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INFORMATION FOR TEACHERS AND PRINCIPALS IMPLEMENTING BIOLOGICAL SCIENCE CURRICULUM STUDY (BSCS) BIOLOGY IN THE SCHOOL PROGRAM IS INCLUDED IN THIS GUIDE. THE RATIONALE AND CONTENT OF THE BSCS VERSIONS ARE EXPLAINED. PHYSICAL FACILITIES, LABORATORY EQUIPMENT, AND LABORATORY MATERIALS THAT FACILITATE TEACHING BSCS BIOLOGY ARE ANALYZED. ADMINISTRATIVE PROCEDURES AND ARRANGEMENTS FOR IMPLEMENTING BSCS BIOLOGY ARE PRESENTED. (AG)

BSCS BIOLOGY--IMPLEMENTATION IN THE SCHOOLS

This is volume Number 3 of a Bulletin Series prepared under the auspicies of the Biological Sciences Curriculum Study

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FOREWORD

The Biological Sciences Curriculum Study (BSCS) was organized in 1959 by the American Institute of Biological Sciences to seek the improvement of biology education and has been under the chairmanship of Dr. Bentley Glass of Johns Hopkins University. Major financial support for the BSCS has been provided by the National Science Foundation. After considerable planning and four years of testing and revising of its experimental materials, the Blue, Yellow and Green Versions of BSCS Biology, several BSCS Laboratory Blocks, and the BSCS *Biology Teachers' Handbook* were made generally available in the fall of 1963.

BSCS Biology represents the cooperative efforts of outstanding high school biology teachers and research biologists. More than 1,000 individuals were involved in the preparation, testing and revision of the books, pamphlets and films. These curriculum materials constitute a significant departure from the way biology has previously been taught in most high schools in the United States, both in terms of content of the course, approach to the subject and implementation in the classroom. BSCS Biology is laboratory- and discussion-oriented, with a de-emphasis on lecture and rote learning.

A large number of highly qualified people have invested considerable time and energy in the preparation of *BSCS High School Biology*. We believe that the BSCS materials can contribute to a substantially improved teaching of biology in American high schools The key to the successful use of these materials is the biology teacher and his environment. With this in mind, the present collection of reports has been prepared specifically for the school administrator who wishes to learn more about the BSCS materials and how to encourage and assist his teachers in the effective implementation of the BSCS program in his school.

This volume is the third in the BSCS Bulletin Series. The titles of the preceding Bulletins are *Biological Education in American Secondary Schools 1890-1960* and *Teaching High School Biology: A Guide to Working with Potential Biologists*. For further information about the Bulletins and other BSCS publications and programs, inquiries may be sent to the undersigned.

July 1, 1964

Arnold B. Grobman
Director

1 INTRODUCTION

Elra Palmer

Much has been written about the importance of science education. The need for change and reorientation of science teaching in the high schools has been obvious for some time. For too long, science has been taught in the schools as a body of classified knowledge rather than as an approach to problem solving and a means of learning how and why things happen in the natural world. The ability of man to control nature as well as himself is certainly one of the great aspects of modern science teaching.

We can no longer afford the slipshod approach to teaching of science in the high schools, for the basic fabric of modern society is woven from scientific discovery. Scientific progress has become a pivotal point in world politics. The young people in our schools today must learn that science is a dynamic enterprise and they must be challenged by the great conceptual schemes of science. Their productive adult years will extend beyond the year 2000; whether or not they become scientists, they will nonetheless need a knowledge of biological concepts to understand and appreciate the world in which they will live.

Biology occupies a strategic place in the secondary school curriculum. More than 90 per cent of America's high schools offer a course in biology and 8 out of every 10 high school students take biology; this represents a higher proportion of students than is enrolled in any other senior high school science course. For a majority of students the high school biology course is the last formal science course taken.

The emphasis in teaching modern high school science—an emphasis which is included in all the new high school curriculum studies such as the Physical Sciences Study Committee (PSSC), the Chemistry Education Materials Study (CHEM Study) and the Chemical Bond Approach (CBA) as well as in the BSCS—represents a completely new approach to teaching. It represents a complete reorganization of the subject matter rather than simply a revision of existing courses by a cut-and-paste method, with the addition of new discoveries and new theories as an appendage to a traditional structure in the discipline. The course materials prepared by the Biological Sciences Curriculum Study (BSCS) represent a completely new approach to high school teaching of biology. The emphasis is taken off memorization, excessive terminology and routine laboratory exercises and is placed on the nature of science, on the men who have worked as scientists and on scientific inquiry. These, the BSCS feels, are best learned in the laboratory and through interaction in meaningful discussion periods. Because the entire approach of BSCS Biology is new and many of the emphases in terms of subject matter are also new, it is important for the school's administrator to be informed about the broad structure of the innovations in biology teaching, even though he will naturally delegate the details of improving his science program to the director of instruction or the curriculum supervisor.

This, then, is the major purpose of this Bulletin. This volume outlines the changes taking place in the teaching of high school biology and indicates to the school administrator some ways in which he can encourage the development of a better biology program. BSCS Biology course materials appear to be an excellent vehicle for the upgrading of high school biology courses, but the most effective use of these new classroom materials depends to a large extent on the support the school administration gives the biology faculty and students. The succeeding chapters of this Bulletin describe the rationale behind the BSCS materials and suggest ideas and information of a concise nature for the school administrator concerned about and interested in the improvement of his biology program.

From the point of view of a science supervisor who has been involved in the BSCS program through the writing and testing stages, I am convinced that the school administrator and supervisor are key people in curriculum improvement in biology and such improvement will be difficult without their informed leadership, enthusiasm and interest.

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THE BSCS APPROACH TO HIGH SCHOOL BIOLOGY

Paul DeH. Hurd and Elra Palmer

At no other time in American history has a curriculum reform in biology been more urgently needed and more vigorously sought than at present. The nature of biology as a science has undergone momentous changes within the span of a few years. Journalists refer to the situation as revolutionary, and to the growth of new knowledge as explosive. Those of us who studied biology before mid-century will find much of today's biology unfamiliar. Discussions on genetics are more likely to be in terms of complex molecules than on the mating of fruit flies. Organic evolution is thought about in biochemical terms, and the evolution of metabolic processes attracts more interest than the sequence of fossils in the earth's strata. Discussions about photosynthesis are as much concerned with events in the dark as in the light. Biochemistry and biophysics have provided new research tools for the study of living organisms. Molecular biology excites the imagination of those who seek to explain life. ADT, ATP, ADP and DNA are new symbols and concepts for the biologists. The teacher of biology who fails to portray these achievements, who neglects the conditions of their attainment and who overlooks the challenges these new concepts present, is not introducing the student to the world in which he lives.

The Organization of the BSCS

The BSCS has worked to reflect the modern trends and emphases in biology in high school curricula. It carries out its work primarily through committees, composed of research biologists, high school biology teachers and others interested in high school biology education. Policy is implemented by a small headquarters staff located on the campus of the University of Colorado. A 27-member Steering Committee, appointed for 3-year staggered terms, sets general policy, and other committees are responsible for policy concerning such special programs as, for example, teacher preparation, test preparation, the special student, etc. An Executive Committee selected from the Steering Committee's membership sets policy between Steering Committee meetings. Most BSCS materials are produced by writing teams, under the direction of a Supervisor; the Supervisor may be either a high school teacher, a research biologist or a person concerned with biology education. All writing teams include college research biologists as well as high school biology teachers. All classroom materials go through an experimental edition prior to general release; that is, one or more experimental editions are tested in a variety of schools before a commercial edition is prepared. Materials of more general interest are issued through commercial publishers; those for a more restricted audience are issued through the BSCS. Regardless of which form of publishing is used, the materials remain BSCS materials in the fullest sense, since decisions concerning content are always made by the BSCS.

BSCS Biology, Blue, Green and Yellow Versions[1]

To date the major effort of the BSCS has been spent on the development of *BSCS High School Biology*, Blue, Green and Yellow Versions. Each version is a full one-year course intended for use at the tenth-grade level with average and above-average stu-

[1]Appendix F includes further details concerning the BSCS materials and programs in the form of questions answered by the BSCS Director.

dents; however, they have also been found suitable for use at the ninth-grade level with above-average students. The versions are parallel courses, of a comparable level of difficulty, but with differing emphases.

PREPARATION OF BSCS BIOLOGY. What should be taught in a high school biology course, and to what ends? The growth of the science of biology and its rapid progress in the past few years suggest that today an education in biology should be different in nature from that which was taught even a decade ago. This means that it must not only be different in biological content, but different in educational purposes and in the methods of teaching and learning as well. A completely new and modern course is needed; it is too late to profit from a mere curriculum revision.

The manner in which the BSCS Biology materials were developed, the extent to which they were tested, modified and retested with students and teachers is unique in American educational history. Writing teams were organized in 1960, each made up of equal numbers of college and university biologists and high school biology teachers. Though each writing team utilized a different approach to the high school biology course, all remained within the design of the BSCS purposes and themes which serve as unifying threads. The experimental materials were tested by 118 teachers with 14,000 students in 15 geographic clusters or Centers distributed throughout the country in 1960-61. Classes were taught in rural, suburban and urban centers, including schools in the inner core of large cities. Weekly meetings of teachers were held to discuss the week's class work and to prepare a group reaction report to the BSCS. Teachers provided weekly written reports on text and laboratory work. Students were tested on specially constructed tests to reflect emphases of the BSCS materials. Professional societies and individuals were invited to review the materials.

All of this feedback was used as a basis for the 1961 Second Summer Writing Conference, which produced the revised editions of the BSCS texts and laboratory manuals. These revised materials were again tested by 500 teachers and their 50,000 students in 35 states and the District of Columbia. Again the various kinds of feedback reports were systematically collected and used as the basis for a further revision of the materials during the summer and fall of 1962. And revision based on this experience was incorporated into the 1963 editions currently available through regular commercial channels.[2]

CONTENT AND APPROACH OF BSCS BIOLOGY. The BSCS texts and laboratory manuals provide curriculum materials that are not just reorganized from conventional books but are new in concept and purpose. The content is up-to-date and reflects the status of contemporary biology and the best thinking in terms of philosophy and objectives. For too long, biology—the science of life—has been pickled, pressed or embalmed.

