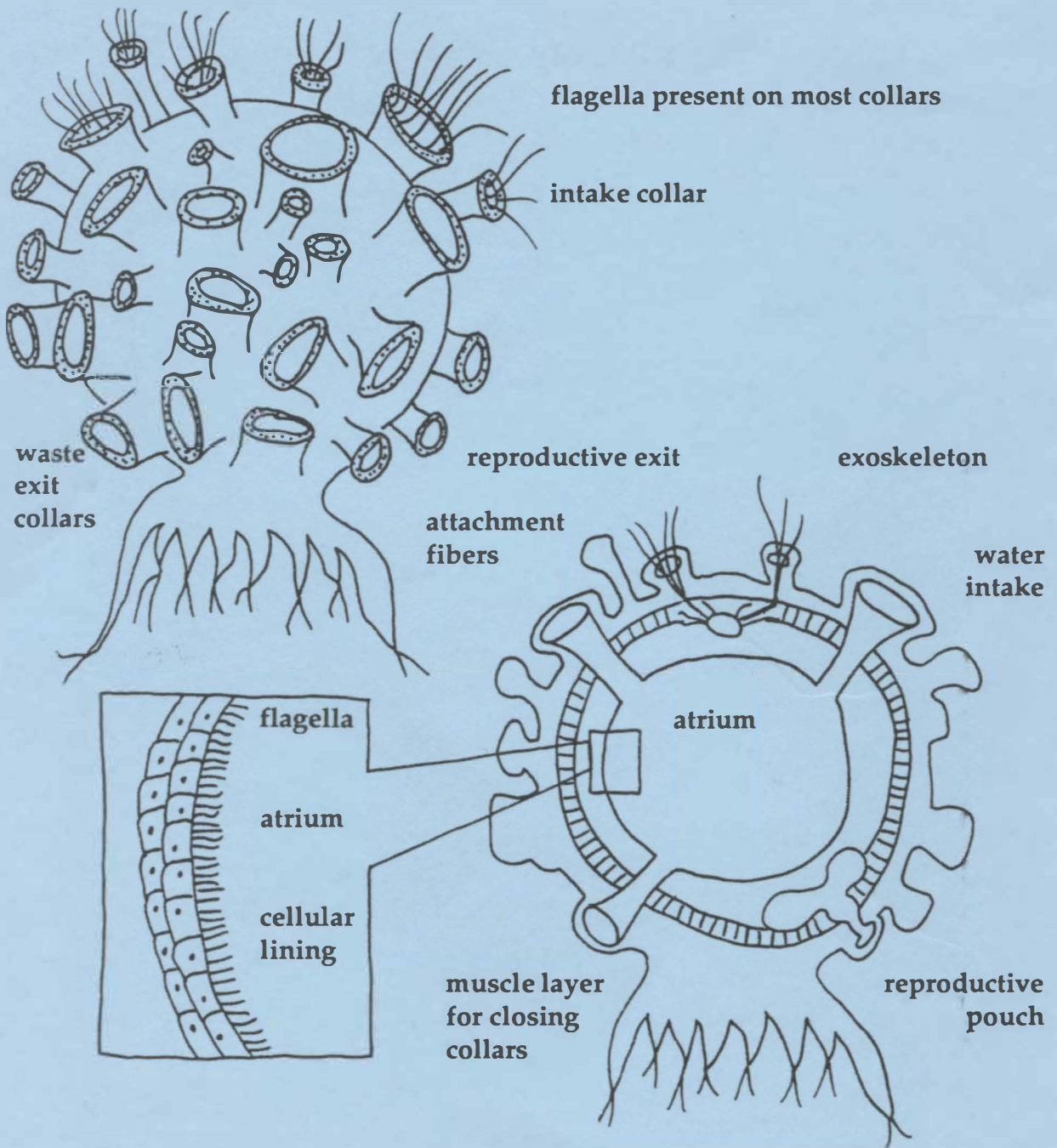




Diagram Identification for *Torquatus hybolious*



# **Bioscene**

## **Journal of College Biology Teaching**

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**Cover Illustration:** Diagram of *Torquatus hybolious*, a benthic invertebrate inhabiting the ocean of Valhalla in the Asgard star system. This animal's tough exoskeleton affords it protection from strong currents that allow it to attach in large numbers to the sheer face of rocky drop offs. It is a filter feeder which can shed its exoskeleton as it grows. Its primary reproductive mode is parthenogenic.

