A Summer Biology Program for High-Ability Students

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The NSF summer programs for secondary school students are well known to all biology teachers. The director of one such program tells about his experiences. He is Assistant Professor of Zoology and Science Teaching.

Providing stimulating science experiences for talented youngsters has become an important concern of the scientific community. New curricula and advanced science courses are now being offered in many high schools. Also, colleges and universities, in cooperation with the NSF, have developed special programs for these students. During the summer of 1964, more than 200 programs were conducted throughout the country, involving some 7,500 bright science students. One such resident summer program in biology has been offered at Syracuse University for the past four years. The Syracuse University program is discussed in this article with the hope of stimulating further interest in this type of endeavor.

Program Objectives

What could be done during several weeks in the summer that would be most worthwhile for these bright youngsters? We felt that, whatever was to be done, the program should:

1. Be challenging and provide unique experiences that the student might not otherwise be exposed to in high school or college.
2. Expand the scientific background of the participants.
3. Develop an appreciation of the true nature of science and research, including philosophy, objectives, uncertainties, and methodology.
4. Excite and motivate these capable students, and provide them with a basic framework that would better equip them for future scientific pursuits.

With our primary emphasis upon motivation and whetting appetites, we decided to offer a broad course including many different biological topics. The emphasis would be on laboratory work and unique experiences. Also, by exploring many different aspects of biology, some students might discover a field of special interest for future research.

Initially, two courses were organized, one in botany and another in zoology. In 1964, it was decided that the students might benefit more from one unified course in biology that included significant aspects of both botany and zoology.

General Outline of the Program

Forty-one outstanding high school science students were selected as participants in 1964. Students were expected to pay for their own room and board. Limited NSF funds were available to assist those qualified individuals who could not otherwise afford to attend. A modern dormitory housed all of the program participants as well as a number of other talented high school students who were enrolled in liberal arts courses. A resident staff was assigned to this dormitory, and the high school students were subject to the same regulations as the University undergraduates; also, all of the usual student facilities were available to them. The class met from 9 A.M. until 5 P.M. daily for five days a week for the duration of the six-week program.

Selection of Participants

We believed that the students who might benefit most from our particular program would be those who were bright, capable of coping with biology at an advanced level, but who had not had extensive biological training. Our selection criteria were:

1. Scholastic achievement.
2. Letters of recommendation from two high school science teachers.
3. Completion of a high school course in biology and preferably one in chemistry.
4. Official data and recommendation from the school guidance counselor or principal as outlined in a special questionnaire supplied in the application.
5. Grade level; the student must have at least completed the 10th grade.

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6. Questionnaire for the student requesting a discussion of his laboratory experiences in biology, interests, and a list of what he considers to be significant, unsolved problems in biology.
7. P.S.A.T., S.A.T., and I.Q. scores when available.

The staff of the program selected approximately 100 superior students who seemed well-suited for our program. Then the really difficult job began of narrowing these applicants to forty. When we reached the point where no further distinctions could be made among students according to scholastic criteria, we gave some consideration to geographic distribution, attempting to achieve diversity in this respect. One of the most valuable aspects of the total experience is association of these high-ability students with their peers; the greater the diversity in geographic representation, the more valuable this part of the experience is likely to be.

Although high school juniors were generally preferred, bright sophomores who had just completed their high school biology course were eager, enthusiastic, impressionable, and capable of handling the work in our program. It was our feeling that the earlier a student could participate in the program, the more quickly he could decide whether or not science best suited his needs and interests. This practice also provided a feedback into the high schools and could serve to stimulate other high school students with high scientific aptitude. In addition, it was believed that, having participated in a broad course such as ours, a student would be ripe for a research participation program the following summer, or would be stimulated to do independent research at his high school. Thus, we felt that a mixture of students about to enter their junior or senior year in high school was generally desirable.

Despite the multiple criteria used for selection, there were several relevant features such as motives, emotional maturity, attitudes, and quality of previous science courses, that could not easily be evaluated from applications. When students arrived, we found a heterogeneous group with respect to these characteristics. Rather than attempt to assure homogeneity, we designed the program with the expectation that there would be heterogeneity. Accordingly, we planned a hierarchy of activities with research projects being available for the more capable of these advanced students.