One of the questions most frequently asked concerning the BSCS is: "How does the *BSCS High School Biology* differ from conventional biology courses?" Briefly, BSCS differs in several ways: *First,* it is the product of the cooperative efforts of teams composed of research biologists, high school biology teachers and other educational experts. *Second,* it is constructed on a basis of up-to-date ideas and concepts in the field of biology. It is not simply a revision of old concepts and ways of thinking. *Third,* it places considerably more emphasis on laboratory work than do traditional courses. Moreover, greater stress is placed on exercises of an investigative nature that introduce the student to science as a process of inquiry, rather than on the traditional illustrative type of laboratory exercises. The approach to inquiry may be characterized by the liberal use of such expressions of uncertainty as, "we do not know," "we have been unable to discover how this happens," "the evidence about this is contradictory." Frequently, the BSCS materials replace the customary authoritarian statements of conclusions with accounts of the development of our knowledge. That is, current views on a subject such as genetics are developed step by step through a description of the experiments performed, the data obtained and the interpretations made of them. The laboratory work is organized to convey a sense of science as inquiry. For example, the conventional illustrative type of laboratory exercise is frequently replaced by simple investigations. Some of the investigations treat problems for which the text does not provide the answers. They introduce the student to situations in which he may participate in the in-

[2]A detailed report of the 1960-62 evaluation is included in *BSCS Newsletter* No. 19, September 1963. A report of the 1962-64 evaluation is in preparation.

quiry. A new type of teaching material, "Invitations to Enquiry," designed to show how knowledge arises in biology and how it may be interpreted, are used to provide specific experience in the many phases of inquiry. Each "Invitation to Enquiry" reveals something about the nature of science as well as adding to the student's understanding of biology.

With these purposes in mind, nine themes were selected to convey the content and structure of biology. These unifying themes are common to all versions and reflect the goals of an education in biology:

science as inquiry
intellectual history of biological concepts
change of living things through time—evolution
diversity of type and unity of pattern in living things
genetic continuity of life
complementarity of organism and environment
biological roots of behavior
complementarity of structure and function
regulation and homeostasis—the preservation of life in the face of change

The first two themes convey the logical structure of the course; the others define the content. Each version of BSCS Biology is built around the same basic themes; the difference among the versions is one of emphasis and the content of all three is up-to-date and reflects the status of contemporary biology.

The organization of BSCS Biology around these integrating themes which extend throughout the course, requires that the content be presented in a particular sequence. In BSCS Biology, ideas and concepts are developed through a series of learning cycles; students utilize knowledge learned in the earlier parts of the course to build toward a deeper understanding of the same concepts later. The diverse data needed to develop concepts are presented at the point when they are likely to be best understood and utilized by students.

In BSCS Biology, there is greater emphasis upon molecular and cellular biology, the world biome, the biological community and the study of populations, in contrast to conventional biology courses where the stress is at the organ and tissue level of biology. In traditional courses at least half of the time is taken with the applied aspects of biology, while minimizing attention to basic ideas.

BSCS Chairman, Dr. Bentley Glass, describes the BSCS objectives in this way:

> There are two major aims in studying any natural science. One aim, the lesser in importance, is to become acquainted with the significant scientific facts upon which rest the major concepts and theories of science. These are the ideas that have so profoundly altered our views of man's place in nature and have so tremendously enlarged human powers over the forces and resources of nature. In biology, this objective also includes a first-hand acquaintance with living organisms and the outstanding features of their lives.
>
> The other aim is indispensable to young scientists and nonscientists alike—to everyone who hopes to participate intelligently in the life of a scientific age which so constantly demands difficult decisions and real wisdom. This second objective is to know what science really is—to recognize its spirit and to appreciate its methods. Science is not magic, and a scientific civilization surely will not endure if most people of intelligence regard science as a sort of magic. It is a way—or a composite of many ways—of finding out reliable, confirmed knowledge about all natural phenomena. It is compounded of the observations of the human senses and the inferences and deductions that can be derived from such experiences.[3]

Since the BSCS courses are new in concept and purpose, they must be taught in a manner and style that may be quite different from those used in conventional biology courses. The teacher of BSCS Biology finds his clues for classroom practice in the nature of the structure of modern biology, in its modes of inquiry, its theories and models, its concepts and the relevant facts. It is expected that the course shall be taught as a science and presented in a way characteristic of an experimental science. In describing this approach to biology, Joseph J. Schwab, Supervisor of the BSCS *Biology Teachers' Handbook*, comments:

> The gross implication of this revisionary process for science education is frighteningly obvious. It means that the notion of coverage, of conveying the current knowledge of a field, which was once the essence of science teaching, is called into question. It means that *expertise*, authoritative possession of a body of knowledge about a subject matter, is no longer enough to qualify men as the best teachers of science. It means that the education of the science teacher must be something more than, perhaps something quite different from, the inculcation of conclusions, and training in ways and means to pass them on. It means that time-hallowed instruments of instruction—the lecture which aims to be simple, clear and unequivocal; the textbook which aims to eliminate doubt, uncertainty and difficulty; the test which aims primarily to discover what the student knows and how he applies what he knows about a subject these will be inadequate or even inappropriate for much science teaching.[4]

[3] *BSCS High School Biology, The Laboratory*, 1960-61 experimental edition, *Blue Version, Green Version* and *Yellow Version*.

[4] Joseph J. Schwab, "Some Reflections on Science Education," *BSCS Newsletter*, No. 9, September 1961.

If the understanding of concepts and the development of inquiry skills are accepted as major goals for the teaching of biology, the manner in which the course shall be taught is then defined. The demand is for a classroom situation that stimulates questions, invites speculation and utilizes procedures of inquiry as learning activities. The teacher is a director of learning rather than a commentator upon the facts of biology. More is demanded of the student than just the ability to define terms and to relate structures to functions. An understanding of biological concepts must arise from the student's own efforts and from his own intellectual activities. This means, then, that the center of activity in the classroom is the student, and the teaching facilities should be planned around the learning procedures used by students.

THE BSCS LABORATORY. In the conventional biology course, most of the laboratory exercises are of a descriptive or illustrative nature. Specimens are examined grossly or microscopically and their structure is noted. Models and charts are frequently used either as substitutes for direct observations or to supplement them. A reasonably accurate drawing of the observed specimen, properly identified and labeled, is used as evidence that the work has been done and that the student's understanding of biology has been enhanced.

The value of observational and illustrative exercises in biology is not denied. But since much of the work is done with non-living organisms, its importance for understanding the nature of life processes is limited. The study of living things as they are found in nature is always a possibility, but then very few high school students have had this experience. In BSCS Biology courses, one purpose is to provide an authentic experience with living forms through carefully planned laboratory and field studies.

In BSCS Biology, the place, nature and importance of laboratory experience in the learning of biology has been re-defined. The entire effort has been one of developing laboratory activities that provide an opportunity for revealing a valid image of biological investigation. Scientists use the results of laboratory experiments as a primary source of knowledge and understanding. The BSCS writers felt that work in the laboratory should:

—contribute to an understanding of the many ways to investigate biological problems
—provide experience in how data are gathered, ordered and displayed
—raise problems as well as answer questions
—provide experience in independent learning

In the BSCS courses, data are gathered in the laboratory according to a plan, then used in combination with existing concepts to either clarify or extend their meaning. The work of the scientist in the laboratory is that of testing ideas or seeking understanding. The methods of inquiry used are those that offer some promise of success, but failures are usually more common than successes. The BSCS has developed a plan of laboratory work that provides many opportunities for students to engage in scientific inquiry. Wide use is made of laboratory experiments that provide quantitative data which require interpretation and explanation.

Such laboratory activities are in contrast to a laboratory situation that consists of a routine for gathering predetermined data that are to be fitted mechanically into specified blanks. The introduction to the laboratory manual in the experimental editions contained this statement:

> The laboratory is where the work of science is done, where its spirit lives within those who work there, and where its methods are transmitted from one generation to the next. One does not really learn science from books; one learns science by asking nature the right questions. And the laboratory is the place where one learns most readily what questions can be asked fruitfully, and how they must be put. It is where one learns why science insists on precise measurements, accurate observations, and conciseness and clarity in communication.[5]

To fully achieve purposes of this kind would require a new approach to high school biology laboratory work, a new kind of biology laboratory designed for the BSCS course and also taking advantage of the biological resources of the community.

Other BSCS Materials[6]

The BSCS has prepared other materials for high school biology teachers and students. The Blue, Green and Yellow Versions of BSCS Biology each includes a text and a laboratory manual which may be bound

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[5]*BSCS High School Biology*, 1960-61 experimental edition. *op. cit.*

[6]Appendix A lists complete titles of BSCS publications and the respective publishers.

separately or together, but which are complementary, with the laboratory representing an integral portion of the presentation. Each has a series of tests specific to the version and reflecting the types of learnings the BSCS is concerned with. There are also two end-of-course tests, the BSCS Comprehensive Final and Processes of Science Test, which reflect the broader objectives common to the three versions.

Each version also includes a teacher's guide to the text and laboratory exercises, to aid the teacher in implementing that particular version. The BSCS has prepared a BSCS *Biology Teachers' Handbook* which has general information concerning the philosophy of the BSCS, and ways of implementing this philosophy in the classroom. It also includes background information needed by the teacher in statistics, chemistry and physics, and a bibliography of classroom films and reference books for the teacher. (The student volumes include student references.)

To enrich and supplement BSCS Biology, a series of *Laboratory Blocks* has been prepared. Each of these is a six-week unit which may be used with any of the versions of BSCS Biology. They may also be used to enrich non-BSCS tenth-grade biology courses. The blocks are intended to provide the student with a laboratory experience in some depth in a particular area of biology, as, for example, plant growth or genetics.[7] *Innovations in Equipment and Techniques for the Biology Teaching Laboratory* is a useful adjunct to teaching the blocks.

A series of research problems has been outlined in the BSCS *Research Problems in Biology* series; each of the research prospectuses in these volumes outlines a problem and some possible starting points for profitable research. These research prospectuses are not meant to be science fair projects. Each problem may take a year or two to complete, and the problems are intended for individual use by those students who are extremely interested in biology and are willing to devote considerable out-of-school time to the development of an individual problem.

In the BSCS *Pamphlet Series*, eight pamphlets appear during the school year. Each pamphlet treats one area of biology—as for example, the origin of life or population genetics—to bring up-to-date information on a single subject. The pamphlets extend the BSCS Biology course and may be used as a classroom resource for supplemental reading or for teacher background information.

