An Experimental Approach in Teaching Elementary Botany

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"In Botany 1 this semester, we shall have no textbook, no laboratory manual, and no formal lectures by the professor." This announcement, made to a freshman class in elementary botany resulted in raised eyebrows, not only in the class but also among some of the professors who heard the announcement. Now that the course has been completed, and some attempt at evaluation has been made, the story might interest those who are faced with teaching science to freshman classes.

The course had been taught for five years in the traditional manner, with two lectures and a three hour laboratory period each week. There were several students' comments which stimulated reorganization of the course. The comments were perfectly ordinary, and stimulating more in their implication than in the questions themselves. Such remarks as, "Is this what I am supposed to see?" "How many petals is this flower supposed to have?", seemed to imply that the students were afraid to trust their own observations.

I suddenly recalled a class in high school physics that I had once observed. The teacher was demonstrating the electromotive series, using a jar of electrolyte on his table, a series of metallic electrodes, and a huge voltmeter that could be read easily by all the students. The metals were introduced into the bath, and the class read the voltage from the meter and entered the reading in their notebooks. This went along very nicely until, in one demonstration, the meter read 1.9 volts. The teacher checked the metals, washed them off, and returned them to the bath—still 1.9 volts registered on the voltmeter. The teacher was obviously disturbed, and finally announced that the reading should have been 1.1 volts, whereupon the students immediately erased the 1.9 and dutifully wrote in the 1.1 value. My thought at the time was, "Is *this* teaching *science*? Here are these students being taught to overlook the evidence of their own senses in favor of the authoritative dictum of the teacher. Is this scientific?"

My thoughts reverted to our own Botany class, and I found that in lecture, and even in the laboratory, the students were depending more upon the utterings of their instructors than upon the materials presented. I was rather horrified to find out that my criticism of the high school physics teacher applied also to myself. The question was, how could the students be introduced to botany on a basis of lab work? Could we build up a basic background in botany founded upon the students' experiences in lab? To do so would involve study of plant materials without prejudice on the part of the student, so that sources of prejudice should be eliminated as far as possible. It was felt that the main sources of such prejudice were the text, laboratory manual, and the lectures, since each of these gave the student an idea of what to expect. The idea of offering a freshman course without a text, lab manual, or lectures seemed appalling unless some sort of continuity could be introduced into the laboratory

It was thought that if a long-term problem were presented to the students, the step by step attack on the problem would give continuity to the course. With this hope in mind, we drew a deep breath, and launched out into our experimental approach.

The First Class Meeting

The following notes were used for the first "lecture".

1. The course this year is new in organization; in method; in laboratory; and in examination.
2. There will be no formal lectures, unless

the class at some time specifically requests a lecture upon some definite topic. Such lectures may be delivered by the professor, or by appointed members of the class, as a symposium.

3. There is no assigned textbook for the course, and no laboratory manual. There are, however, many books on botany, both elementary and advanced, in the Biology Library. These are *not* on reserve, you may select any book that you wish for references.

   May I point out at this time that there is no such thing as an accurate text. Botany is advancing so rapidly as a science that it is impossible for an elementary text to be up-to-date in all fields. Even if it were up-to-date when written, it would be partially out of date when published. Therefore, WE SHALL NOT USE ANY TEXT AS AN AUTHORITY FOR ANY OF OUR CONCLUSIONS. Our conclusions *must* be based upon our observations in the laboratory. Books may serve well as a source of *ideas*, but let us not use them as a source of *facts*. These come from the plants studied in the laboratory.

4. The organization of the course is YOURS. YOU will decide what we will study, and when we will study it, BUT:
   You will be held for a knowledge of the structure and function of seed plants, and at the end of the semester you will be expected to know quite a bit about plants, how they are constructed and how they function.

5. Here, basically, is your problem: We have here on display a series of bean plants of varying ages. (The display included seeds; seeds with root emerging; seedlings with cotyledons emerging; seedlings with first leaves; seedlings with compound leaves; plants in flower.)

   If we take this bean, and plant it, we find that this whole plant, complete with flowers, develops. Your problem is: "What has occurred in the meantime? How did these various parts, root, stem, leaves, flower, develop? Where did they come from, and just how are they formed?"