The species was created by Jason Robertson, a student in the invertebrate biology class at Alma College, as part of a three-species exercise throughout the term. Details on the project are available through Kay Grimnes, Department of Biology, Alma College, Alma MI 48801.

# **Bioscene: Journal of College Biology Teaching**

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# Role-playing of Clinical Situations to Promote Critical Thinking

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My students are among the brightest, by their statistics, and they are willing to prove this repeatedly on standardized tests. The strategy of straight memorization has paid off well for them in the past. However, the choice to concentrate on jargon, as opposed to integration, is especially ineffective in a field like immunology. Terminology must be learned, but it does not reveal important functions of the immune system. Students must move past their compartmentalized view of the subject, and into a more critical-thinking holistic approach to the material and, horror of horrors, how it related to previous course work.

## Clinical role-playing

In an attempt to provide students with experiences that enable them to integrate material, and invite them to become active participants, I introduced role-playing into my immunology class. This is a senior level course at Alma College with an enrollment of between 18 and 30 students, most of whom have strong medical interests. I divided the class into teams (3-5 students/team) which were carefully chosen to equalize the type and quality of thinkers on each team. I informed them that they were medical interns on an immunology rotation at a small city hospital. They were seeing patients in the hospital and emergency walk-ins. I would supply a case history, but they would need to puzzle out the problem by using direct patient questioning and by ordering medical tests of the sort we had discussed in class. They would work together as a group and could utilize any knowledge they possessed, except for the book. There were only two restrictions: all communications with the patient were to be written out so other groups could not eavesdrop and no outright guessing or jumping to conclusions was permitted. Their line of reasoning had to be clear to all members of the group and to me. My students readily agreed to participate, possibly envisioning that this would consume most of the lecture time, if nothing else.

## The Scenario

I went out of the room and reappeared as the patient, Betty Miles, a forty year old woman. With my hand on my chest, I drew shallow noisy breaths and told them that I had been mowing hay when the tractor kicked up a swarm of bees from a crushed hive. "I'd been stung," I said, "I didn't know how many times. My cousin had died from a bee sting, but I wasn't going to die, was I?" "No, no," they assured me, as each group frantically wrote out questions. Outright guesses (such as pulmonary pneumonitis from moldy hay, an example from their textbook) came first and were tossed back without an answer. They saw that I went from group to group in order; a useless question would waste their place in line. Results for the clinical tests they ordered came in the form of graphs and tables which required analysis. Asking for a very costly or time-consuming specialized test on sheer speculation also caused a delay, as I told them they had not yet gotten the results.

After a few moments of panic at the new situation, the students settled down, consulted as a group and asked more focussed questions. "Are you allergic to bee stings?" "Well, I don't know, I never have been before, but these things can come over you sudden-like, I heard. I don't want to die." "So you've been stung before?" "Oh, yes. I knew I better drive over here right away." "Drive? You drove here?" "Of course I did, I live way out in the country, you know!" They concluded that a 30 minute drive ruled out a bee sting allergy. Adroit questioning of the patient determined that the breathlessness came from the walk up the stairs; the patient had used the back entrance by mistake. Further questioning revealed that she didn't have a regular doctor, she wasn't sick very often, and well, her family just got over what ailed 'em (another clue), like that real bad sore throat she had two winters ago . . . it went away without the doctor (major clue). It became apparent that she had the same kind of

breathlessness whenever she exerted herself. She admitted that she used to jog every morning, but had given it up about a year ago; she guessed she was getting old. Listening to her heart (suggested by a student from the cardiac rehabilitation class), they heard faint signs of a cardiac valve abnormality. A test for anti-streptococcal antibodies revealed that a high titer was present in her blood. Group by group, the students concluded that the untreated sore throat, which might have been a streptococcal infection, had resulted in the production of antibodies which defeated the sore throat, but eventually produced a well-known cross reaction with heart valve tissue (rheumatic fever). Cardiac insufficiency under stress conditions resulted in the breathlessness they observed.