A *Single Topic Film Series* is presently being developed for classroom use. This will include short silent films of 4 to 8 minutes in duration and will deal with concepts found in each of the versions of BSCS Biology; the BSCS plans to make these available in 8 and 16 mm. The films are designed to illustrate concepts which cannot be presented as effectively in a book or through laboratory exercises.

The BSCS Biology versions are intended for the upper 65 to 75 per cent of tenth-grade students who now take biology. Extensive testing has indicated that the materials are within the academic ability of students at or above the 40th percentile on a general ability test and 4 out of 10 students below the 40th percentile are also able to handle the course materials. For those students who are not academically able to handle the regular materials, the BSCS is preparing *BSCS Biology-Special Materials* (for the slow learner). Experimental editions are currently being tested and general release is tentatively planned for September 1966 or 1967.

An increasing number of schools are developing a second course in high school biology to follow the tenth-grade course. The BSCS has prepared *BSCS Biology—Second Course, The Interaction of Experiments and Ideas*. A prerequisite is a first course in high school biology, preferably one of the versions of BSCS Biology. *BSCS Biology—Second Course* is not intended as an advanced placement course; rather it is a liberal arts course for those students of average and above-average ability who are interested in biology and want further biology experiences in high school. These experimental materials have been tested over a three-year period prior to preparation of the commercial edition, which will appear in late Spring or Summer 1965.

For the teacher, the BSCS has prepared a series of *Techniques Films* which are intended for teacher preparation purposes. These help the teacher in mas-

[7]A more detailed description of the purpose and suggested use of the blocks is included in *BSCS Newsletter* 23, in press.

tering laboratory techniques which may not be familiar to him. The films are not intended primarily for high school classroom use.

The BSCS is issuing a series of monographs under the title of *BSCS Bulletin Series*. These monographs deal with subjects relevant to biology education. The present volume is No. 3 in the series.

The *Special Publication Series* is concerned with teacher preparation from the standpoint of the person responsible for teacher preparation in collegiate institutions or in school systems. The most recent issue in this series is available upon request by persons concerned with teacher preparation for BSCS Biology.

To keep interested persons informed of the activities of the BSCS and new publications that become available, the BSCS has a periodic *Newsletter* available upon request by interested persons. Also, an Information Film, *The Story of the BSCS*, is available for free loan to groups who wish to know more about the BSCS. It is particularly useful for showing to parents and faculty in those school systems introducing BSCS for the first time.

Outdoor marine lab. Riverview High, Sarasota, Fla.

3 FACILITIES FOR TEACHING BSCS BIOLOGY

Paul DeH. Hurd

The planning of biology facilities at the time of a science curriculum reform and when there are other demands for fundamental changes in the organization of the secondary schools poses many problems. It is unlikely that the traditional biology facilities will be entirely appropriate for modern courses. It is also apparent that the most satisfactory facilities for r w courses have yet to be fully tested. We can be certain, however, that the most satisfactory facilities will be those designed to support a particular curriculum with its unique instructional materials and style of teaching. The new biology courses produced by the BSCS are sufficiently different from most traditional courses to suggest the need for reappraisal of the facilities and resources for teaching high school biology.

The major purpose of this chapter is to illustrate the influence these changes taking place in the teaching of high school biology have for the design of teaching facilities. Some of the new developments in secondary school organization—team teaching, programmed learning, flexible scheduling—that have implications for the design of classroom-laboratories will be considered; but these are not the focus of the study. The suggestions for design and arrangements of facilities are not intended to be prescriptive; they are suggestions which can have many variations. Moreover, they are recommendations that will make it possible for any biology course to be taught with maximum effectiveness.

Planning BSCS Biology Facilities

The BSCS research staff has found that the adequacy of laboratory facilities is a significant factor in the achievement of students on BSCS tests.[1] This does not imply that there is an "ideal" BSCS Biology room, but it does suggest that a well-planned room which is adequately equipped is needed to foster the kinds of learnings demanded by BSCS Biology. Without the opportunity to carry out the supporting experiments of the BSCS courses, there is little chance of realizing the purposes of the course. While there is no "best" kind of facility for teaching biology, there is *good* planning and *good* design that make it possible for the teacher to realize the goals of instruction. A science room and its equipment are education tools essential to effective instruction.

The first phase in planning a learning environment for biology is to establish the goals of the course and the kinds of teaching activities that are implied by these goals. In BSCS Biology, a major goal is "the understanding of science as inquiry." Therefore, the laboratory work should be so organized as to convey a sense of "science as inquiry" by engaging the student in a variety of scientific investigations. There is much more laboratory work in BSCS Biology than in conventional courses because the major goals of the course cannot be easily realized by other means of instruction. The center of activity in the BSCS classroom is the student rather than the teacher, and consequently the teaching facilities must be supportive of the learner.

It is also necessary to consider the most appropriate facilities for efficient learning. In the BSCS courses, there is no sharp distinction between discus-

[1] *BSCS Newsletter*, No. 19, September 1963.

sion and laboratory work. The major activities of the student are those associated with inquiry and these cannot be distinguished as either a discussion or a laboratory activity. In BSCS courses, there are many ways by which data may be gathered: from extensive reading, direct observation of an organism, a film or photograph, an investigation, a teacher, a textbook, an experiment or demonstration, specimens, models or charts, and the field. The organization and interpretation of the data that have been collected is a continuing activity and cannot be designated as either a class or a laboratory function. Since this continuous process involves utilization of such a wide variety of instructional resources, the place where biology is taught must be flexible and adaptable to accommodate the many learning activities taking place at one time within the same room This suggests that a multi-purpose or combination classroom-laboratory room is most suitable for teaching biology.

Since modern biology courses emphasize investigation, development of inquiry skills and independent learning, the learning areas for the student must be carefully planned to provide for these. Ample work space is needed to set up experiments and leave them for several days, and for students to work together. Student furniture would, therefore, be chosen because of its suitability for supporting the kind of teaching and learning that takes place in the course. It cannot be repeated too often that a biology room owes its special characteristics to the unique ways in which the teaching and learning of biology should occur.

In planning facilities for the teaching of biology, a rationale should be established for the room design and for all its furnishings in terms of their potential contribution toward achieving the instructional goals. A teaching space that cannot be described in this manner is likely to be either a hindrance to learning or educationally sterile. Because of the diversity of equipment and materials needed to teach biology, the development of good teaching facilities for biology is somewhat more complex than for chemistry or physics. There are living plants and animals to be maintained, with each genus requiring a different set of survival conditions. Bacteria, coleus, ferns and algae each require special growing conditions; but starfish, amoeba, frogs and mice do not survive under the same conditions. There is need for refrigeration, the constant heat of an incubator and temperatures effective for sterilizing. Microscopes must be stored separately from chemicals. And the handling of specimens as mounts, skeletons, skins or preserved is different in each case. Since the best teaching of biology is done from living organisms, and since living organisms require time to grow and develop, this necessarily increases the space requirements for the teaching of biology. There are also special problems of lighting and ventilation, and of humidity and temperature control. These are all problems that illustrate the need for careful planning and special care in the design of biology facilities. They also show the importance of having several experienced biology teachers who can assist the architect in the development of the educational specifications.

The majority of high schools constructed today are expected to serve the district for 40 or 50 years—at least to the year 2000. The rate at which the science of biology is advancing and teaching procedures are improving, make it obvious that the biology curriculum will be reorganized several times between now and the time a school may be abandoned. To prevent the physical facilities from gradually impeding the best possible teaching of biology, a science room should be designed so that it is adaptable to curriculum changes. One way that a science suite can be kept flexible is to plan the use of available space in terms of instructional space, rather than in terms of fixed units.

Flexibility in design to meet curriculum changes can be helped by the use of:

- nonload-bearing walls whenever possible
- a minimum of dividing walls between such work areas as preparation, storage, project rooms, etc.
- non-specialized storage units beyond the need for safety (chemical storage)
- protection of delicate equipment (microscopes and models)
- display cabinets and bulk preserved specimens
- moveable and modular furniture
- multipurpose furniture
- service and waste lines located so that they may be tapped at many places

A science wing or building in a high school is more adaptable in the long run than widely separated science rooms for each subject—biology, chemistry, physics and general science. At the time of original construction, plans should be projected for a possible future expansion of the science wing.

The Laboratory-Classroom for Biology

The room for teaching BSCS Biology does not require a special arrangement or design beyond that demanded for the teaching of any modern biology course in which the subject is appropriately taught as a "living" science, and the instruction is of an investigatory nature. It is not the purpose here to prescribe a specific design but to illustrate and suggest facilities for the teaching of biology that are supportive of good teaching and learning practices. The facilities pictured in this chapter are all from schools in which BSCS Biology was taught during the years of its development. The biology rooms of most of the BSCS experimental schools were visited by BSCS staff members, all of whom were experienced biology teachers; during visits, notes were made concerning the suitability of the biology facilities in each school. Comments were obtained from teachers regarding the advantages and disadvantages of their room arrangements, storage units, auxiliary rooms, furniture, services, equipment and other items; their suggestions are given in the following pages.

The concensus among the BSCS teachers was that the most effective student iearning was accomplished when the class size did not exceed 30 students, and they indicated that 28 students was preferable. A study by the BSCS research staff showed that class-size was related (significant at the 1 per cent level) to the learning of students as judged by end-term comprehensive tests of achievement on biological materials and the mastery of desired skills.[2] Thus, the suggestions for the planning of biology facilities throughout this bulletin are based upon a class size of approximately 28 students.

