LAB LESSON PLAN
(Cover Page)

California Agriscience Institute for Agriculture Teachers
California Department of Education

LAB TITLE: PHOTOSYNTHESIS

Ag Model Curriculum Standard(s), Learning Outcomes(s) & Biological Standard(s)

Addressed: Plant Science A-1, 5, 6

Biological Standard #11

Objective(s): Upon completion of the lab activity, the learner will be able to: Use of activity will enable student to identify these colors of light important to photosynthesis. Explain why different colors of light are more effective in photosynthesis.

Teacher Preparation: One day

How many class periods will lab take? Two days of class to set up and two weeks to observe.

Procedures (activities):

Method(s) of Evaluation: Laboratory writeup.

Time required for experimental effects: 2 weeks

PHOTOSYNTHETIC EFFICIENCY OF DIFFERENT COLORS OF LIGHT

AGRICULTURAL APPLICATIONS AND PRACTICES

The control of light is an important technology of horticulture. Growers can control plant growth, flowering, and senescence by regulating the intensity and duration of light in greenhouse settings. Most plants grow best under the high light intensities of full sun and growth is reduced at low light intensities. The duration and intensity of light is dependent upon the season of the year, climate and geography. In the summer, under naturally long days of bright sunshine, natural light intensity is sufficient for optimum plant growth. However, during the winter season it may become necessary to provide supplemental illumination for optimum growth. The most effective sources of artificial light are those which most closely replicate the wavelengths from the sun's radiation reaching the earth.

The rate of photosynthesis is proportional to the intensity of light up to about 13 klx (klx is the abbreviation for kiloluxes, a measure of light intensity). The wavelengths of light utilized by plants are about the same as those for vision. However, chlorophyll responds to light differently than the human eye. Chlorophyll synthesis is highest under the violet-blue and red light spectrums.

The high cost of providing supplemental light limits its use to primarily the production of high-value florist crops. When feasible, growers often use a combination of light sources to produce a spectrum of light which closely resembles that of sunlight. Combinations of tungsten, fluorescent, and high intensity discharge lamps are used for optimizing photosynthesis.

INTEREST APPROACH

Begin this lesson with a basic review of colors and properties of light. What causes color? Why are most leaves of plants green? Have students hypothesize the effect of varying color and duration of light on the rate at which photosynthesis occurs in the plant. In this laboratory exercise the students will be able to test these hypotheses.

SCIENCE CONNECTIONS - QUESTIONS FOR INVESTIGATION

1. How is radiant energy measured?

2. What effect does latitude and the position of the earth (seasons) have on solar radiation available to plants?

3. What colors (wavelengths) of light are most effective for photosynthesis?

4. What intensity of light is necessary for optimum photosynthesis?

5. Why do plants which are grown in light-deficient environments become etiolated?

6. Which sources of supplemental illumination are most effective in satisfying a plant's photosynthetic requirement?

PURPOSE OF THE LABORATORY AND STUDENT PERFORMANCE OBJECTIVES

The purpose of the laboratory exercise is to determine the effect of various wavelengths of light on the photosynthetic capability of the plant. Through this experiment and related discussions, students will be able to:

1. Identify those colors (wavelengths) of light which are the most effective for photosynthesis.

2. Explain why certain colors of light (wavelengths) are more effective for photosynthesis.

3. Describe the effect on photosynthesis of varying the light spectrum available to the plant.

4. Explain how light is used by the plant and develop strategies for optional utilization of light in crop production.

MATERIALS AND/OR EQUIPMENT

4 herbaceous plants with large leaves
3 sheets of colored cellophane (red, green, blue)
1 sheet of clear cellophane
4 cardboard boxes

PROCEDURES

1. Cut an opening in each of four cardboard boxes that is slightly smaller than the sheets of cellophane. (The boxes must be large enough to cover your plant specimens and not interfere with plant growth.)

2. Tape the cellophane over the opening of each box.

3. Place small holes in the sides of the box which will facilitate air flow but let a minimum amount of light enter each box. Prepare each box in an identical manner.

4. Place the four plants in the boxes and care for all plants in an identical manner (water, exposure to light, fertilizer, etc.).

5. Observe the plants every other day for two weeks and record your observations.

DATA SUMMARY AND ANALYSIS

Have students record observations every other day for two weeks for each plant specimen. At the end of the two-week period students should be able to determine which light produced the best growth, which color was least effective, and how the color of the leaf is related to the results of the experiment.

ANTICIPATED FINDINGS

The plant grown under clear cellophane will appear the healthiest and show the most growth. The plants grown under the red and blue cellophane will be the weakest. Red and blue light would have been absorbed by the leaf and utilized in photosynthesis if they had not been reflected by the cellophane.

IDEAS FOR OTHER EXPERIMENTS

1. Different colors of cellophane could be obtained and tested using the same procedures identified for this experiment.

2. A starch test could be done to test for the rate of photosynthesis occurring in the leaves for each treatment.

UNDERLYING SCIENCE CONCEPTS AND PRINCIPLES

A. <u>Plant Biology Concepts</u>

Photosynthesis

B. <u>Key Terms</u>

1. <u>Light intensity</u> - measured in lumens, is the radiant flux emitted from a light source.

2. <u>Illuminance</u> - radiant flux intercepted per unit area.

3. <u>Etiolation</u> - the morphological expression of light deficiency caused by the effect of light on auxin distribution and synthesis.

4. <u>Compensation point</u> - light intensity at which plants will maintain themselves but not grow.