#### Debriefing

What did the students gain from this exercise? They were extremely pleased with themselves when they solved this problem and wrote extensive comments to several questions I supplied at the conclusion of the exercise. They hadn't realized how hard it would be to integrate the material that they had memorized, nor how rewarding it would be to apply it, they said. Students seemed to appreciate that memorization had a purpose, a connotation within the class, but it was insufficient for true understanding. Reading data in the form of tables or graphs was difficult; they had more trouble than they had anticipated in figuring out what the control values meant, and if the data were significant. By their own admission, charting a logical progression was problematic, but the students all agreed it was extremely worthwhile. Those students with medical careers in mind were surprised to see how much of their success might rest on what the patient hadn't told them. When asked about group dynamics, they readily admitted that the best answers had not always come from the "best" students, and acknowledged the contribution of all students to success. This conclusion led to a brief discussion of the role of cooperation in science. They left class still replaying the experience and didn't seem to mind that the application had been a "game."

#### Risks and Rewards

This exercise required an entire lecture period, in which I could have covered half a chapter of information. I risked looking extremely foolish in

front of an often critical audience. The questions came rapid-fire, often with no discernable logic, which forced me to discriminate between valid requests for information and guess work. I carefully monitored the information I gave out, slowing the best group by asking very pointed questions, while dropping hints to the slowest group, so that groups progressed at somewhat equal rates. I had to redirect the energy of impatient or frustrated students and divert their anger, both from myself and from each other.

What did we gain? By their own acknowledgement, many students began to view the lecture and the basic information presented therein as tools with a purpose. We discussed explanation, argument and evaluation as critical thinking skills which took time to learn, but that could be improved. They began to ask questions that went beyond basic levels; such questions were increasingly rewarding to hear, but correspondingly more difficult to answer. I turned the very difficult questions back to the students with the hope of generating an open discussion format, an approach which I still need to refine. I have already experimented with case studies during exams, in a guided-speculation format. I would like to expand the number of experiences available to the students each term, possibly by creating a charade-like situation where the students themselves are the patients in small group situations. I am also interested in transferring this approach to other classes.

#### How to prepare for role-playing

This technique could be applied to a number of biological areas, especially where medical implications are involved, such as physiology, genetics, or microbiology. Alternatively, a real scientist could be role-played (Randak, 1990), either from the past, or the present. The format could be a case study in a medically related area such as physiology or biochemistry (Davis, 1993; Hunt and McMurray, 1993; Kaleta *et al.*, 1993), an interview, a news conference over a new discovery (a major advance in AIDS research), or a competitive research situation between several teams of scientists all vying to solve the same research problem. It is easier to start with a few steps and gradually build to a full hour-long exercise.

The actual scenario, in the case of a patient simulation, must have a certain degree of complexity, yet still be accessible to the relatively naive student. Authentic case studies, such as

those found in the *New England Journal of Medicine*, are usually far too involved and require too much specialized knowledge to be of much use, although they may provide ideas. Additional idea sources include case studies in biochemistry (Montgomery *et al.*, 1990), as well as immunology (Kuby, 1994; Roitt *et al.*, 1994) and clinical pathology texts (Standler and Klionsky, 1992). I try to select a problem with at least two levels, and then choose a patient who becomes an additional part of the puzzle. A wealthy socialite visiting a clinic in the poor part of town is there for a reason (a recurring and embarrassing parasitic infection) and the freighter captain's allergy may be related to his cargo. As far as simulating the patients, I try for accents and emotional overtones, but have not tried to dress the part. I try to stay in "character" as much as possible, but if the students veer off-track I may drop the role and redirect their questions.

Once the problem has been identified, I create the data that students are most likely to require. Although I have some blank diagnostic test forms, I often create my own graphs to meet specific situations. I try not to overwhelm students with extraneous detail, but I include more than just the clue they need. Since I produce the graphs and tables on the computer, it is a simple matter to adjust the numbers to get the effect I desire. I try to stay within realistic values whenever possible.

Running the scenario is the most rewarding and difficult part of the entire enterprise. It is remarkable how quickly students can get side-tracked, and what outlandish suggestions they make. Monitoring progress and watching group interactions can be very revealing in terms of assessing intellectual maturity. I do not attempt to grade these exercises; instead I award points for participation. This seems to bother only the most competitive students; they feel they have somehow been cheated.

#### Summation

The addition of patient simulations to my immunology class has enriched the atmosphere of the class and student appreciation for the complexity of the subject. In addition, they have begun to appreciate the levels of learning beyond memorization. I would like to hear about other instances of simulations or role-playing in the classroom, no matter what the subject area. I am especially interested in experiences for entry level students.