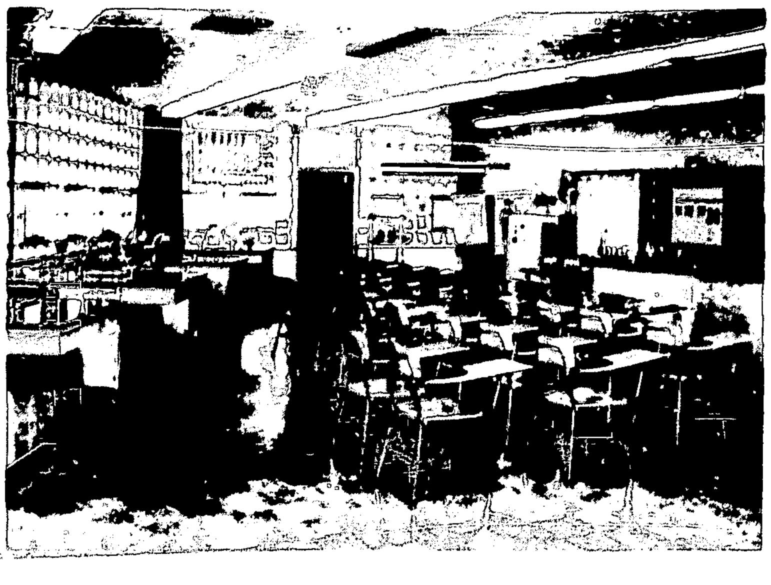
[2] *Ibid.*

Size of the Biology Room. The size of a biology laboratory-classroom is influenced by: class size; shape and arrangement of room; instructional methods to be used; space available in auxiliary rooms; number of classes using the room per day, and the extent to which the room is used for the teaching of other sciences. If sciences other than biology are taught in the same room, there is need for additional storage space. Classes taught by procedures that require students to use the inquiry and discovery techniques suggested by the BSCS require more space per student than the less effective lecture-demonstration method.

The room which has to accommodate six or seven sections of biology or some first- and some second-course biology sections should be larger than one in which fewer classes are held. The logistics of space requirements for growing plants, living cultures and continuing experiments serve to illustrate the problem. If there are to be separate storerooms, outdoor laboratories, a greenhouse, a preparation room and a project room associated with the laboratory-classroom, then the size of the classroom may be reduced.

If the biology room must have separate sections for discussions and laboratory work with two separate sets of furnishings, more space will naturally be required than if these instructional units are combined. (Figures 1 and 2.) In BSCS Biology, the students use a wide variety of learning resources, and carry on more actively in the learning process than is typical of classes taught by conventional teacher-centered techniques. Therefore, a BSCS class requires more aisle space, more student work surface, and

Fig. 1. Perimeter arrangement of lab tables with tablet chairs for discussions. Whitingham High, Jacksonville, Vt.



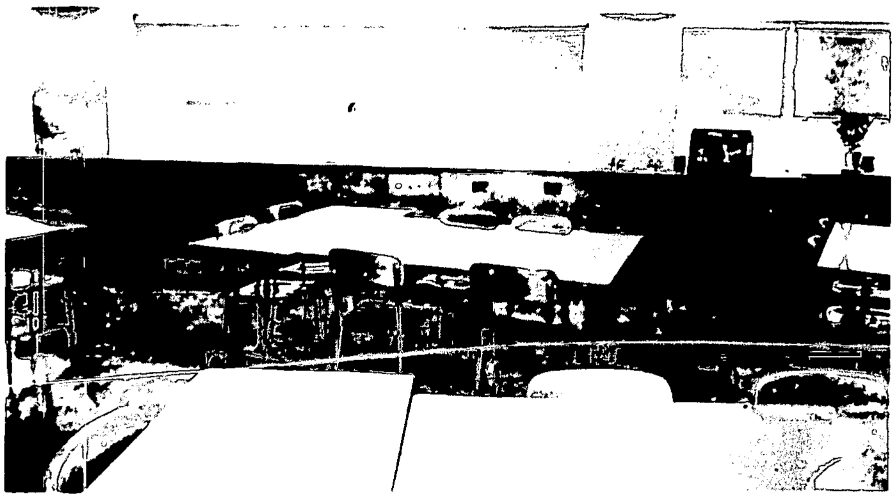
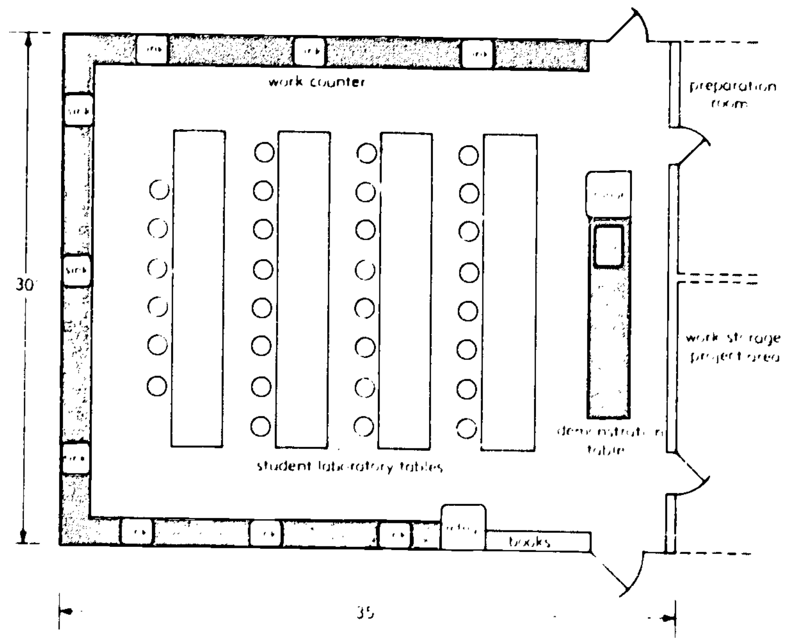


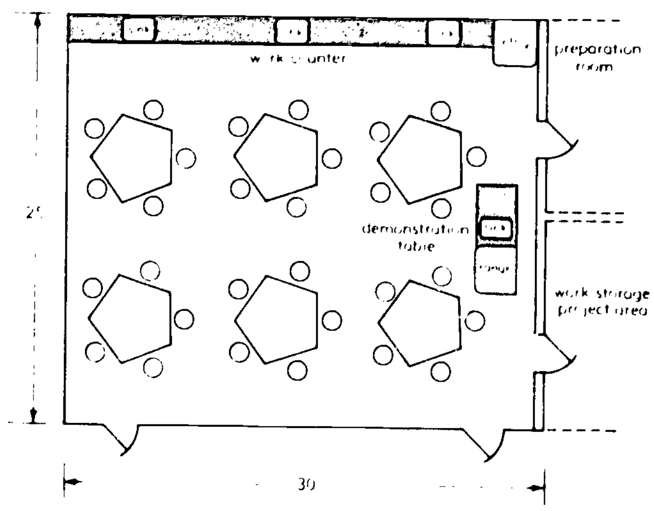
Fig. 2. Movable two-place lab-classroom tables. Note A-C receptacles in floor. Abraham Lincoln High, Denver, Colo.

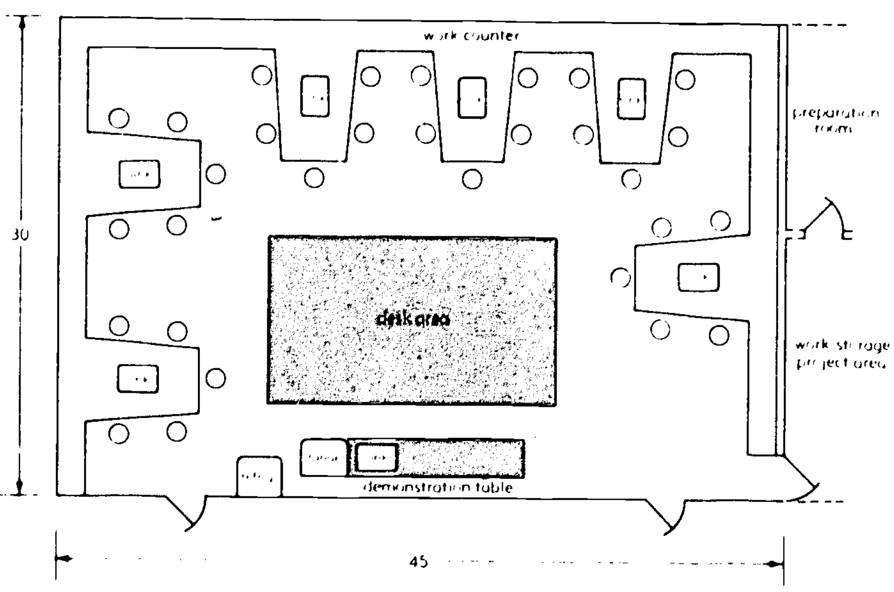
more shelves for reference books than are usually found in standard biology rooms.

Schools designed to accommodate a team-teaching approach in biology require a different organization of instructional space since there is a different concept of teaching. Rooms designed for a perimeter arrangement of laboratory counters, or those to accommodate island laboratory tables will again have different space requirements for the same number of students. A room approaching a square in shape is more manageable than a long narrow room of equal floor space. This is the present trend today, and will aid greatly in creating efficient classrooms. Separate class and laboratory rooms represent other kinds of problems in space management.

Some possible arrangements of biology classrooms are shown in Figures 3, 4, 5, 6, 7a, 7b, 8a, 8b, 9, 10, 11.







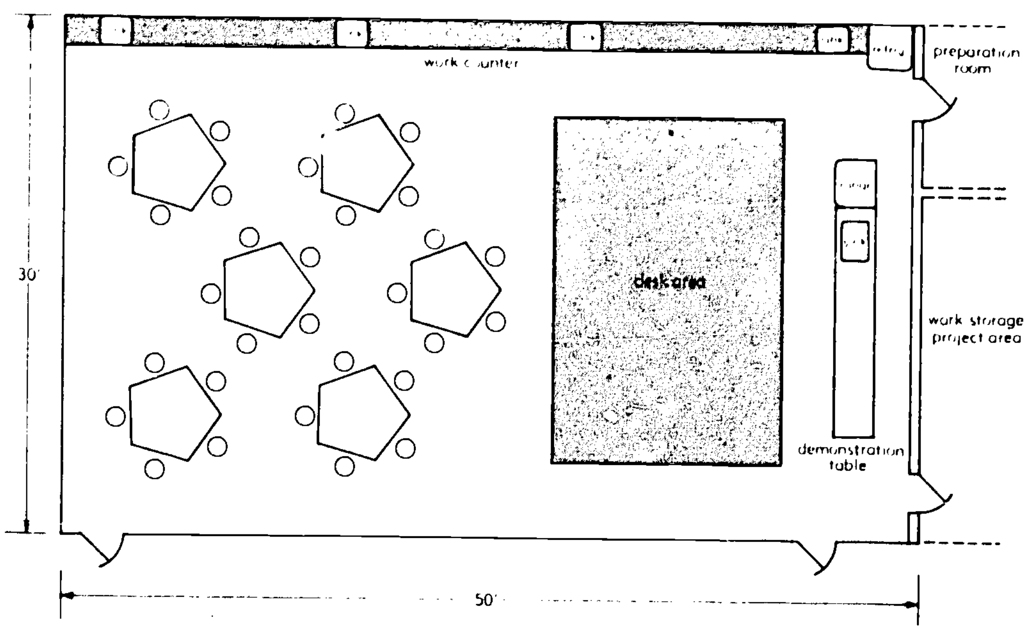


Fig. 3,4,5,6. Floor plans for furniture arrangement of biology lab-classroom. *BSCS Newsletter* No. 9.

