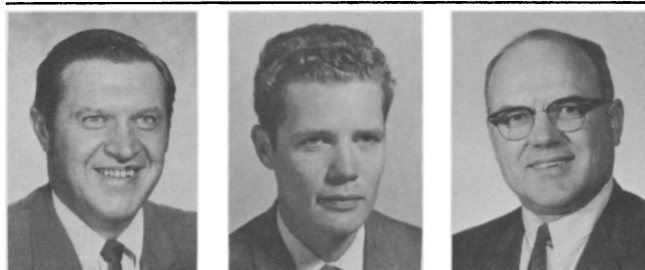


An AT Program in High School Biology

By CURTIS SMILEY, KENNETH BUSH, and DAVID McGAW

Would you like to have more time to work with individual students during class time? Would you like higher-ability students to tutor students who find biology difficult? These questions prompted the biology staff at West Lafayette (Ind.) Senior High School to incorporate audiotutorial (AT) programming during the 1969-70 school year. S. N. Postlethwait, of Purdue University, was the first to use AT in biology with large groups of students, and the nearness of our school to the Purdue campus permitted our students to use Postlethwait's materials and facilities. 24 juniors and seniors participated in the trial experiences. These students responded so favorably to AT that we decided to implement AT in the freshman biology program at West Lafayette.



The authors are instructors in biology, West Lafayette Senior High School, West Lafayette, Ind. 47906. Curtis Smiley (right) is a graduate of the University of Illinois and obtained his master's degree at Purdue University. He was also a Shell Merit Fellow at Cornell University. Kenneth Bush (left), with bachelor's and master's degrees from Purdue University, was the Indiana Biology Teacher of the Year in 1970. David McGaw (center) graduated from Purdue and has an M.S. from Ball State University; he is a member of Indiana's Outdoor Education Advisory Committee. The three men are co-authors of *A Systems Approach to Biology* (see references).

Four considerations were emphasized during the planning: (i) implementation, which included such items as a systems approach, use of student helpers, advantages and disadvantages of AT as part of the system, and the cost factor; (ii) cognitive experiences, which included student options for learning; (iii) affective experiences, which included student decision-making, discussion topics, and attitudes or behavior; and (iv) evaluation, which included grading of students and evaluation of the course.

Implementation

In order to implement AT we made the following major decisions:

1. Four rooms would be made available to the students.
2. 36 inexpensive carrels would be constructed.
3. Each carrel would be provided with a cassette tape-player, a set of headphones, a slide-viewer, and two textbooks for references.
4. Performance and instructional objectives would be written for every lesson.
5. A study guide would be written for each lesson.
6. Students would be allowed to establish their own pace.
7. The units for the year would be assigned to the three teachers, each teacher being responsible for writing, setting up, and testing three or four particular units.

The program was developed in accordance with the following goals:

1. To make the best use of the instructor's time.
2. To allow for the best use of the students' time.
3. To use performance and instructional objectives.

4. To have the students attain mastery of the course content.
5. To use students as tutors for other students.

We also decided to invite the students to meet with teachers after school to help decide what improvements should be made.

Necessary equipment in addition to carrel hardware included demonstration tables and various film-loop projectors.

The entire AT program, with all related activities, can take place in a single room (fig. 1) for a single class and can be conducted by one teacher. This one-room system was used for one grading period. However, team teaching appealed to us, and we combined our classes so that all students could move freely within four rooms: the 36-carrel tape room, a room set aside for reading, and two laboratories. One teacher remains in the tape room; the other two teachers are in the laboratories. Discussions are held when and where convenient. Students may take quizzes at any time in a reserved section of the carrel room. At the end of each unit a unit test is given in a large lecture room for all who desire to take this test.

Students are no longer grouped by ability, as they were before the AT program. The course is modified for students of different abilities, individually. Because the relationships are personalized, other students never know that a low-ability student has to answer only selected performance objectives.

In programs that involve self-pacing there are some students who lack the self-discipline necessary to meet deadlines. Students who consistently evade deadlines for the C grade (explained below) are restricted to the supervision of a specific teacher.