#### Acknowledgements

I am in debt to the Model United Nations Program, where I first experienced the thrill of role-playing, to murder mystery weekends, and to the students in my classes who were willing to experiment.

## Literature Cited

- Davis, T.A. 1993. Alternate teaching methods in vertebrate physiology lab: Time to STOP and learn it again for the first time. *Bioscene* 19(2): 6-10.
- Hunt, C. and M.A. McMurray. 1993. Teaching infectious disease by the case method. *Bioscene* 19(2): 18.
- Kaletka J., S. Rose and M. Vought. 1993. Problem solving sets and clinical case studies: a nontraditional approach to the undergraduate biochemistry experience. *Bioscene* 19(3): 24.
- Kuby, J. 1994. *Immunology*, 2nd edition. W.H. Freeman: New York. 659 pg.
- Montgomery, R., T.W. Conway and A. A. Spector. 1990. *Biochemistry: a case-oriented approach*, 5th edition. C.V. Mosby Company: St. Louis, MO. 905 pg.
- Randak, S. 1990. Historic role-playing. *American Biology Teacher* 52: 439-442.
- Roitt, I. N., Brostoff, J., Male, D. K., and Gray, A. 1994. *Case Studies in Immunology*. Mosby: London.
- Standler, N. and B. Klionsky. 1992. *Cases in pathology: a clinical approach for students*. Churchill Livingstone: New York. 242 pg.

# The BIOLOG System as a Teaching Tool for Bacterial Identification

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Once the initial morphological and gram-staining characteristics are determined, bacteria are differentiated primarily by their biochemistry. Biochemical tests can be tedious and expensive. Bochner (1989a, 1989b) has developed a system which can test up to 95 different substrates using a redox dye as an indicator. If the bacterium metabolizes the chemical, the colorless redox dye becomes purple. Patterns of metabolism can be compared with a computerized library of known organisms. The procedure is now outlined in Pelczar *et al.* (1993) and is described as one of the latest breakthroughs in automated technology for microbiology.

While a completely automated system, complete with automatic reader, is costly (over \$20,000); the principle can be taught at the undergraduate level for the price of the MicroPlates, under \$10 each. The MicroPlates are manufactured in several varieties, including the "GN" for Gram-negative bacteria, "GP" for Grampositive, "ES" for *Escherichia coli* and *Salmonella*, and "MT" (empty, except for the redox dye). The GN Microplates are recommended for students, since the "MicroLog Software Demonstration Disk," features 18 gram-negative bacteria in its database. The demonstration disk is available at no cost to teachers.

Other essential equipment for the procedure are the following, per student, or pair of students:

Pure cultures  
Sterile TSA plates  
Sterile swabs  
2 tubes of 20 ml sterile 0.85% saline  
Sterile dispensing pipettes, to deliver 150  $\mu$ l,  
96 times. (We use Pasteur pipettes)  
2 sterile cuvettes for the Spectronic 20  
Spectronic 20 or turbidimeter  
IBM-compatible computer

Complete instructions come with each set of MicroPlates, and additional literature is available from BIOLOG<sup>1</sup> upon request. The instructions stress careful adherence to streaking technique for the preparatory culture, concentration of the inoculum at 10<sup>8</sup> - 1,010 cells/ml, and attention to the age of the inoculum when results are read.

I introduced the technique this past semester as a laboratory exercise for General Microbiology. The students commented that it was one of their favorite exercises because it was so "up-to-date." They found inoculation of 95 wells with a single pipette tedious, but after having inoculated Durham tubes the previous week, they realized how they were multiplying their data fields. They enjoyed using the demonstration software program and found it easy to use.

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<sup>1</sup> BIOLOG, Inc., 3938 Trust Way, Hayward, CA 94545

## Literature Cited

- Bochner, B.R. 1989a. Sleuthing out bacterial identities. *Nature*. 339: 157-158.
- Bochner, B.R. 1989b. "Breathprints" at the microbial level. *ASM News*. 55: 536-539.
- Pelczar, Chan, & Krieg. 1993. *Microbiology, Concepts and Applications*. McGraw-Hill: New York.

# Measurement of the Effects of Light Quality and Other Factors on the Rate of Photosynthesis

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Light can affect plant growth and development in two distinct ways. The first system for light effects is modification of growth patterns and development through interaction with specific photoreceptors (see Kendrick and Kronenberg, 1986). Relatively small amounts of light with specific spectral quality or spatial direction is responsible for activating these pigments.

