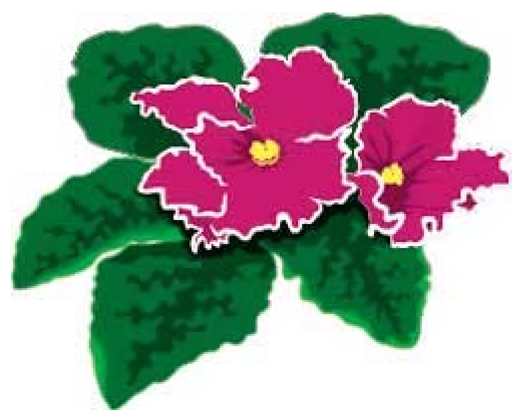
Part 1: Preparing Indicator Test Paper from Goldenrod Photocopy Paper

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

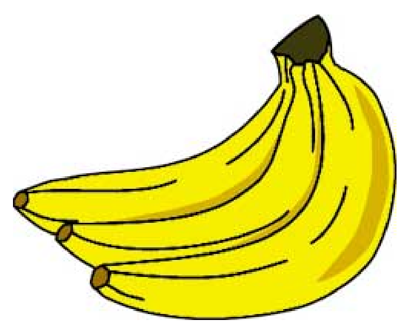
Gather examples of tropical rain forest products such as: Brazil nuts, vanilla beans, cinnamon, piece of teak wood (or something made from teak wood), coconut, coconut product (like a bag of shredded coconut), a can or bottle of tropical fruit drink, a piece of elephant ivory (like an old piece of jewelry 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.