Fig. 7a,7b. Classroom-lab with lab tables at rear of room; note sliding chalkboard in lab area. Note the use of window counter, number of storage cabinets and darkening blinds. Northport High, N. Y.

Fig. 8a,8b. Biology lab is separate from classroom. Storeroom connects classroom with lab. Manatee High, Bradenton, Fla.

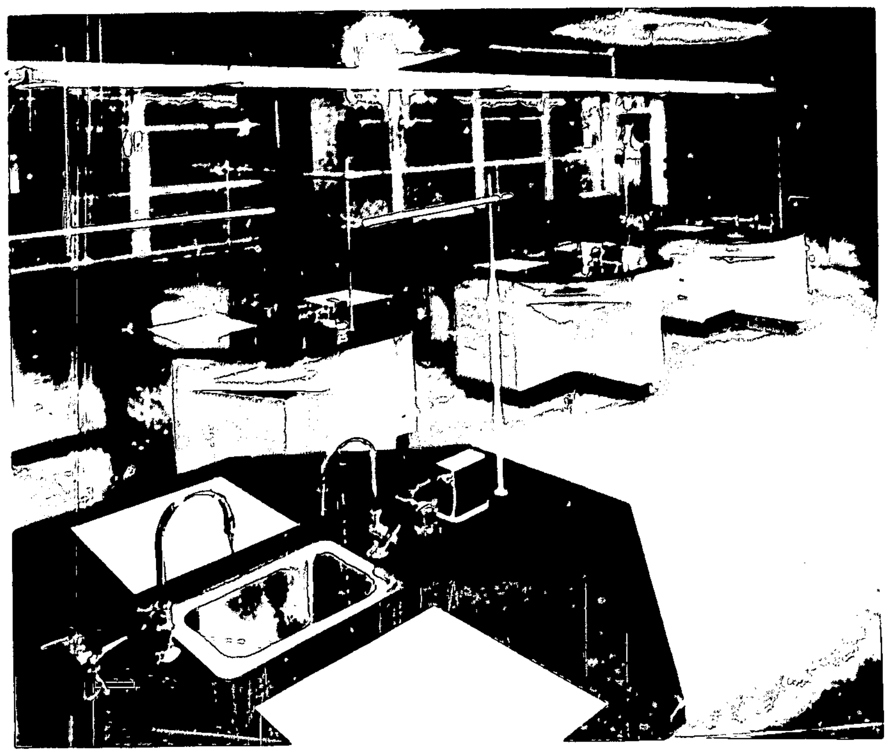


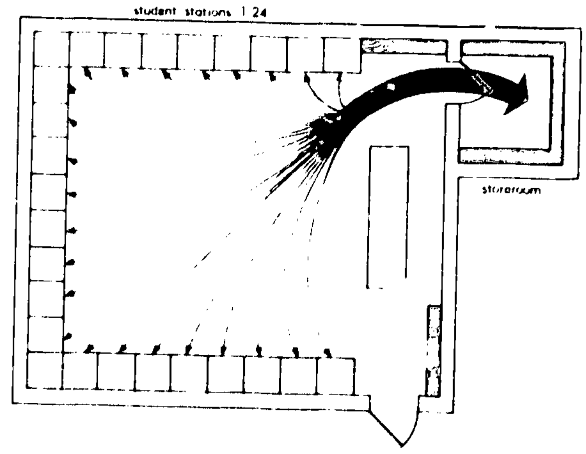
Fig. 9. Lab section of classroom-lab. Menlo-Atherton High, Calif.

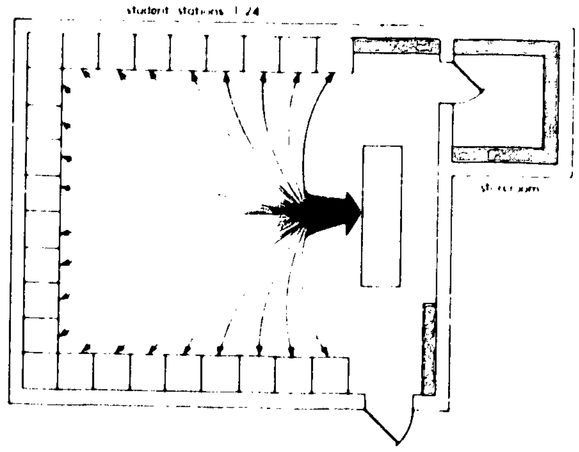
Fig. 10. Six-place tables in combination lab-classroom. Mercy High, Baltimore, Md.

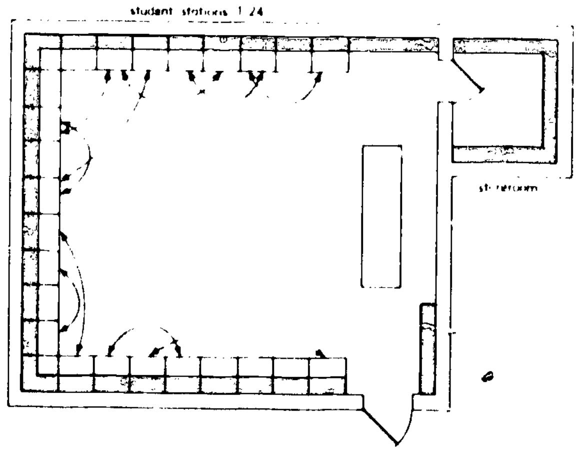
Fig. 11. Movable tables easily arranged for group work Huntington High, N. Y.

LABORATORY-CLASSROOM TRAFFIC FLOW. The term "science in action" describes BSCS Biology teaching. Students are expected to carry out their own experiments and, in part, to direct their own learning. The amount of equipment and the variety of materials used in these experiments can create a student traffic problem unless the laboratory-classroom is carefully planned. Ample aisles will help to solve the problem, but the proper planning of storage facilities for equipment and supplies is more important.

If as many supplies as possible are stored at the point of usage, traffic is minimized. In-room storage of frequently used materials is much more convenient than dispensing materials from a storeroom. Locating storage cabinets and drawer space around the perimeter of the room will reduce traffic by providing the necessary supplies near to the point of usage. (Diagrams 1a, b, c.)