To encourage students to keep track of their progress toward the C grade or the A and B grades (explained below) for each unit, grade sheets are pinned up in a convenient display case. The grade sheets are kept up-to-date daily to tell students what has been completed and what is still incomplete. The students did not object to having their grades displayed—by number, not by name. This may sound as though the students became numbers instead of persons, but the students did not feel that way.

To encourage students to express their thoughts freely a suggestion box is placed in the tape room. Many good ideas have originated from the students. The suggestion box also serves as a release of emotions for some students who would like to tell someone how they feel but might be reluctant to do so publicly. Unsigned statements and questions are often received. When appropriate, the instructors' responses are posted on the bulletin board for all students to read.

Taking attendance is a problem, because the students can move from room to room. We considered it a waste of time to make students take seats for roll-taking at the start of class. Instead, when each student enters the classroom he places a small card



Fig. 1. Carrels set up in a single, self-contained classroom.

in a slot above his name on an "in and out" board on the wall; then he goes to the place where he plans to work.

As is evident, the student has many freedoms in this system. However, with freedom there must be structure in order to give direction and keep track of progress. We eventually evolved a flow chart (fig. 2), which brought more order to the classroom and solved many of the early problems encountered with the placing of certain responsibilities on the students. On the chart, every unit has cognitive material based on performance and instructional objectives. The student has several options in studying the cognitive materials. The student decides to be tested on the material when he feels he is ready. If mastery is obtained, the student may elect to work toward an A or a B grade by participating in the other activities shown on the flow chart; or he may be satisfied with stopping after achieving mastery of the cognitive material.

All activities beyond the mastery tests are optional. Each of these activities has a point value, and the points accumulate toward an A or a B grade. Here again the student decides what activities to pursue, according to his desires and interests.

Each student receives a copy of the flow chart; from it he is able to identify his responsibilities in determining his activities and level of learning. Although the flow chart is associated somewhat with the grading system, its main value is to bring about order and organization for students and instructors alike. The cognitive part of the system and that which uses AT encompasses those parts of the flow chart shown with shaded areas. The unshaded boxes represent the activities having more to do with behavior or in general what we consider to be affective.

We encourage past biology students to serve as laboratory assistants during their study-hall period. Because most juniors and seniors in our school have no study halls during nonscheduled classes, we draw mostly sophomores from study halls. These assistants

do odd jobs, such as making stock solutions, demagnetizing and cleaning tape recorders, duplicating tapes, helping keep grade sheets up to date, and duplicating and collating study guides. They receive partial school credit, which is recorded on their high school transcripts.