Pre-Planning

It was obvious that six weeks was a very limited span of time for our type of program, and so it became imperative that the schedule be very carefully pre-planned. The more thorough the planning, the better the course, and the easier its administration and teaching. In addition to the work of planning a syllabus, arranging trips, acquiring guest lecturers, ordering supplies, and handling the selection process, we were faced with the job of preparing the students for the course. Past experience had indicated that there was likely to be a lag period of adjustment at the start of the course. It was our intention to minimize this adjustment period so that the students could derive as much as possible from the six-week experience. This was done through letters describing the program and the dormitory living, and by advance assignments. In preparation for an evening student panel discussion, the students were told to read Rachel Carson's *The Silent Spring* before coming to Syracuse. They were also told to read John Steinbeck's *The Winter of Our Discontent* for another panel discussion to be held with the liberal arts high school students. Students were also asked to list some possible biological topics for a twenty-minute discussion to be presented in class. Thus the students were actually doing some of the course assignments before they arrived on campus. As a result of these assignments, the vast majority of the participants were psychologically prepared for a busy summer right from the start. This proved to be very effective in shortening the adjustment period and setting an intensive pace for the program.

We prepared ourselves for the students by attempting to be well-acquainted with them from their applications before meeting them for the first time. Thus we could establish good rapport from the start and anticipate some possible problems. Students were also required to submit a health form from their physician before coming to Syracuse, and health insurance was also arranged for their stay on campus. This was a very important part of the pre-planning, since minor acci-

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dents involving special care were not uncommon.

Course Content

The general plan of the course was to span important biological subjects from the molecular to the organism and population levels. The daily schedule involved the following:

1. A lecture and discussion session from 9 a.m. to 10:30 a.m. daily, Monday through Friday.
2. The 11 a.m. to noon interval devoted to guest lecturers, special demonstrations, and student oral presentations.
3. Lunch from noon to 1 p.m.
4. Laboratory from 1 p.m. to 4:30 p.m.
5. Several evening speakers and activities scheduled on selected evenings.

We believe that the students are often stimulated by the whole experience rather than any single aspect of it, and we attempted to create an exciting atmosphere where every moment was filled with challenging and interesting opportunities for learning. We appreciated the fact that these were not ordinary students, and would not be stimulated by an ordinary course. These students were eager to learn and had a tremendous capacity for achievement that we intended to push to its limit from the very beginning. As long as the students complained about the impossibility of maintaining the rigorous pace, we knew that the course was going well. We expected complete devotion to the program five days a week; the weekends were the students' own. We did plan recreational events for some weekends, but attendance was optional. In general, opportunities for laboratory work were eagerly sought after and appreciated by these students, and they often worked in the laboratory during evenings and weekends.

Lecture and Discussion Period

These sessions dealt with fundamental concepts and modern research developments in many biological areas, with special emphasis upon molecular biology and the cell. We attempted to keep these lectures on as high a level as possible. We realized that "watering down" subject matter with these bright students would be disastrous and and completely contrary to the purposes of the program. Accordingly, the questions asked, and the discussions provoked by the students were generally sophisticated and intellectually stimulating. We sought to impress them with how little they and research scientists know about basic life processes, and to point out the unsolved problems in biology and reveal the endless nature of science.

Student Oral Presentations

All participants presented a short discussion on a biological topic of their choice. These topics were not discussed elsewhere in the course. Thus, the student not only had the experience of presenting a scientific discussion to a peer group, but he also helped to broaden the scope of the course content. In relation to his topic, each student was required to submit critical discussions of ten articles from three different scientific journals. The student thus gained some experience in the utilization of journals, assembling a bibliography, and evaluating scientific investigations. The participants had access to all of the University library facilities and also were permitted use of the library at the Upstate Medical College of the University of the State of New York. A tour of these libraries was conducted on the second day of the course, and students were encouraged at the start to make maximum use of these facilities.

A number of the oral presentation hours were devoted to guest researchers who discussed their specialized field of research. This generally involved a one-hour presentation and then a half-hour discussion period. This summer, researchers gave talks on protein synthesis; electron microscopy; chromosome puffing; slime molds; mitosis; growth control mechanisms in mammals; bacteriology; virology; photosynthesis; paleobotany; parasitology and malaria; and immunology. After each session, the researchers had lunch with a group of the students so that informal discussions could be carried on.

In addition to the above, we had some researchers who conducted tours of their laboratories, gave demonstrations, or organized laboratory sessions relating to their speciality. Among these events were the following:

1. A demonstration of the electron microscope.
2. A two-day lecture-laboratory session on neurophysiology, including a demonstration of the electronic equipment used in this research field.

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3. A two-day lecture-laboratory session on the anatomy, physiology, and pathology of the human mouth.
4. An introduction to radiation pathology, highlighted by autopsies on irraiated rats.
5. A two-day laboratory in bacteriology.
6. Tours of the modern biological research building at Syracuse University and of Bristol Laboratories.

These guest presentations were very interesting and inspiring to the students and served to provide uniqueness in the program.