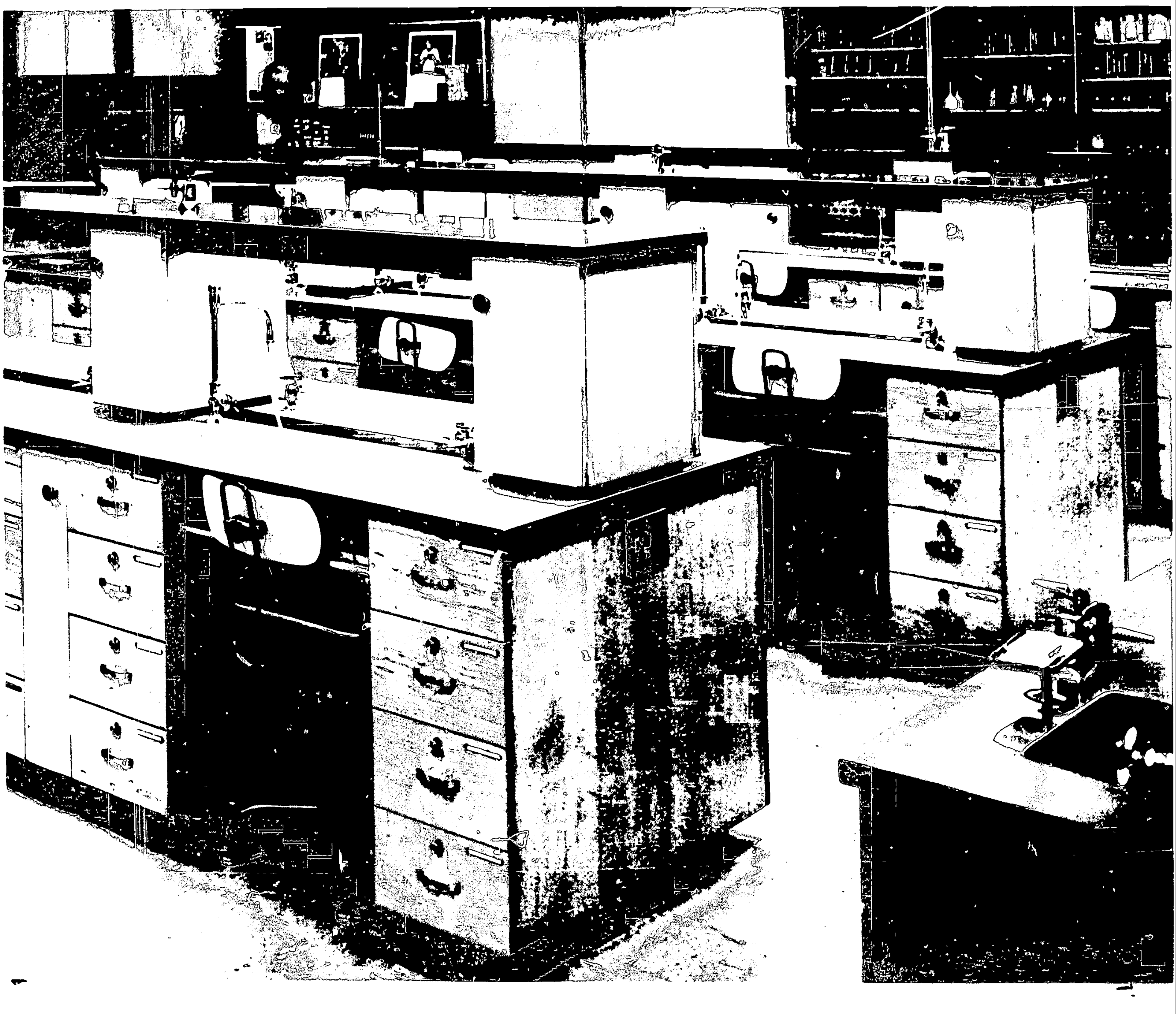


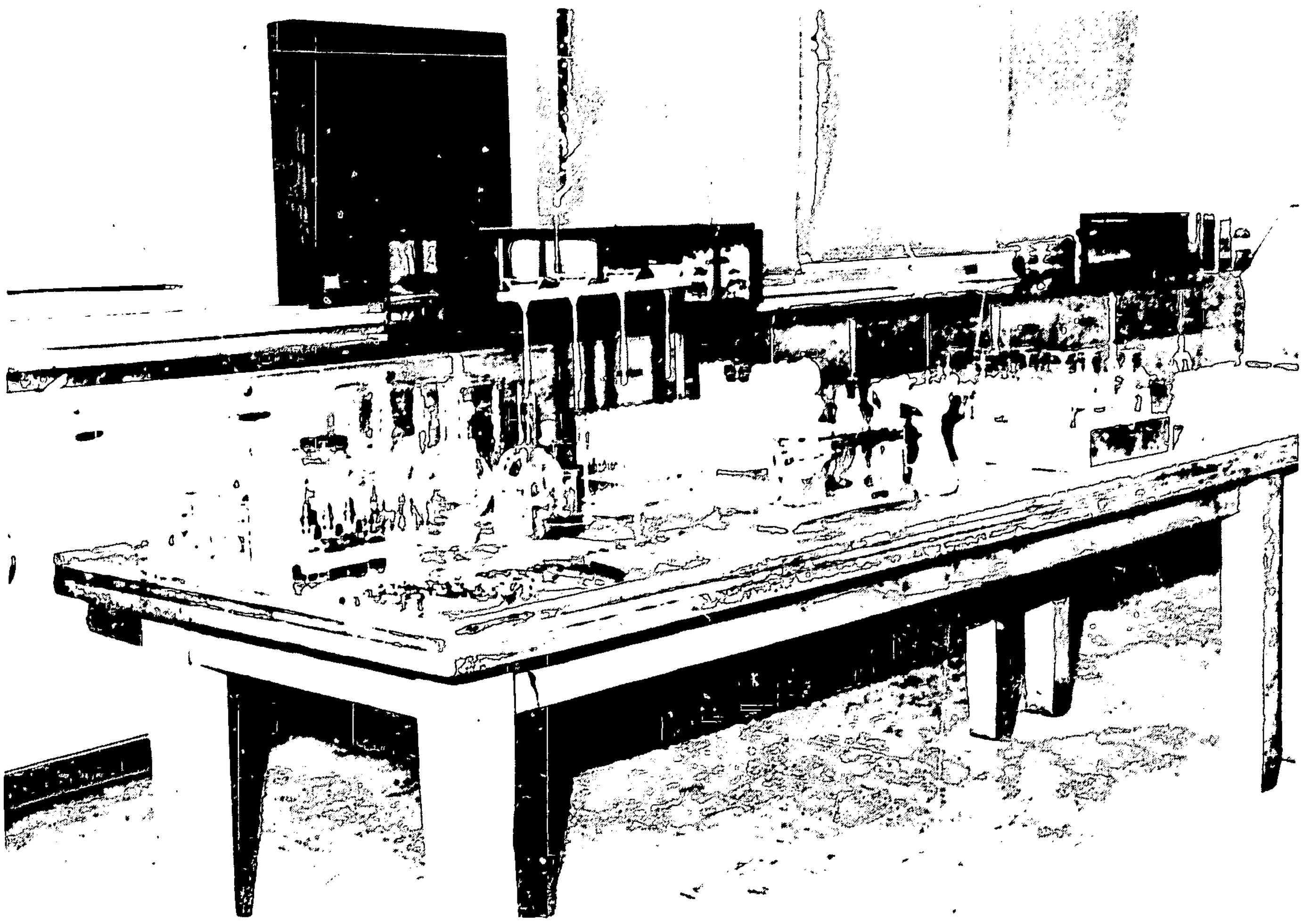


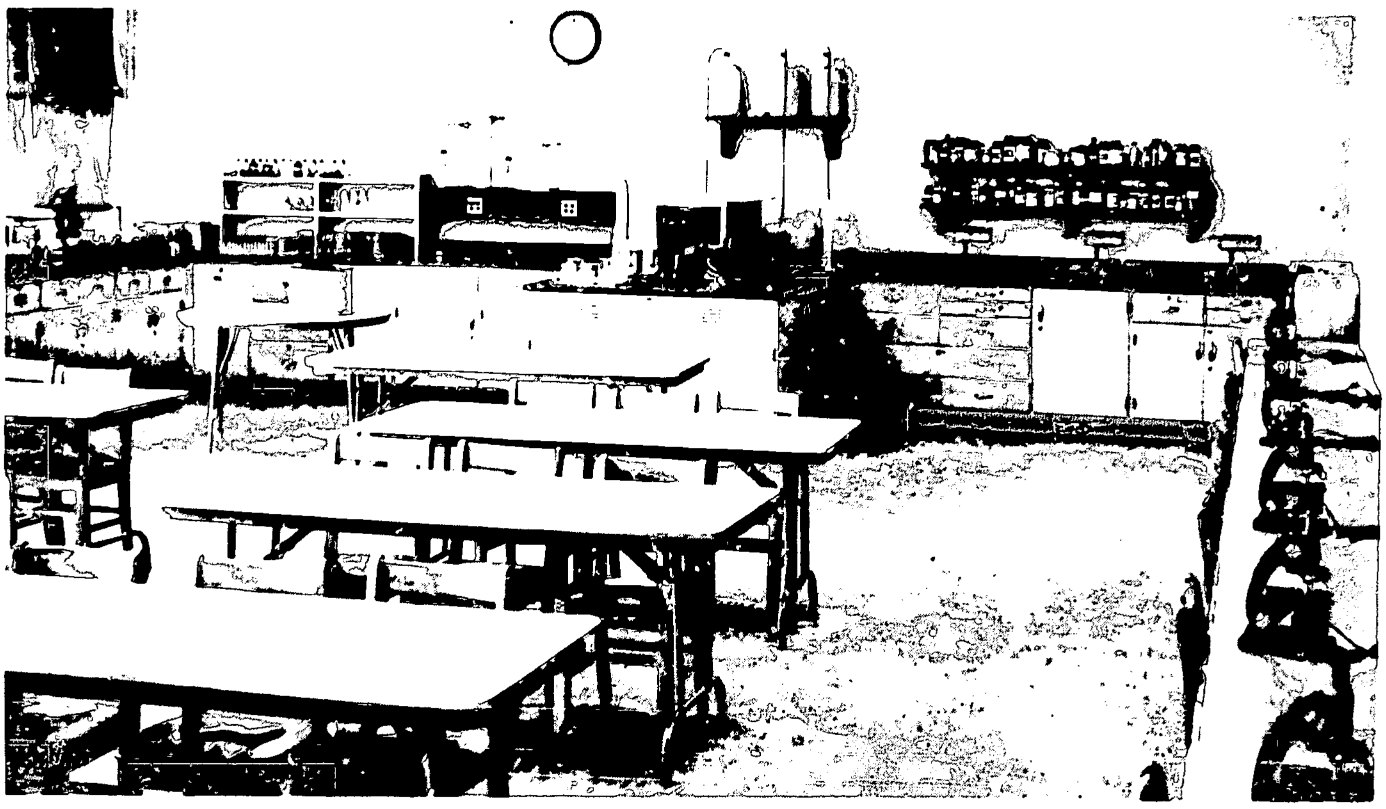
Diag. 1a,1b,1c. Traffic patterns—
Where materials are distributed from storeroom and little in-room storage.
Where materials are distributed from demonstration table.
Where storage is concentrated near student stations.

A dispensing table near the center of the room, or movable laboratory carts which can be stocked with the special materials needed for the day will also serve to lessen the necessity for students to move about the room. (Figures 12, 13, 14, 15.)

Fig. 12. Lab stations with storage in tables and close by minimize student traffic. Note microscope storage cases on tables. Oak Park-River Forest High, Ill.







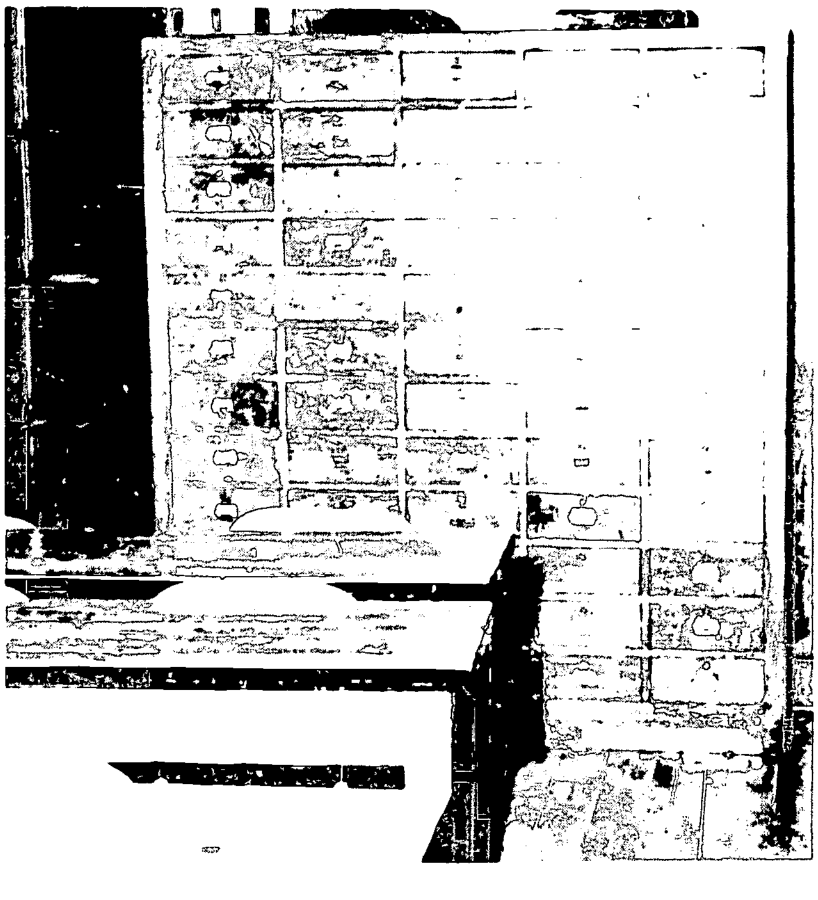


Fig. 13. Supply table properly located in classroom minimizes student traffic during lab periods. North High, Denver, Colo.