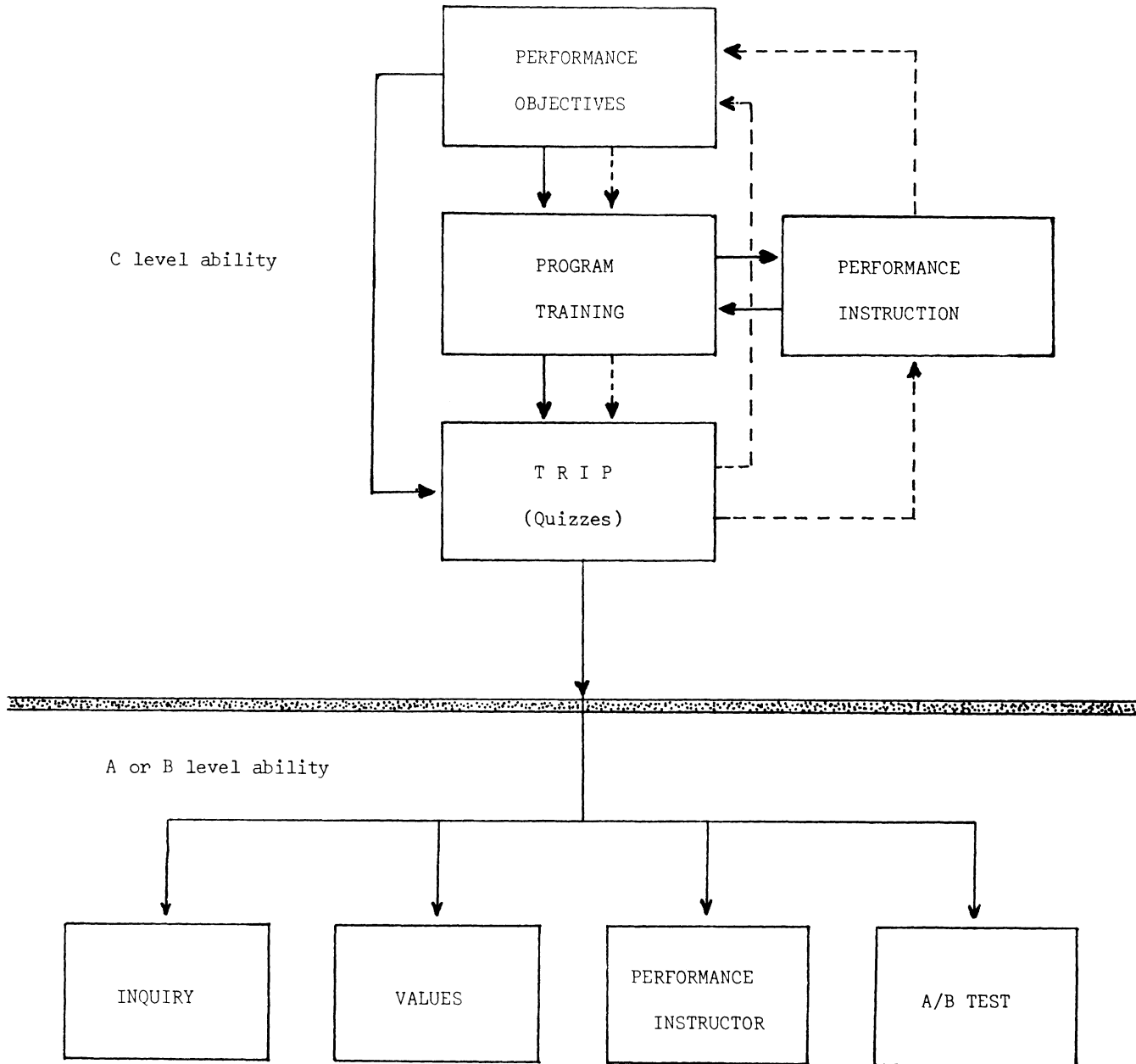
Required and developed curriculum units for beginning biology are as follows: techniques, plant diversity, animal diversity, chemistry, cell, energy,

microorganisms, genetics, development, and ecology.

Based on our experience at West Lafayette, we feel that the advantages of the AT system for secondary biology are as follows:

1. The teacher does not repeat the same lecture four or five times daily.
2. The teacher works more closely with the student.

Fig. 2. Flow chart of activities. TRIP stands for testing regular instruction performance.



———— Possible pathways toward a successful A, B, or C grade.

----- Possible pathways if student is unsuccessful on his quiz attempt.

3. It provides greater freedom in the choice of study methods.

4. The student can take quizzes when ready (self-pacing).

5. Students do not compete for grades.

6. Low-ability students can make an A or a B grade.

7. A student can repeat any lesson by rewinding the tape when necessary.

8. No student ever fails. Only incompletes are recorded.

9. Students who might not even raise their hands in the usual classroom situation will come to the teacher for help.

10. The students like freedom of movement.

11. The students like freedom to select experiments.

12. The students like coming from study hall to do classwork.

13. Most students prefer to structure their own time.

14. Much more feedback is received with the AT system.

We feel the limitations of AT in secondary biology are as follows:

1. Some teachers who have been accustomed to years of teacher-centered instruction may not be able to shift to a student-centered organization.

2. Some teachers may object to testing small groups daily.

3. Some students who have always been in classes with considerable external structure may find it difficult to change to more open, independent action.

4. Some administrators may be reluctant to endorse the program because of the imagined high cost of the hardware involved.

The cost of AT can vary according to ability to pay. Many expensive pieces of hardware are available, and this could make the cost relatively high per pupil. A system such as the one used at West Lafayette High School would require approximately \$1,500 worth of hardware to serve about 500 students, assuming best use of space and the teachers' time.

Cognitive Experiences

Students decide for themselves which option to use from the three options relating to cognitive learning outcomes: listening to the tapes, reading the textbook, or being tutored by another student who has already passed the lessons.