Laboratory

In the laboratory, special effort was made to introduce the students to a variety of techniques and organisms through carefully selected experiments and exercises. Included were laboratories on salivary gland chromosomes in Drosophila; chromatography; mouse parasites; and a dissection of the fetal pig. In addition to the regular laboratory meetings, each student did a Drosophila cross and analyzed the results; each student went through the process of making a histologic preparation, involving fixing, embedding, and staining techniques and use of the microtome; each student did a planaria regeneration experiment; each student was given an unfamiliar vertebrate to dissect, and a student presentation concerning the different vertebrate classes was held during the final week of the course.

In addition to the laboratory assignments, each student assembled a three-dimensional DNA model (*DNA Model Kit* by Van R. Potter available from Burgess Publishing Company, Minneapolis, Minnesota, at $1.50 each). Another assignment was to write a critique of a provocative letter on evolution from Dr. Van der Waerden, a well-known mathematician, to Professor Th. Dobzhansky, a leading evolutionist. Upon submitting a critique, the student was given a mimeographed copy of Dobzhansky's reply to Van der Waerden, thus making the unpublished views on evolution of two outstanding scientists available for the student's own evaluation. This assignment was giving during the first week of the course and was due during the final week thus providing an interesting subject for "spare time" thinking and discussion.

Provision for minor research projects was made for those students who were capable of handling more than the regular schedule. This generally involved learning a specialized technique, or doing some preliminary research that the student could continue at his high school. This year, one student learned techniques for determining antibody titers in mice; two students studied the effects of radiation on blood cells in the mouse; two students studied the effects of temperature on the expression of the vestigial wing locus in Drosophila; one student did chromatographic studies of eye pigments in Drosophila; one student spent almost full time working on the effects of trace elements on the formation and germination of spores in bacteria.

The availability of a hierarchy of laboratory activities ensured challenging all sufficiently, despite the heterogeneity in the backgrounds and abilities of the students.

Cultural, Social and Recreational Activities

These students were anxious to participate in as many intellectually stimulating activities as possible, and we attempted to arrange cultural, social and recreational events that would contribute to their development as young adults. We spaced the extra-curricular events carefully, so as to achieve a balanced program.

Beginning the second week of the program, Wednesday and Thursday evenings from 7:30 p.m. to 8:30 p.m. were reserved for guest lecturers who spoke to the NSF and liberal arts high school groups. The sessions were held in the dormitory lounge. The Wednesday evening lectures were concerned with animal models of human diseases; "beat" literature; modern art; and a discussion of Faulkner's works. The Thursday night sessions were conducted as forums with enthusiastic student participation. A psychiatrist led a provocative discussion related to his field; a research chemist from England aroused a hearty discussion on science careers for women; two student panel discussions were held . . . one concerned Rachel Carson's *The Silent Spring*; the other pertained to American morality and was based upon John Steinbeck's *The Winter of Our Discontent*. All of these events aroused interest and we often continued well beyond the hour planned.

Scheduled weekend social activities included coed swimming at the gymnasium pool;

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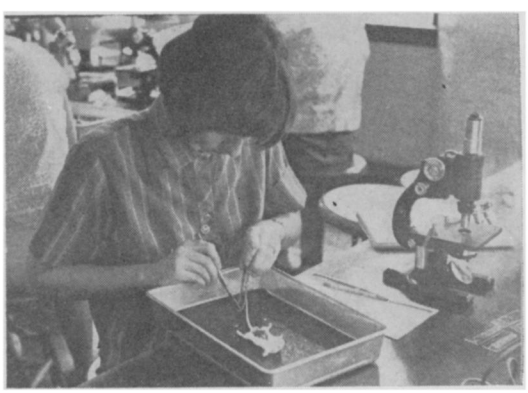
picnics; staff-student softball games; a group theater party (to see Shakespeare's *The Merry Wives of Windsor*); and a dinner at the termination of the course at which time the students were presented with certificates attesting to their participation in the program.

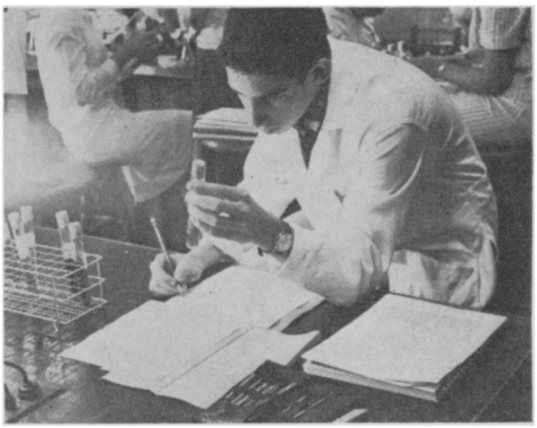
Credit, Examinations and Evaluation

We attempted to remove the usual pressure of grades so that the students would feel less restricted in their questioning, discussing and learning. Accordingly, no final grade was given in the course. The students received a diploma testifying to their participation, and a letter describing the course of study was sent to an official in the participant's high school. If a youngster did outstanding work during the summer, we commented to this effect at the bottom of the course description. We hoped that this information would become a part of the student's school record.