Fig. 14. In-room storage with supply center and clean-up station at rear. East Brunswick High, N. J.

Fig. 15. Tote trays fit as drawers in student desks. East High, Denver, Colo.

ROOM LIBRARY. An objective for teaching is to build interest and habits so that students will be encouraged to continue their learning beyond the context of the course, since, for most students, their post-course learning for the rest of their lives will be done primarily through reading. The best stimulus for reading is that it serves an immediate purpose, that is, it helps to provide data or ideas on the problem under study. The biology classroom is the most logical place to learn the proper use of biology books and magazines. Also, to conduct classes using an investigatory approach to learning requires that books and other reference materials be available as they are needed. This means that a science library is needed in the laboratory-classroom.

Materials for the science library might include the supplemental references at the end of each chapter in BSCS Biology. The *Scientific American* reprints are inexpensive and provide a wide range of reliable up-to-date readings for students and teachers alike; and the BSCS has developed a series of pamphlets, each on a specific area of the life sciences, to extend the range of specialized biology readings available to students.

A classroom reading and reference center accommodating four to six students is one way of providing the classroom library. Whatever the arrangement, there is need for bookshelves, a magazine rack, a table with chairs and a set of file drawers for reprints and pamphlets. Where adjoining biology rooms are planned, it may be more useful to have a small library room accessible from each classroom. (Figures 16, 17, 18.)

Fig. 16. Science library and reading room serving all sciences. Yuba City Union High, Calif.

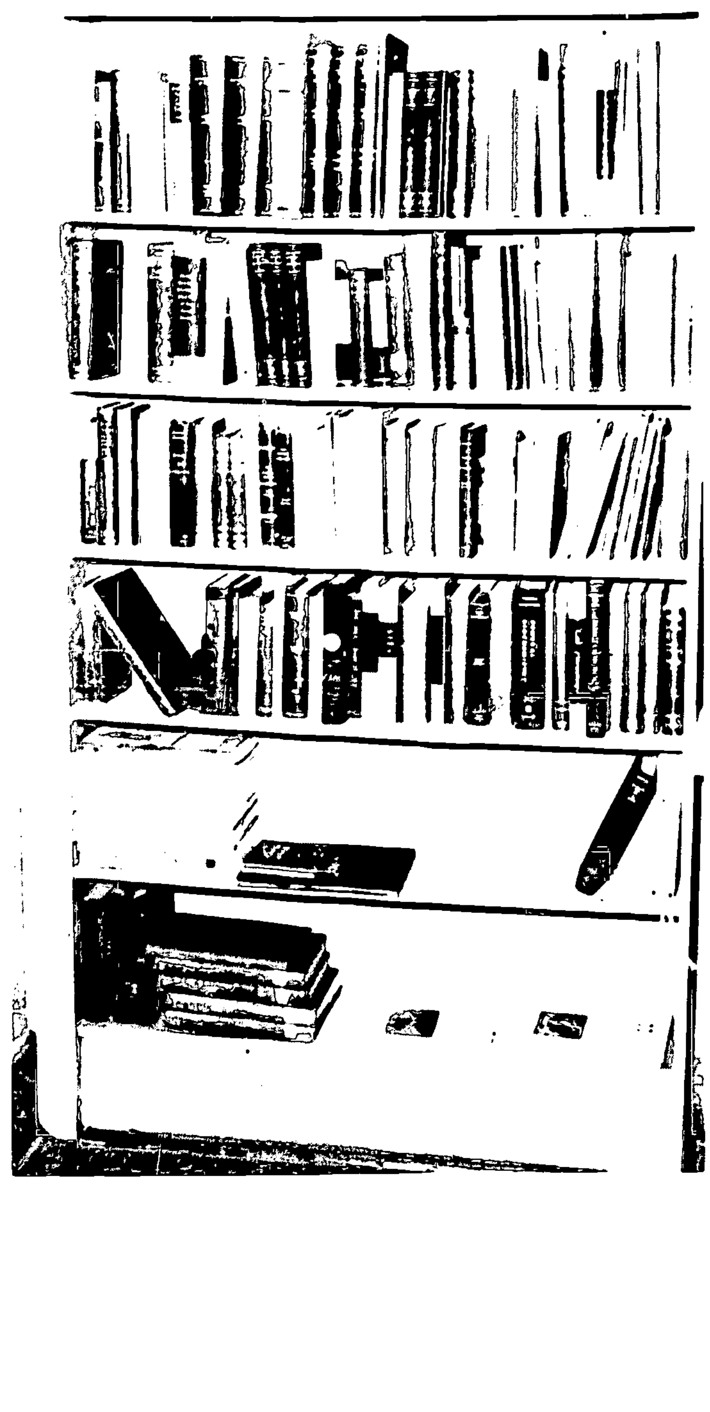


Fig. 17. Classroom reference library is important for an investigatory approach. Loveland High, Colo.

STUDY CARRELS. With the emphasis upon independent study and investigation in the school science program, classrooms are being planned and furniture is being designed to provide a degree of privacy for the student.

For the learning of biology, carrels have been designed as self-instructional centers. Films and slides can be viewed without disturbing other students; reference materials and programmed textbooks are shelved in the carrel along with charts, models and living specimens. Almost everything needed for the learning in a particular instructional unit is at the student's finger-tips. (Figures 19, 20.)

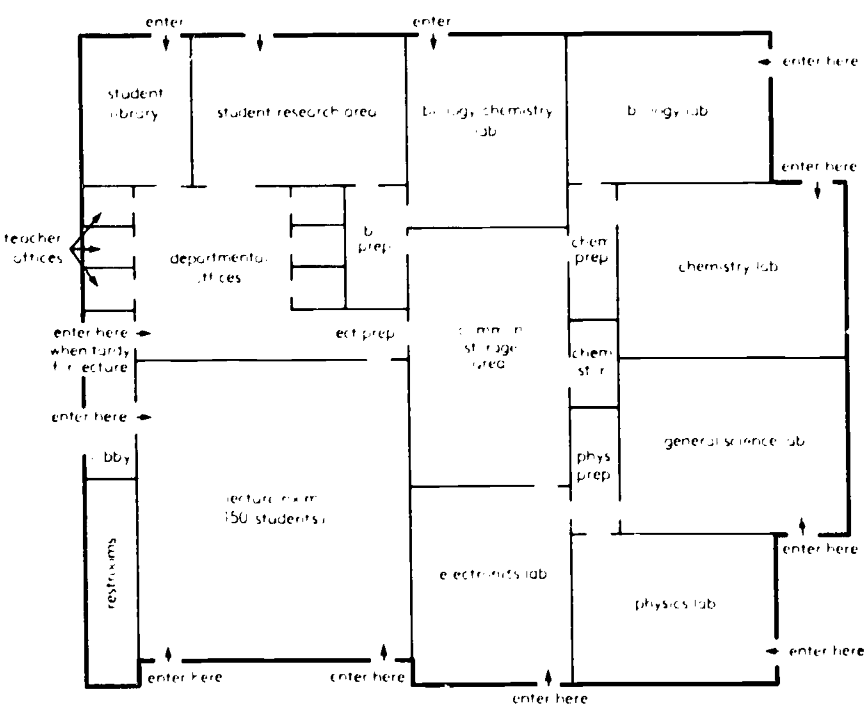


Fig. 18. Arrangement of facilities for team teaching. Fremont High, Sunnyvale, Calif.

Fig. 19. Carrels provide a place where equipment and materials for individual research projects may be left undisturbed. These were student built. Chevy Chase Senior High, Md.

Fig. 20. Carrel designed as an independent study center. Book and supply shelves can be rotated to serve six students in the unit. Note slide projector and screen arrangement. Littleton High, Colo.

There are many variations of the study carrel or cubicle. Typically, this is a study area approximately three feet wide and two feet deep with bookshelves available at the back or sides of the carrel. The blinders that separate carrels are slightly higher than the eye level of the student, thus providing essential visual privacy. Carrels are frequently equipped with a desk lamp and electrical outlets. Carrels located in project rooms or project areas are often equipped as minature laboratories with gas and electrical outlets, shelves for chemicals, limited storage for small equipment and a lockable drawer or two. Primarily, carrels provide a place where the set-up for experiments may be left partially protected for a period of time. There is also the psychological advantage of providing the student engaged in independent research with a place of his own.

TEAM TEACHING AREAS. An exploratory venture current in educational circles is that of team teaching. Much has been written about the educational potentialities of team teaching, but at this time there is little data to demonstrate its actual value for the teaching of biology. However, the reasoning is that the wide differences in the preparation of biology teachers and the special interests of each teacher could be used to advantage in teaching a high school biology course in this way. Teachers trained primarily in ecology would do the field work for several classes, and the teacher with a strong background in biochemistry might direct the laboratory work on photosynthesis for all the biology teachers. However, insofar as BSCS Biology is concerned, if team teaching is used, it should be kept in mind that lecture-demonstrations are not considered the most effective method of presentation and that students should have a maximum opportunity for laboratory and field work in biology and the chance to pursue individual interests.

The team-teaching concept provides for class sizes of 50-100 for seeing and listening activities, and for groups of 5 to 10 students for carrying out research on special topics. In theory, there is more time for attention to the individual student, more time for teachers to prepare instructional material and better opportunities to capitalize on the talents of the master teacher. In a team-teaching program, there is a great deal of moving about on the part of the students, as a result of the forming and dispersing of large and small groups. When large groups are in session, several teachers are likely to be free, and thus to require a place to meet so that they may prepare and organize instructional materials for the classes that follow.[3]

Whatever the plan or arrangement for team-teaching, there is need for a different kind of science facility than that found in traditional high schools. There is need for a room large enough to accommodate 80 to 125 students and equipped so as to permit use of a wide range of audio-visual aids. This means space for a large projection screen, open- and closed-circuit television, equipment to project demonstrations, display centers, a large well-equipped demonstration table specially lighted to increase the visibility of demonstrations, easy access to storeroom, tiered seats for students if the room is extra large, stations for the assisting teacher and aides and a chalk board that is visible to the entire class. All commonly used audio-visual and science equipment should be housed in or near this large instructional room.