The first option is preferred by most students. Each lesson is recorded on a cassette tape. The student can play the tape as often as he wishes. A quick rewind allows the student to repeat a small portion he may have missed. Repetition of this kind is not possible, of course, in the lecture method of teaching.

Tapes 10 to 20 minutes long present basic facts and refer the student to specific features of pictures in



Fig. 3. A display on the demonstration table.

the carrel and to certain pages and paragraphs in the textbook. They also direct the student to the observation of displays on the demonstration tables (fig. 3). For instance, in genetics a student has to count plants with various characteristics to determine the genetic ratio; in development he has to observe the chick embryo on film; in animal diversity he has to mount protozoa on a slide and observe them; and in microbiology he has to use a colorimeter to determine the population of yeast cells.

A study guide also refers to two textbooks wherein the student can read appropriate material if he prefers this method of study. However, he must still look at the things on the demonstration table and carry out assigned activities.

Under the third option—tutoring—the student doing the tutoring will take a student to be tutored to a relatively secluded place in the biology suite and discuss all of the objectives with him. He will refer to the books and the demonstration tables to make sure that the tutored student understands what he is expected to know. A student instructing another student is called a performance instructor (P.I.).

Although students tend to prefer one option over another, preliminary studies indicate that most students use a combination of the options, with considerable variation from unit to unit. It appears their choice of learning activities depends on the difficulty of the subject and the reinforcement.

Affective Experiences

Decisions concerning A- and B-grade activities and their sequence reveal the student's affective motivations. Some students will commit their energy to experimentation and inquiry; others will spend more time on the social applications of scientific results. Many students will select combinations of several activities.

The affective experiences can be divided into three categories: laboratory inquiries, value discussions, and tutoring. A student can accumulate points toward an A or a B grade by taking part in these ac-



Fig. 4. A teacher conducts a discussion (background) while other work proceeds (foreground).

tivities. An A or a B grade can be earned only if the student works beyond the cognitive, or C-grade, requirements. To earn a C requires fewer decisions, although the responsibility of learning at all is still the student's choice.

The choice of working toward an A or a B is made entirely by the student. Further decisions must be made by the student as to what combination of activities to participate in to earn points toward an A or a B. Even further decisions are necessary, because specific responses or answers are not required for most A and B activities. In some instances the student must synthesize data and interpret them; in others he must justify a position he has taken. The aim of A and B activities is to cause students to relate facts to real situations and to recognize science as a complex of interrelated experiences rather than just a body of knowledge.

The inquiries include seminars. A write-up of various inquiries and attendance at seminars concerned with these inquiries will give a student up to 10 points per inquiry. Two or three inquiries are permitted per unit. Students are allowed to substitute their own inquiries for those in the study guide, provided they are approved by the instructors. The emphasis here is on data-collecting, scientific honesty, and interpretation of data. Some synthesis of facts is necessary in order to make the investigations.

Value discussions (fig. 4) are another method of receiving points toward an A or a B grade. These discussions have to do with debatable biologic problems in our society. The questions have no right or wrong answers. The teacher only guides the discussion; he tries to avoid influencing the students in forming their opinions. In these sessions, usually involving 10 to 12 students, every student is expected to be able to discuss the topic, express his opinion,

and support his position. The student learns that discrimination in reading and the ability to use a library are essential to the development of a position. A written position-paper for a topic can earn 10 points toward an A or a B grade. An example of a topic, used in studying plant diversity, is "Should herbicides be used to control weeds?"

The third method of achieving points toward an A or a B grade is tutoring (see above). The performance instructor is permitted to tutor another student only once per set of quizzes, which normally are given three times per unit. The P.I. receives 10 points per lesson tutored. This activity has allowed much interaction between students. At first, students considered this a form of cheating, in that a student who has passed a test is allowed to assist another student. After they recognized that mastery is the aim and that there are several forms of each quiz, they began to see the value of cooperation. The staff considers this activity a form of reinforcement, which tends to foster a positive attitude toward success rather than an attitude of failure or mediocrity. Presently, data are being collected to determine the proportion of students involved in this activity and the amount of time spent in tutor-pupil interaction.