The second light dependent system is photosynthesis. Large amounts of light are transduced to chemical energy which is utilized for growth and development (see Gregory, 1977). The photosynthetic transduction of light energy to chemical energy is central to life. It is the ultimate source of chemical energy for almost all organisms. Approximately  $2 \times 10^{11}$  tons of carbon are fixed each year. This is more than one-third of a million tons fixed per minute.

Central to the process of photosynthesis is the light harvesting ability of plant pigments. Several types of photosynthetic pigments occur in plants and bacteria (Table 1). Chlorophyll and protein molecules are organized into two complexes, Photosystem I (PSI) and Photosystem II (PSII) (Anderson 1980). PSI is a chlorophyll a/protein complex with a maximum wavelength absorbance of 720 nm (far red light). PSII is a chlorophyll a/chlorophyll b/protein complex with a maximum wavelength absorbance of 690 nm (red light).

In addition to these two Photosystems, the yellow-orange pigment carotene absorbs light in the blue region of the spectrum. Only 20-50% of the light energy absorbed by carotene is trans-

ferred to the photosystems. The primary role of carotene appears to be protection of the chlorophyll of the photosystems from excess radiant energy (Krinsky, 1978). Under high levels of radiant energy chlorophyll molecules are excited to the triplet state. A triplet state is an excitation state in which the spin of the excited electron has been reversed. The triplet state of chlorophyll is stable for only several microseconds after which the electron reacts with molecular oxygen to form either singlet oxygen or a superoxide radical.

Table 1. Common types of photosynthetic pigments and their occurrence (adapted from Gregory, 1977).

PIGMENT	OCCURRENCE
Chlorophyll a	All oxygen-evolving organisms
Chlorophyll b	Higher plants and green algae
Chlorophyll c	Diatoms and brown algae
Chlorophyll d	Red algae
$\alpha$ -carotene	Higher plants, most algae
$\beta$ -carotene	Most plants, some algae
Luteol	Higher plants, green and red algae
Violaxanthol	Higher plants
Fucoaxanthol	Brown algae, diatoms
Phycocerythrin	Red algae, some blue-green algae
Phycocyanin	Red algae, some blue-green algae
Allophycocyanin	Blue-green algae, red algae
Bacteriochlorophyll a	Purple and green bacteria
Bacteriochlorophyll b	Some purple bacteria

Both of these forms of oxygen are extremely reactive and lead to irreversible damage to the chlorophyll molecule and other cellular components including membranes and DNA. If a carotene molecule is available, chlorophyll can pass triplet state electrons to the carotene molecule. Carotenoid triplets are harmless because carotene can dissipate the triplet state energy to heat. Thus carotene performs two functions: 1) protection of chlorophyll from oxidation and 2) absorption of light in the 450-500 nm range for utilization by the

photosynthetic processes. Thus, in higher plant species, chlorophyll and carotenoids contribute to the photosynthetic absorption spectra.

The photosynthetic absorption spectra measures the wavelengths of light which are absorbed by photosynthetic tissues. These spectra include absorption of light from primarily photosynthetic pigments. A typical absorption spectra is illustrated in Figure 1. The photosynthetic action or activity spectra measures the utilization of various wavelengths of light by the process of photosynthesis (Figure 2). The activity spectra indicates the photosynthetic yield of various wavelengths of light of differing quantities and energetics which are transferred through the photosystems in the conversion to chemical energy. Without the transfer of energy between pigments, the activity spectrum would consist of two peaks at 720 nm (PSI) and 680 (PSII).

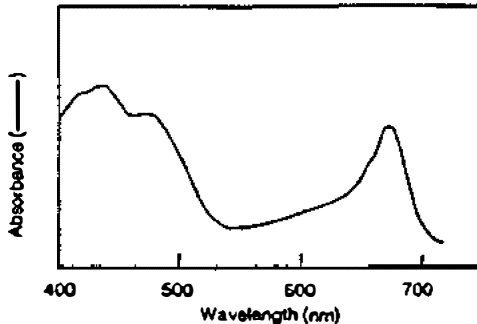


Figure 1. Absorbance spectra for green tissue of higher plants. (Adapted from Withrow, 1959)

Of primary interest to this laboratory experience is energy transfer through Photosystem II. Energy transfer through PSII performs two important functions. First, ADP is phosphorylated to produce ATP which can be utilized by the Calvin-Benson cycle. Second, energy is utilized in splitting water molecules and generating O<sub>2</sub>. The oxygen is liberated as a gas.