6. You will be supplied with laboratory equipment, with some plants, and with greenhouse space where you may grow plants that you wish to study. You will decide what investigations you wish to pursue. I will attempt to act as moderator in your discussions, and will help you, BUT NOT DIRECT YOU, in setting up your investigations. My major role will be to ask questions, which you can answer from your observations. I am *not* an authority, but the plants which you study *are*. The facts lie with the plants, not with what I say about them.

7. You will be working in groups of about six, around a lab table. You are expected to pool your findings with other members of the group, and in cases of disagreement, call in the other groups for consultation. If the disagreement continues, there is no point in calling *me* in to decide the case, because your conclusions must be based upon *your observations*, not upon *my opinion*.

   Naturally, you will find cases which cannot be resolved with the materials at hand. Such cases must be investigated through the use of more material, or must be left unresolved for the moment. We cannot hope to solve all of the questions which will arise during the course.

8. During the regularly scheduled laboratory periods, we shall attempt to pool the findings of the table groups in both laboratory sections, to see if we can draw reasonable conclusions therefrom. We shall also attempt to develop methods of approach to be used in the coming lab period, so that you will know what to do, and how to do it.

   These will be discussion periods, with your professor acting as moderator. The responsibility is *yours* to share your findings with the other groups, and to see that they share their findings with you. You may ask them direct questions if needed. Now, are there any questions?

Q. 1. "Who will decide what plants we can grow?"

A. "You will, and you will be held responsible for such plants as you do grow. If, for example, you grow orchids, gardenias, or roses, in addition to other plants, you will be held for the variations in structure shown by these plants."

Q. 2. "How about examinations?"

A. "At the present time, I do not know, but I think that I shall be able to call each of you into my office during a regularly scheduled lab period, and can have a conversation on what you have learned during the course."

Q. 3. "The bookstore is selling a text for this course. Why?"

A. "The text is demanded in the other lecture section. You may purchase one if you desire. The reason no text is required here is that I do not want you to go into the laboratory with a preconceived idea as to what you are going to see. In short, read the books for IDEAS, not for FACTS."

This concluded the first meeting of the class, and they proceeded to the laboratory, where seeds and seedlings of both castor bean and garden bean were available. The following questions were presented to give starting points for observations:

1. What is the order of development of the various parts of the plant?
2. What similarities and differences can you observe in these two sets of plants?
3. What structures in the garden bean seed correspond to those of the castor bean seed?
4. How many of the structures of the grown plant are distinguishable in the seed of the plant?

The students varied in their reaction. About fifty percent wondered what they should do, but gradually the two groups (at two tables) settled down, one to a strictly comparative approach, the other to a developmental approach.

The comparative approach group even sectioned the stems, and found that the epicotyl of the garden bean was hollow, whereas the hypocotyl and all of the castor bean steam was solid. They reasoned that the hollowness of the stem was due to increase in diameter caused by growth, and all accepted this until one of the students measured the diameter of a young (hollow) epicotyl and found that it was less than that of the older, solid hypocotyl. The reason for the hollowness was left in abeyance, but the FACT was noted.

The developmental group traced all of the features usually "taught" in the seed, and noticed the reduction in size of both the endosperm of the castor bean and the cotyledons of the garden bean, as the seedlings developed. In the second lab section this was carried further in an attempt to homologize the structures in the two seeds. The discussion as to whether the cotyledons of the garden bean were homologous to the cotyledons or to the endosperm of the castor bean, was carried well past the closing hour of the lab.

The entire class participated in this closing discussion. Dissection after dissection was made (excellently, too!), while the remainder of the class and the professor watched. As the dissections were made, the facts were pointed out, and at the close of the period it was accepted that the endosperm of the castor bean was "attached" to the "leaf," and that in the garden bean the "cotyledon" was attached to the stem.