There is a fourth method a student may use to accumulate A or B points. This is the A-B unit test. This test is given only once, and all must take it on the same day. There is an attempt to test such things as comprehension, application, and analysis (Bloom's categories). In each unit the A-B test has 40 possible points.

Role of the Teacher

What do the teachers do during class time? Because the basic presentations are on tape and there are textbooks and study guides available, the principal responsibility for learning is placed on each student. The teacher's role is much less authoritative and tends more toward providing direction, help, and encouragement. During class time the teacher is constantly helping some student with a part of the lesson he is having difficulty understanding; monitoring discussions; helping with laboratory investigations; and even posing new questions for students to ponder.

Much time is spent giving oral quizzes: each student must pass an oral as well as a written test on each lesson. Self-pacing spreads this activity over a period of time and does not present a problem; rather, the personal contact in giving quizzes develops the instructor's awareness of students' personalities and allows a chance to deal with students with different abilities.

It is no longer necessary to prepare lectures and repeat them four or five times a day. The staff feels this aspect of the system is a tremendous advantage. There is no longer the day-to-day pressure of being prepared. One might say there is more concern with the processes of learning and with attitudes than with learning facts.

Student Evaluation

Students are evaluated on cognitive learning for each lesson by means of oral and written quizzes. Two taped lessons usually are combined into one set of quizzes, which the student can take whenever he feels he is ready. If he has not taken the quizzes one week after the lesson started, however, an instructor asks him about it. If he is unable to demonstrate some progress for the week's work, either a P.I. is provided for him or else he is restricted to the supervision of one of the instructors.

A student is entitled to a grade of C if he shows proficiency in cognitive learning by passing all oral and written quizzes for the unit. No one is allowed to receive a grade of D or F; instead, the student who does not complete all quizzes will be asked to return next year when the unit is being studied. The student who does not complete a unit will be asked to complete only that unit, not the whole semester's work, to receive his grade. During the 1969-70 school year only eight of 224 students received an incomplete for the year.

The decision to work above a C rests solely with the student. The format for obtaining points toward an A or a B is the same for each unit and is based on a point total. The student has considerable latitude in choosing ways to obtain these points.

Each inquiry may earn up to 10 points, each value write-up may earn up to 10 points, each successful attempt at performance instruction will earn 10 points, and each A-B test has a maximum of 40 points. Accumulation of half the total available points for a unit by any combination of activities will earn a B grade. An A is earned by accumulating two-thirds of the total available points. Each unit has its own make-up of activities and potential points.

Bonus points may be obtained by exceptional response on oral quiz questions or by doing special work, such as a BSCS film loop with write-up.

All points are cumulative over a semester; this seems to add to incentive. Each semester has found more than 65% of all students receiving As and Bs.

Course Evaluation

We have used the Nelson Biology Test to weigh our progress against national norms. All biology students enrolled are included in our data. In the 1969-70 school year, pre-test data indicated a mean at the 19th percentile. The post-test mean was at the 69th percentile of the national norm—a significant change.

Currently we are studying the students' attitudes toward this system. Data will be collected during the entire school year. Analysis will be done in cooperation with the educational psychology department of Purdue University. An attitude scale instru-

ment developed during the 1969-70 school year is being used to obtain data. In addition, we are attempting studies of correlation of biology achievement, IQ, past science achievement, and attitude.

We hope the findings of these studies will support the intuitive feeling of the instructors that AT biology benefits the students.

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DDT, PCB IN THE OCEAN

Scientists have found concentrations of DDT in most specimens and polychlorinated biphenyls (PCB) in practically all specimens of plants and animals they collected on extensive cruises throughout the Atlantic Ocean.

The cruises, by vessels of the Woods Hole Oceanographic Institution, were part of the continuing United States program for the International Decade of Ocean Exploration. Scientists aboard the vessels were conducting projects designed to obtain baseline data for the study of marine pollution as part of the Environmental Quality Program of the IDOE.

Plants and animals sampled include *Sargassum* weed, zooplankton, flying fish, triggerfish, dolphin-fish, sharks, and many animals, including small fishes, that daily migrate from the surface to as deep as 900 m. Polychlorinated biphenyls are used as an insulator in electrical capacitors, as transformer oil, as a heating medium, and as a plasticizer; and they are present in hydraulic fluids and lubricating oils.