C. <u>Principles of Photosynthetic Efficiency Related to Light</u>

1. The sun is the primary source of energy available to the earth. This energy is transmitted 93 million miles in the form of radiation at a speed of 186,000 miles per second.

2. Visible light is only one portion of the energy which is emitted from the sun. Light rays perceived by the human eye fall into the range of 380 nanometers (nm) to 780 nm. This range of wavelengths of light is similar to the wavelengths used by plants during photosynthesis with some minor differences.

3. Humans perceive light best at 555 nm, but the wavelengths of light most effective in photosynthesis are between 400-510 nm and 610-700 nm. The green leaf "sees" two wavelengths of light best.

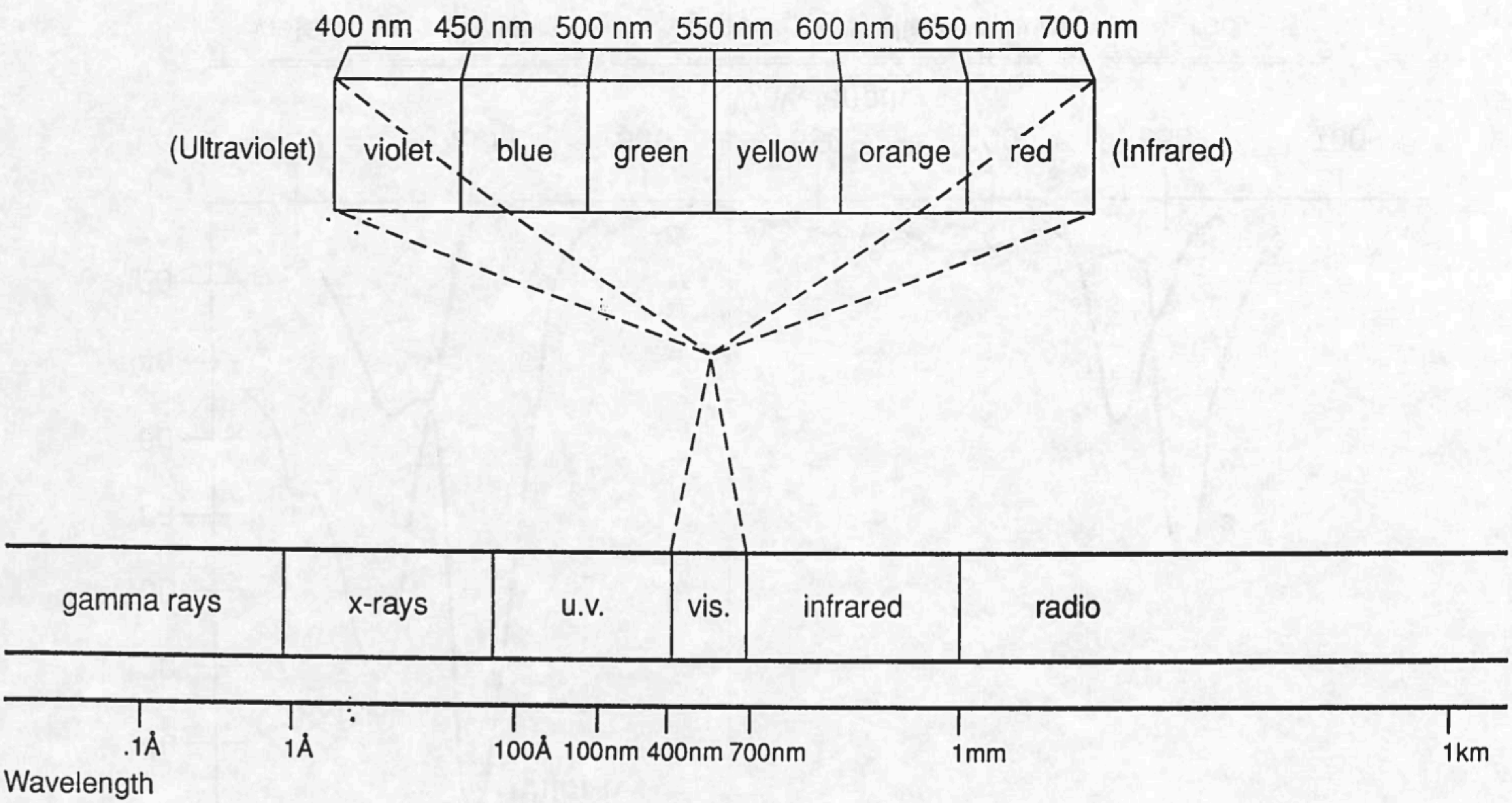
4. The green color of leaves is due to the fact that chlorophyll reflects light which we see as green and absorbs light which we see as red and blue-violet. Plants use red light most effectively.

5. Plants grown in the absence of light but which are getting their source of energy from a seed, tuber or bulb have elongated, spindly stems. This expression of light deficiency is known as etiolation. Light also influences other plant response such as germination, flower formation, and sex expression.

6. Most plants grow best in the high intensities of full sun which is 108 kiloluxes (klx), however, a leaf is fully saturated at 13 klx. The higher intensities are needed because of leaf shading. Most plants cannot grow when exposed to 1-2 klx of light which is the level of light in most rooms.

7. The control of day length and light intensity is possible under greenhouse conditions. Supplemental illumination can be provided by incandescent lamps, fluorescent lamps, and high intensity discharge lamps. The most satisfactory growth occurs when a combination of light sources are used which emits light in the full range of wavelengths utilized during photosynthesis.

Electromagnetic Spectrum



Source: A Laboratory Guide to Biology, Contemporary Publishing Company

Absorption Spectra of Chlorophylls a and b