Topic 4: Energetics – 4f. Leaf Pigments

Resources: Campbell et al. *Biology: Exploring Life,* Prentice Hall, Chapter 8.

Campbell et al. *Biology: Concepts and Connections,* Pearson, Chapter 7.

Miller and Levine. *Biology.* Prentice Hall, Chapter 8.

Building on: Cells need energy to live. Basic biochemistry including chemical reactions, bonding, enzymes and activation energy should have already been discussed. Also cell parts and functions should have been taught so that you can refer back to the chloroplast as the site of photosynthesis. Students will also be familiar with the basic concepts of photosynthesis from grade school.

Links to Chemistry:
Solubility
Chemical bonds
Chemical reactions
Organic chemistry

Links to Physics:
Kinetic and potential energy
Light waves – frequency/wavelength, reflectivity and color
Light energy
Conservation of energy

Stories: Students who may not have had physics are nevertheless interested in the visible spectrum of light. They become intimately aware of color from an early age, though their experience with the visible spectrum is limited to "rainbows" and possibly prisms. I usually introduce this lab by discussing the properties of color as the reflection of certain wavelengths and the absorption of others. If you're ambitious, you can even get into a discussion of the invisible (radio waves, X-rays, infrared, ultraviolet, gamma, etc. . . .) wavelengths of light, in particular, their applications in modern astronomy and technology. As you discuss the fact that plants would like to maximize their light absorption in the leaves, a student who is thinking may ask, "then why aren't leaves black?" This could lead into a discussion of transpiration (water loss through the stomata of leaves) later on.

Lab Instructions and Materials for the Teacher:

This is a common lab found in many textbooks. Chromatography strips can be obtained from any science supply company. You can experiment with different solvents to use to dissolve the pigments; acetone is my current choice, though I have used carbon tetrachloride (in a very controlled manner in which the students are not handling it), ethanol and isopropanol. Any non-polar solvent should work to dissolve the non-polar pigments of the leaf, though some will do a better job of depositing the pigments on the chromatography paper. Store-bought spinach leaves work well, but you may want to experiment with various outdoor or house plants.

Leaf Pigments

Purpose: The following laboratory has two main objectives:

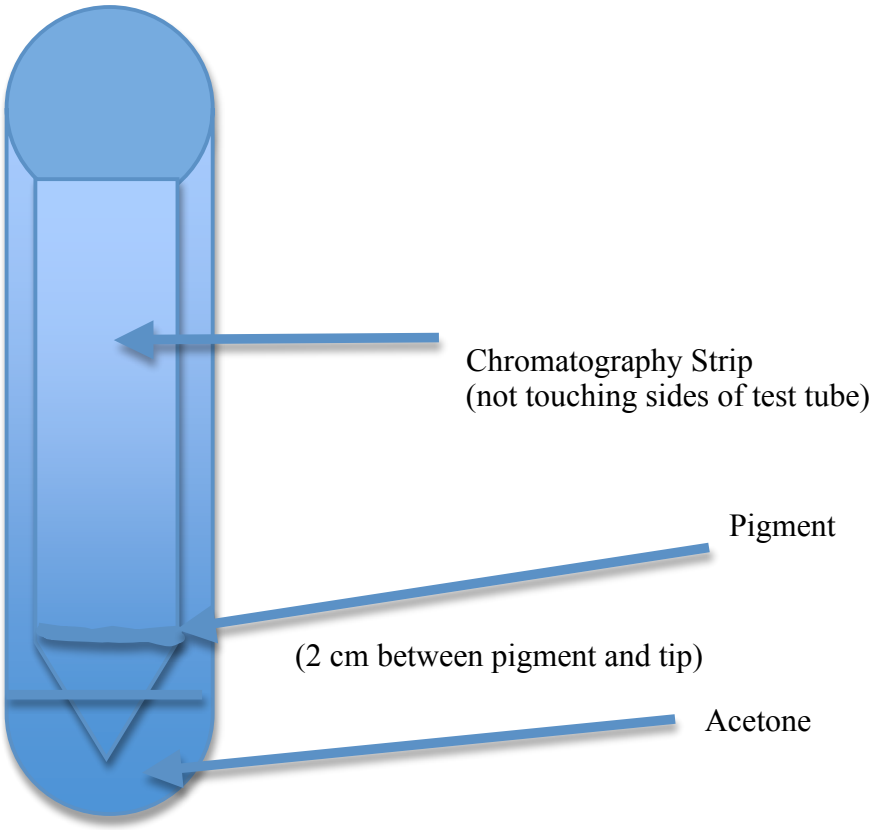
1. The study of plant pigmentation
2. The development of an understanding of a laboratory process called *paper chromatography*

Materials:

Chromatography strips
Test tube and cork Stopper
Acetone
Sharp-edged U.S. quarter
Spinach leaves

Procedure: Cut a strip of filter paper, pointed at one end, so that it fits into the test tubes containing the acetone (see diagram below). At a distance of approximately 2 cm from the pointed end of the chromatography strip, apply a "line" of pigment by rolling a sharp edged U.S. quarter across a spinach leaf and then across the strip and *allow it to dry.* Repeat this application of a "line" followed by drying many times until you have *an intense green.* Place the chromatography paper strip with pigment into the test tube containing the acetone.

Cork the test tube and observe the migration of pigment up the filter paper strip.



Data/Analysis Sheet:

1. Movement of pigments is based on their solubility in acetone. Define solubility.

   _____

2. Carotine, a yellow pigment, is more soluble in acetone than chlorophyll a.
   What color appears to be moving up the strip faster, yellow or green? Explain why.

   _____

   _____

3. After about 10-15 minutes, remove the filter paper strip and re-stopper the test tube.
   When the paper is dry, outline the different color regions you find with your *pencil.*
   Draw, color and label your strip below.

4. How many regions do you observe? _____

5. These green regions represent chlorophyll a and chlorophyll b. On your strip, *label* in pencil, Chlorophyll a and Chlorophyll b.

6. *Label* the yellow region Carotene and the red region, if any, Anthrocyanin.

7. From the location of the red region, what can you say about the solubility of the anthrocyanin pigment in acetone?
   Is it soluble or insoluble?_____

8. As fall approaches, leaves lose their green chlorophyll pigments and with them their ability to photosynthesize. Many also note the change in season by stating that leaves "turn" yellow and red. Do leaves "turn" color? Explain. In other words, why do leaves appear yellow or red in fall?

   _____

   _____

   _____

9. How many different pigments are found in green leaves? _____

10. List these different pigments, along with their color.

    _____

    _____

    _____

11. What property of leaf pigments allows us to identify them using paper chromatography?

    _____