This laboratory exercise explores the effect of light energy of various wavelengths on photosynthesis. Oxygen evolution from PSII is used as a measure of photosynthetic activity. This laboratory exercise requires minimal equipment and is presented in a form which can be used in an introductory level course. Modifications are suggested at the end of this exercise which increase the complexity of data analysis and interpretation for use in advanced courses.

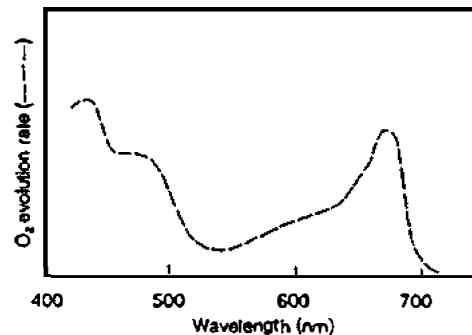


Figure 2. Action spectra of photosynthesis of higher plants. (Adapted from Withrow, 1959)

### GOALS OF THE EXPERIMENT

1. Determine the effect of light quality on photosynthetic evolution of oxygen.
2. Determine the effect of light quantity on photosynthetic evolution of oxygen.
3. Observe the results of the transfer of light energy between photosynthetically active pigments.

### TIME REQUIREMENTS

- 0.5 hr approximately 10 days prior to the experiment to plant seed.
- 1.0 hr prior to the experiment to prepare test solutions and calibrate filters.
- 1.0 hr to leaf discs and setup the experiment,
- 1.0 hr to run the experiment and collect data.

### MATERIALS AND EQUIPMENT

- Seed [radish, turnip, Chinese cabbage, Fast Plant (*Brassica rapa*) or almost any *Brassica* sp.]
- Plastic 35mm film cans

Osmocote fertilizer pellets

Nail punch

Soil mixture (1:1 peat: vermiculite)

Unwaxed cotton cord

Plastic storage box or plastic shoe box

Pellon fabric

Scott brand household paper towel

10 ml disposable syringes

Cellophane or transparent film — yellow, red, blue, green, orange

1 M sodium bicarbonate solution

Fluorescent light strip

0.1 N HCl

0.1 N NaOH

pH meter

Plastic soda straws

Wire test tube racks

Various glassware

Distilled water

Photographic light meter

## METHODS

**Seedling Preparation.** This step of the experiment should be done in advance of the experiment by the students or instructor. Seeds are planted in plastic film cans as illustrated in Figure 3 and 4. Plant 5 seeds per film can. Each student should prepare 4 film cans. Students can prepare the film cans during the laboratory period a week prior to the experiment; the instructor will add water to initiate the germination approximately 10 days before the laboratory period. For optimal growth, place the seeds/seedlings under a fluorescent light bank to maintain constant illumination at < 350 ft. candles and 22° C. Seedlings are used when the first true leaves are fully expanded; this should require 8-10 days, depending on the species which is selected.

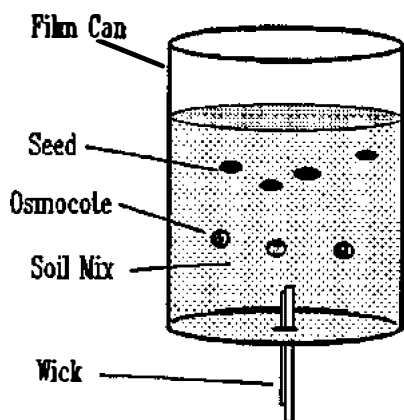


Figure 3. Diagrammatic representation of the use of plastic 35 mm film cans to germinate and grow seedlings and plants. Hole in bottom of can is made using a nail punch. Unwaxed cotton cord is used as a wick. The soil is peat:vermiculite (1:1). Three or four pellets of Osmocote are placed in each can as fertilizer.