Although the class was unselected, the initiative that they demonstrated was quite surprising. They reasoned, during a lecture period, that the growth of the root from the radicle had to be due to either the enlargement of cells already present, or to the increase in number of cells. Thus, in a later lab, they took young roots of onion, cut them into six pieces, and gave one portion to each member of their table group. Each student cut up and stained his portion in iron aceto-carmine, and then they pooled their findings to discover that the higher portions had longer and wider cells, and only the lowest portion (the root tip) showed evidence of cell division. In the next lab period, each student studied squashes of root tips in aceto-carmine. They noticed the changes occurring in the nucleus, and drew the configurations which they could observe. These drawings they arranged in order on the wall of the laboratory, in a sequence proceeding from one cell to two cells. The final series of drawings was an excellent presentation of the process of mitosis. Of course they did not learn the terms for the various "phases" of mitosis, but they did demonstrate an understanding of the process. Their presentation of some two dozen transitional stages on the wall of the laboratory emphasized their concept of cell division as a continuous process.

At the beginning of the course, we felt that the students would cover less material, might cover it less intensively, but should retain more of what they learned. Experience has shown us that the students actually cover more material, cover it more intensively, and appear to retain it more effectively. Also, since the students are actively engaged in working out their own problems, they are more interested in the materials before them. Probably the strongest criticism, mentioned by less than 10% of the class, was that they felt that they were not covering enough material. However, this feeling was not borne out by their achievement in tests. The most frequent favorable comments by the students were, in order: (1) the experimental approach was highly desirable; (2) the approach was interesting; (3) it was a stimulant to learn more, not only in botany but in other fields, using the same approach.

The course has been offered following this method five times, and will, I presume continue to be offered along these lines. Although the procedure is far more demanding of the instructor's time and thought than is the conventional teaching method, the instructor profits from having greater stimulation from a more inquisitive group of real students.

Eye Care Pamphlet

A blind worker waits at an intersection. A young man assists him across the street.

"I'm new at this," the blind man says. "Lost my sight six months ago. Some chemicals exploded in the factory where I worked—right in my face."

These words are from the introductory paragraphs of a 28-page pamphlet entitled "Save Your Sight" published by the Public Affairs Committee in cooperation with the National Society for the Prevention of Blindness. The pamphlet is being offered at 25 cents per single copy by the National Society, 1790 Broadway, New York 19, N. Y. to increase public awareness of the need for eye care.

Two cups of heavily roasted coffee contain your daily requirement of the vitamin niacin.

Biology in the News

BROTHER H. CHARLES, F.S.C.
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A KILLER OF MEN, Frank C. Hibben, Outdoor Life, March, 1957, pp. 45-47, 77-79.

This account of tracking a sloth bear which had become dangerous to a small area in India contains many ideas of the conditions existing in another part of the world.

LIVING MYSTERIES OF THE DEEP, Daniel P. Mannix, Saturday Evening Post, March 9, 1957, pp. 24-25, 109-119.

Collecting rare and interesting animals from the sea is profitable for talented skin divers.

AMERICA'S NEWEST WILD ANIMAL, William Byron Mowery, Saturday Evening Post, March 16, 1957, pp. 51, 137-141.

The coydog, or brush wolf, a hybrid between the coyote and the dog, is our newest and wildest predator. It is gradually increasing and may replace the coyote in many regions.

CHILDHOOD'S NO. 1 ENEMY, L. Emmett Holt, Jr., M.D., Good Housekeeping, March, 1957, pp. 34-35, 131.

Over 12,000 people died as a result of accidents during the past year. This article suggests means which parents and others can take to prevent accidents. A good article to stimulate safety campaign.

91 POUNDS OFF, Dawn Crowell Norman, Ladies Home Journal, March, 1957, pp. 80-89.

Excess poundage is a social as well as a physical hazard. Excellent material to initiate a discussion on dieting.

THESE 7 PEOPLE WERE SAVED FROM CANCER, Patricia and Ron Deutsch, Ladies Home Journal, March, 1957, pp. 128-129, 231-232.

Sane notions about diseases, which can be acquired in early life, brought these people to the doctors in time.

Most of the niacin in roasted coffee is formed during roasting, and at least some of it appears to be made from a related compound, trigonelline, which has no vitamin activity. The niacin is easily dissolved out of the ground coffee during preparation.