ENVIRONMENTAL EDUCATION THROUGH INDEPENDENT STUDY

Students at Skyline College (a California community college) can enroll in a two-semester unit independent study course in biology. In this course the individual student chooses a topic to investigate through laboratory and field experimentation. There are no formal class meetings; however, the student works closely with an instructor in weekly consultations regarding procedures, progress, and interpretation of data.

The student perceives, through his own experience or during a biology course, that a question exists, and then with help from the instructor the student formulates a tentative answer to the question and collects data to support his hypothesis. The independent learning experience offers the student an opportunity to undertake a study that he sees as meaningful and to get the satisfaction of developing expertise in an area.

My students have undertaken some unusual studies that are not only useful in furthering the students' learning but also have practical applications. One student performed bacteriological monitoring of an industrial waste outfall for a three-month period, and his findings were used by state officials in determining polluters of San Francisco Bay. This student learned about specific pollution assay methods in more detail than is covered in any classroom-laboratory situation. He had to evaluate his information, which was not standard "laboratory data," and this caused him to appraise his own methods and techniques as well as those used by others in similar techniques.

Environmental baseline data were accumulated by ten students over a two-year period (each individual student enrolled in Independent Study for one semester during that time) on a local coastal creek draining from the Coast Ranges to the Pacific Ocean. The individual topics on which students did reports were (i) aquatic insects of the creek; (ii) birds and mammals; (iii) bacterial flora; (iv) flowering plants; (v) storm drain and sewer contamination; and (vi) physical and chemical quantitative data. One student prepared a 35-mm slide presentation synchronized with a tape-recorded monologue on "A Day at the Creek." This creek is presently the subject of two Environmental Impact Reports (California Environmental Quality Act) and one federal Environmental Impact Statement. The data acquired by Skyline College students are being used for the required biological impact sections of these reports.

The independent study projects not only provide environmental baseline data to local planning agencies but also give instructors current information on local

Fig. 1. Students Garrett Jones and Susan Keach indentify plants as part of a biological assessment in an Environmental Impact Statement.

areas for use in the classroom. Instructors do not often have the time necessary to gather such data themselves, but through their involvement in the students' independent study projects they are able to supplement well known "textbook" examples of biological and ecological principles.

A commitment of time is needed on the part of the instructor. I spend from three to five hours per week with my independent study students. The number of students varies; an instructor may have up to five each semester. Field projects take less instructor time than laboratory oriented projects. The instructor need not be present for each field trip taken by a student but the instructor is often needed in the laboratory to supervise work and arrange for materials and supplies. During semesters when the instructor's time is limited due to class schedules, field projects should be encouraged for independent study students.

The student's work is evaluated on the basis of approach to the problem, the number of hours devoted to the project (usually six hours per week), and a written report submitted at the end of the semester. The report must include some literature survey, procedures used by the student, data and results, and a discussion and conclusion. Each report is kept on file in the biology department and instructors and students may use them for reference material.

Nonscience majors can partially fulfill their science requirement through enrollment in independent study. There is a prerequisite of one previous college biology course.

The availability of money is not a limiting factor for

Fig. 2. For their independent study projects, Linda King and Steve Roller press plants for a herbarium collection for the college.

independent study projects. Some studies, such as identification of flowering plants, marine algae, lichens, or birds of an area, do not cost the instructor or the college any money. The students enjoy the field work and can do most of the identification after initial help from the instructor. With some money available to the instructor plankton nets, hydrometers, dip nets, and other limnological equipment can be purchased for aquatic studies. Microbiological analyses require the purchase and preparation of media. I have used Millipore (membrane filter) equipment for about half of our bacteriological studies with good reproducibility of results. Larger budgets will allow the purchase of boats or spectrophotometric equipment, but these projects really need not be elaborate. Recently I have obtained funding that allows five students to go out weekly on a research vessel performing coliform counts, other bacterial surveys, and fish and invertebrate studies on San Francisco Bay.

Independent study projects have merit in the experience they give to the student, whether in studying bacterial degradation of crude oil or an enumeration of the lichens in a U.S. Government Survey quadrangle of farmland. I have found student interest is greater when their projects have meaning in relation to real environmental problems rather than biological abstractions. Pure research has merit and the data are meaningful, but the lower-division college student does not have the scientific background required for many such studies. Natural history and environmental data lend thenselves to these students' experience. The knowledge gained in independent study has led a number of students to major in biology, but this is not the purpose. The purpose is to create an awareness and concern in the student about his environment that results in an understanding of biological principles.

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ANATOMY OF A GREEN PEA

I employ the following laboratory exercise in my high school biology course as the culminating experience of the botany unit. It correlates the flower to the fruit as well as demonstrating other botanical concepts. Because the pea pod is the product of a flower, it is a fruit; specifically, a typical legume fruit.

This exercise lends itself nicely to a classroom lab activity. Only simple readily available materials are needed. These include fresh green pea pods (stringbeans or lima beans may be substituted), scalpel or razor blade, hand lens, glass slide, and microscope.

1. Observe the external features of the pea pod (fig. 1). The pea pod is an example of *dry dihiscent* fruit. When it is fully mature, it will split along very definite lines. As it opens, its seeds may be dispersed. Note the two seams that run the full length of the pod. One of the seams is *concave* and runs *into* the pod. The seam on the opposite side is *convex* and either lies flat or *rises* away from the pod.

2. Note the stem end of the pod. The *sepals* from the pea flower remain. There are five sepals. Since the pea plant is classified as a dicotyledon, we would expect its floral parts to be in fives or multiples of five. At the opposite tapered end of the pod, observe the remnants of the *style*. The entire pea pod is an enlarged *ovary*. It has grown considerably from its original size to accommodate the seeds inside.

3. Note the green coloring of the pod. This color usually indicates the presence of chlorophyll in plants. To prove this supposition, cut a very thin slice of the pod and observe it under low power of the microscope. The spherical pale-green structures that you observe are *chloroplasts*. Photosynthesis takes place in these

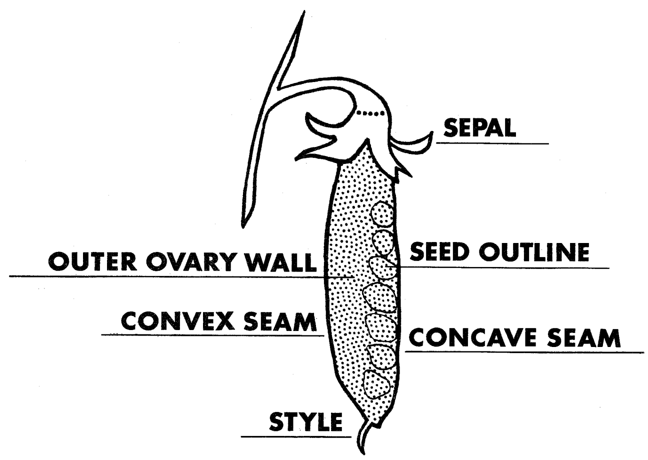

Fig. 1. External view of the pea pod.

structures. Pea pods not only protect the seeds inside but also contribute to their food supply by carrying on photosynthesis.

4. Now observe the internal structures of the pea pod (fig. 2). Carefully open the convex side of the pod