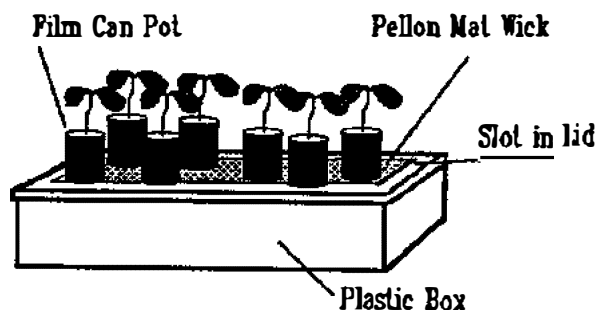


Figure 4. Planting trays for use with the film can system. Plastic boxes are used as water reservoirs. A slot is cut into the lid of the box. A rectangle of bleached Pellon covers the top of the box and extends through the slot into the reservoir. The Pellon mat serves as a wick.

**Solution Preparation.** A solution of 1 M sodium bicarbonate should be prepared. The pH of the bicarbonate solution should be adjusted to 8.0. Each student will need approximately 70 ml of solution.

**Filter Calibration.** Cellophane or transparent plastic is used as filters to provide light of different wavelengths for this experiment. Cellophane can be purchased from many scientific supply companies, floral supply companies or office supply companies (in the form of overhead transparency material or report covers). For optimal results similar quantities of light should be transmitted through the filters. To calibrate the quantity of light that is transmitted by the filters you can use a hand held photographic light meter. Cut small test squares of the filter material and place them between the light source (a small fluorescent light stick usually works best) and the light meter. Adjust the distance from the light source and the number of layers of filter material to obtain similar light meter readings. The spectral quality of the light can be measured by placing a strip of the filter material in a spectrophotometer and measuring the absorbance spectra of the material. If a larger budget is available, Wratten filters can be purchased from any photography store. Information concerning the spectral characteristics of these filters can be found in the CRC Handbook of Chemistry and Physics.

**Leaf Disc Preparation.** Excise the pairs of first true leaves from the seedling using a single edge razor blade. Place the excised leaves in pairs from the same seedling on a moist paper towel. The leaves should be fully expanded and bright green at this stage. Uniform discs can be cut from the leaves using a plastic straw. Care should be taken to avoid major veins within the leaf; the vascular tissue is not photosynthetic and has greater density which can bias the results.

**Photosynthesis Chambers.** Each student should prepare a minimum of six chambers (1 replicate). Each chamber consists of a 10 ml syringe. Wrap each chamber with the appropriate color of cellophane or plastic filter material. When wrapping the chambers, use the number of layers of cellophane/plastic which was determined in filter calibration. Remove the syringe plunger from each of the chambers. Place 5 leaf disks in each chamber. Add 8 ml of the bicarbonate solution to each chamber. Replace the plunger in each chamber and remove the air from the chambers. The volume of bicarbonate solution in the chambers after

air removal should be 7.5 ml. The leaf discs will float until the discs are degassed and the intercellular spaces within the discs are filled with the bicarbonate solution. It is critical that each chamber is degassed in the same manner. To degas the leaf discs, place your finger over the end of the syringe. Next, slowly pull the syringe plunger to the 10 ml/cc mark on the syringe. Hold the plunger at the 10 ml/cc mark for 20 sec. before releasing the plunger. You should shake the syringe to swirl the leaf discs. If the leaf discs do not sink, you should repeat the procedure. You should place the chamber/syringe in the dark (a desk drawer is fine) after the discs sink. The procedure is repeated for each syringe/chamber until all are degassed.

#### EXPERIMENTAL PROCEDURE

1. Place the degassed photosynthesis chambers in test tube racks. The distance which the test tube racks are placed from the light source was determined in the METHODS section under Filter Calibration.
2. Turn on the light source and record the time.
3. Observe the chambers and record the time at which each disc floats in each treatment. If any discs do not float or require times of greater than 125% of the period required for the initial disc(s), examine the discs at the conclusion of the experiment.
4. Average the time periods required for the discs to float for each treatment.

#### OBSERVATIONS AND QUESTIONS

Plot a graph of the time versus color. If the spectral absorbance maxima for the filters are available, plot the graph of time versus the maxima. What changes occur in the color of the cotyledons during the experiment? Is degreening delayed or promoted by any of the treatments?

Compare your activity spectra to the standard activity spectra in Figure 2. How do the spectra correspond? How do the spectra differ? How do you account for differences?

Why should you average the times required for the discs to float?

Examine the leaf discs which did not float or required excessive periods of time to float. Do you see any differences in these discs? Develop a hypothesis to explain why these discs did not float. How would you test your hypothesis?

The filters were calibrated to provide similar quantities of light, but is all light equal? (Hint—

Does a unit of blue light contain the same amount of energy as a unit of red light?) If all light is not equal, how would this fact alter the interpretation of your results?