At the same time that we wished to free the participants of grade-consciousness, we realized that they desired an opportunity to express their knowledge, insights and ideas. Accordingly, we gave one written "progress indicator" during the fifth week of the program. The "indicator" was designed at a level of difficulty beyond the usual first year college freshman biology course. The students were told how they ranked within the group; however, we stressed that the comparison was not completely valid because of the heterogeneity in backgrounds. In the future, we are considering administering an examination at the start of the course, so that we will be in a better position to evaluate this heterogeneity. Also, we feel that several "progress indicators" instead of one exhaustive examination may be more useful.



Sondra Kopet searches for parasites in the mouse.



Ronald Germain observes an indicator color change in an experiment on photosynthesis.

During the final week of the course, we interviewed each student, examined his laboratory dissections and notebooks, questioned him, and discussed various highlights of the course and his future plans.

What Have We Done?

Every time we review the items included in the above program, we are amazed at what these students are capable of accomplishing. They often are surprised themselves at their capacity for achievement. They are also overwhelmed at the extent of what is known, and especially impressed at what is not known that they previously thought was known.

It would be fine if we could say that every student who participated in the program left with an enthusiasm for science that would lead him towards a brilliant scientific career. This was certainly not the case. A number of students came to our program uncertain about their interest in science, and doubtless, some of them left convinced that biology was not for them. This was important for these students to know at an early age so that they could devote their high ability to more suitable ends. Certainly, the student who knows his future calling at an early stage in his college career is at an advantage. Other students presumably left our program more enthusiastic about a future in science than before they came. Letters from past participants lead us to believe that this was true in many cases. But how do we know what, if anything, the program has done for the students? We may do follow-up studies and find out that 90% of the past participants have majored in

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science at college. But how many of these would have majored in science even if they had not participated in the program?

Although there are serious difficulties in objectively evaluating the effects of such programs, we cannot escape the conclusion that we are moving in the direction of better education. We cannot deny that these bright students have the opportunity to associate with their peers from many different geographic locations; that they are living the life of a college student; that they are discovering and appreciating their own capabilities and learning more about themselves; that they are developing a sense of responsibility and self-reliance; that they are growing intellectually; that they are developing attitudes that may influence their behavior in the future; that they are encountering one of the unique experiences of their lives. We feel secure in saying that a student cannot help but benefit in some way from this sort of experience. Even if only one out of many individuals is motivated further towards a career in science by his participation in such a program, we believe that we have sufficient justification for our efforts.

Science Is Easier to Teach Today

Dr. Edward Teller, Nobel prize winning physicist and Associate Director of the Lawrence Radiation Laboratory at the University of California, Berkeley, says, "It is wrong to teach high school students chemistry, physics and mathematics as separate subjects." He thinks students might learn more in a simpler and more unified manner if these subjects were taught together.

Appearing as a guest on the "Science All Stars" television program, Dr. Teller said he does not believe science is more complicated than it used to be, but rather, it is much more systematic. He suggested that young people who take all of the physical sciences together in high school learn more facts and are able to pick out the more essential ones better than in separate courses.

Dr. Teller stated that many young people are not sufficiently challenged in high school science courses today. "My general experience is that children are much more clever than grown-ups, and they can learn about ten times as fast. Children should start absorbing science when they are very young." The program is seen on the ABC-TV network.

Wildlife Pamphlet

Most people associate wild birds and animals with National Parks and National Forests. Not enough people, however, realize that other public lands have as many, if not more, big game animals. For these Americans, who have just as much a stake in lands administered by the Bureau of Land Management as they do in lands managed by the U. S. Forest Service and National Park Service, a new booklet should prove to be an eye-opener.

Available from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 35 cents per copy, "Wildlife on the Public Lands" describes more than 50 wildlife species and presents a profusion of full-color illustrations. Included are maps showing BLM lands in Alaska and the West, plus an ecological treatment of wildlife communities ranging from the deserts, grasslands, plains, forests to the tundra country of Alaska. You should find the booklet extremely useful in presenting students with basic ecological concepts in condensed form.

Laboratory Safety

Copies of the monograph of the Laboratory Safety Workshop can be ordered from the Higher Education Section of the National Safety Council, 425 North Michigan Avenue, Chicago, Illinois, 60611. The Workshop was sponsored by the Campus Safety Association and the Chemical Section of the National Safety Council at Rutgers University in July 1964, and the monograph costs $1.80.

Rabies Carriers

The two most suspected carriers of the virus that causes rabies are the bat and the spotted skunk.

Book Review Index

This journal is now being indexed in Book Review Index, published in Detroit, Michigan.

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