The solutions in the photosynthetic chambers were degassed at the beginning of the experiment. Photosynthesis requires the gas carbon dioxide. What was the source of carbon dioxide for the leaf discs during the experiment?

#### SUGGESTIONS FOR MODIFICATIONS AND ADDITIONAL EXPERIMENTS

1. Compare the effect of different quantities of light on photosynthesis by changing the light source. A light meter which provides light intensity in foot-candles, Einsteins, or other units is required to calibrate the light sources. Syringes without filters can be used. Plot the intensity of the light source versus the time required for the disc to float. Interpolate the line to the X-axis (light intensity). The point where the line crosses the X-axis is the light compensation point. At high light intensities, the plot will plateau. The plateau indicates the light saturation point.
2. Compare the floatation rates of leaf discs removed from C-3 and C-4 plants. Students can observe the differences which exist for the two types of plants in photosynthetic rates at the same light intensity, different light compensation points, and different light saturation points (Chollet and Ogren, 1975). Corn and soybean are C-4 and C-3 plants which most students recognize and are ideal for this experiment.
3. The action of several herbicides can be examined. The herbicide DCMU is a specific poison for Photosystem II. The herbicide fluoridon inhibits carotenoid biosynthesis. Thus the protective role of the carotenoids is negated. Tissues can be pretreated with fluoridon and moved into dim light or placed in the dark approximately 24 hr prior to the experiment. During the experiment the exposure to bright light destroys the chlorophyll present within the discs.

#### POTENTIAL PROBLEMS AND CONSIDERATIONS

Two potential problems exist. First, all of the photosynthesis chambers must be degassed with consistent vacuum. If excessive vacuum pressure is placed on any single sample, the sample will give aberrant results. Thus the plungers of

syringes should be drawn back to the same position to degas uniformly.

Secondly leaf discs should contain no major veins. The density of the tissue must be as consis-

tent as possible. If the students avoid cutting discs which contain the midrib, high consistency can usually be achieved. Similarly necrotic or yellowing regions of the leaves should be avoided.

## Literature Cited

- Anderson, J.M. 1980. Chlorophyll-protein complexes of higher plant thylakoids: distribution, stoichiometry and organisation in the photosynthetic unit. *FEBS Lett.* 177:327-331.
- Chollet, R., W.L. Ogren. 1975. Regulation of photorespiration in C-3 and C-4 species. *Botanical Review* 41:137-139.
- Gregory, R.P.F. 1977. *Biochemistry of photosynthesis*. 2nd edn, Wiley, New York.
- Kendrick, R.E., G.H.M. Kronenberg eds. 1986. *Photomorphogenesis in plants*. Martinus Nijhoff Publishers: Boston, Massachusetts
- Krinsky, N.I. 1978. Non-photosynthetic functions of carotenoids. *Phil. Trans. R. Soc. Lond.* b284:581-590.
- Withrow, R.B. ed. 1959. *Photoperiodism and related phenomena in plants and animals*. Publication No. 55. American Association for the Advancement of Science: Washington, D.C.

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### Editor

Bioscene: Journal of College Biology Teaching  
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Dear Editor:

I detect a slight interruption in the early morning caffeine infusion ritual as the perforated cellin g tiles announce "We apologize for the delay, now that the fog has lifted we will begin boarding USAIR flight 228 to Pittsburgh." At 10,000 feet, dilated pupils contract in response to the overwhelming brilliance of the cloudscape. Is it airspace or cyberspace? Once again I return home satiated from the Annual AMCBT Meeting.

Approximately 90 AMCBT members and prospective members made the trek to Henderson, KY to share ideas and visions for teaching college biology. Unfortunately, only 12 attendees returned the 1995 program planning sheets before leaving. Others have been promised, and I know I will hold them soon. However, for those who were unable to attend, a copy of the planning form is printed in this issue. Please consider attending and making a presentation at the 1995 AMCBT Annual Meeting at Alverno College, Milwaukee, WI, to be held September 28-30. The theme for this meeting is "Breaking Through Technological Barriers." We are not just seeking presentations from techno-junkies and cyberpunks, but also presentations from neophytes who have no intention of metamorphosing into hackers. Please plan to share your ideas and experiences (rewarding and/or frustrating) as we enter the fascinating world of cyberspace.

Thanks.

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