Study centers for students should include a variety of areas such as laboratory space, conference room, library area, carrels, project room, display centers and an instructional area for small groups of 10 to 20 students. The teachers' preparation room, the resource center, the outdoor science court, the storeroom, and the live plant and animal centers should be planned with access to both the large and small group instructional areas. In general, the conventional block arrangement of rooms as a series on one or both sides of a hallway is not easily adaptable to team teaching, since the space arrangements are too inflexible. The style of team teaching planned for the school will determine the feasibility of low partitions, moveable storage walls, curtain separators, non-load-bearing walls, or combinations of these for separating the instructional areas.

Back-to-back scheduling of two biology classes—so that the classes may meet as one when desirable—might require a different organization of facilities. If science classes other than biology are also using team teaching, the design would again be different.

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[3]A further discussion of team teaching appears in Chapter 4 pages 55-56.

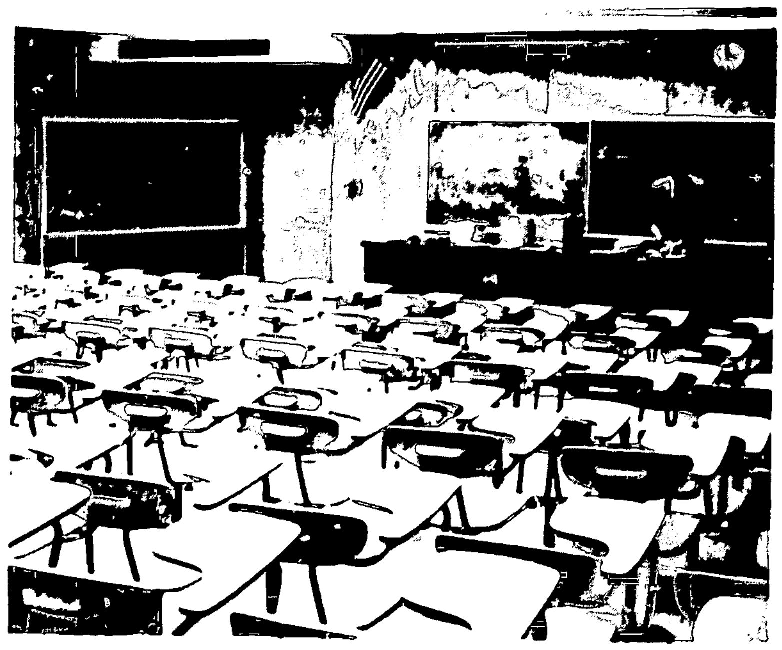
Some examples of team-teaching facilities are shown in Figures 18, 21, 22.

LOCATION OF BIOLOGY FACILITIES. A biology room is best located on a ground-level floor from which there is access to the out-of-doors. The outdoor laboratory, greenhouse, animal room, pond and other accessory institutional spaces should be easily available to the laboratory classrooms. The biology complex should be thought of as a natural science center, with each unit providing an appropriate learning resource for the study of biology.

The orientation of a biology room can only be generalized. There must be ample light for the growth of plants and the proper maintenance of aquaria, but direct sunlight is not to the advantage of either. Artificial light of the proper quality and intensity is in most instances better than can be obtained by natural means. The greenhouse may be located to take advantage of natural light, unless excessive heat or extreme cold temperatures are a factor. With the change of seasons, the conditions of light and temperature will always vary in a growing area and become more or less ideal for specific varieties of plants and animals. Both cactus and ferns are not likely to be successful under the same growing conditions, nor will frogs or lizards. Even different areas of a laboratory-classroom have different micro-climates and are more suitable for the maintenance of one variety of organisms than another. Advances in lighting, temperature and humidity controls and in air-conditioning minimize the problem of orientation for biology rooms.

Fig. 21. Large room for team teaching with tiered seating for 150 students. Fremont High, Sunnyvale, Calif.

Fig. 22. Lectures, demonstrations, tests and films are presented to five biology classes at one time. Homestead High, Cupertino, Calif.



CLASSROOM-LABORATORY EQUIPMENT FOR BIOLOGY. The major equipment required for the teaching of BSCS Biology is not much different from that found in any well-designed and adequately equipped biology room which reflects an investigative approach to the subject. Careful planning in the arrangement and location of equipment and furniture can result in a laboratory that will accommodate a greater variety of learning activities and at the same time be more efficient. The pictures of biology rooms found throughout this bulletin represent furniture and equipment arrangements that have proved to be functional in at least one school where BSCS Biology is taught. However, administrators, architects and teachers should view these pictures as a source of ideas and not as blueprints. (Figures 23, 24, 25.)

STUDENT LABORATORY STATIONS. The most economical arrangement of student stations is a combination desk serving both class and laboratory functions. This equipment is widely available through commercial companies in a variety of sizes and styles, in moveable and fixed units, with or without services, and with or without storage units. Tables are available for 2, 4 or 6 students, and other combinations are possible. (Figures 3, 10, 11, 14.)

Fig. 23. Well-organized service counter in the biology preparation room. Note hood and oven arrangement. Oak Park-River Forest High, Ill.

Fig. 24. Service counter in the biology lab-classroom. Homestead High, Cupertino, Calif.

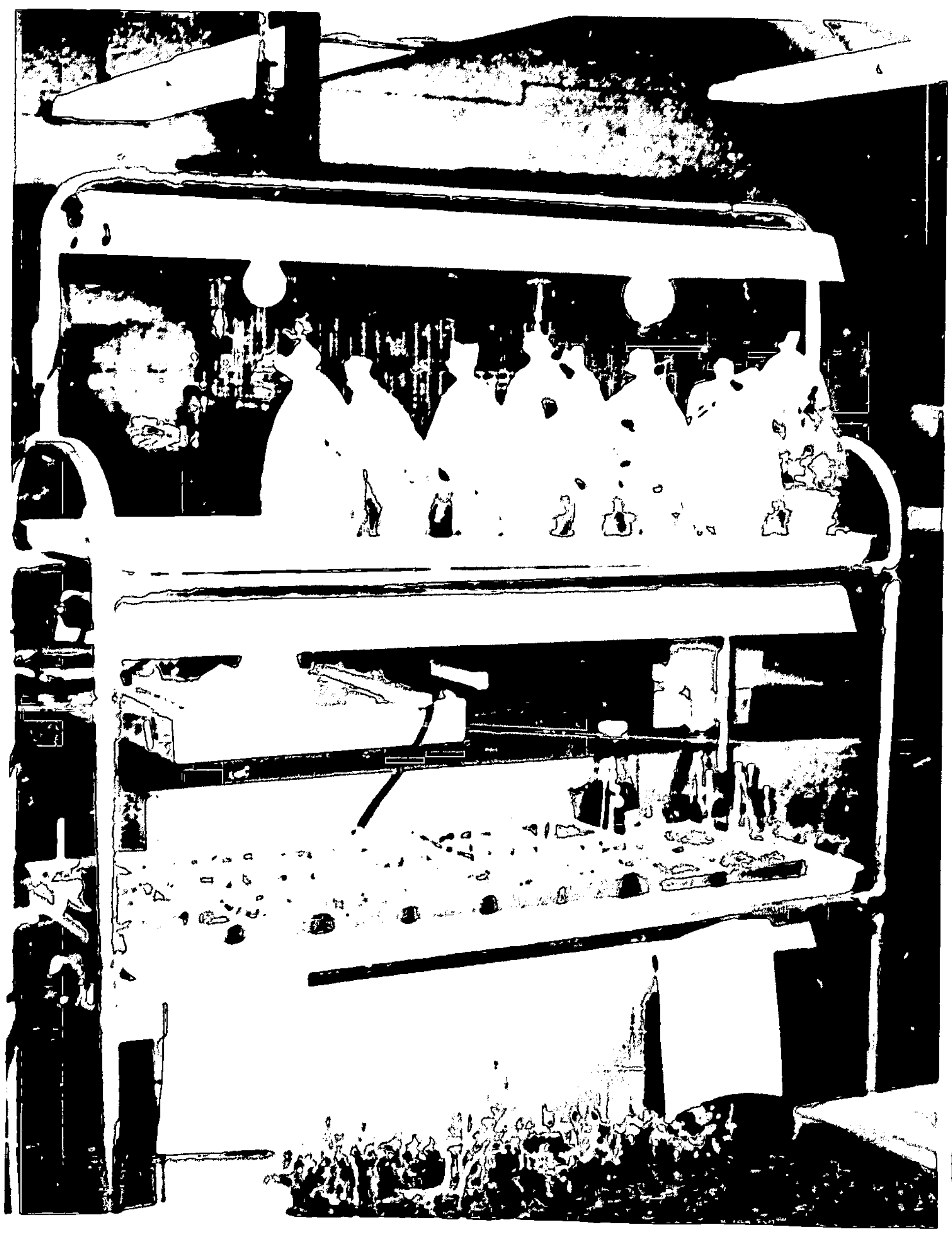
Fig. 25. Service counter in the classroom-lab. Note built-in hot plate and bulletin board arrangement. Riverview High, Sarasota, Fla.

Some teachers prefer to have separate furniture for class and laboratory work. This may be achieved in several ways: island laboratory benches at the rear of the room with a desk area in front (Figures 1, 6, 7); or the laboratory work area along the side walls in a "U" arrangement enclosing a desk area in the center of the room (Figures 2, 3, 5.).

CLASSROOM STORAGE. The proper location of supplies in a classroom is a major factor in classroom traffic control and in obtaining maximum time for teaching within a class period. In planning storage facilities, it should be kept in mind that equipment and supplies change from one phase of the course to another, and also with each laboratory block. In the section under traffic control, the principle of storage at the point of usage is outlined. Further, storage units should be kept as flexible as possible by the use of adjustable shelving and tote trays or other movable containers.

One advantage of the perimeter arrangement of laboratory furniture is the convenience of the storage space in the wall cabinets. (Figures 7a, 10, 14.) Biology laboratory tables with special sections for such community-used equipment as microscopes, glassware, Bunsen burners, ring stands, scissors, etc. provide another means of storage. In BSCS Biology, students frequently work in pairs or squads. This makes it possible to distribute the storage of basic equipment among adjacent student stations.

The display cases within the room can be regarded as storage units if the specimens therein function in the instructional program at some point. Strictly museum items are better housed away from the active instructional centers of the room. (Figure 26.)



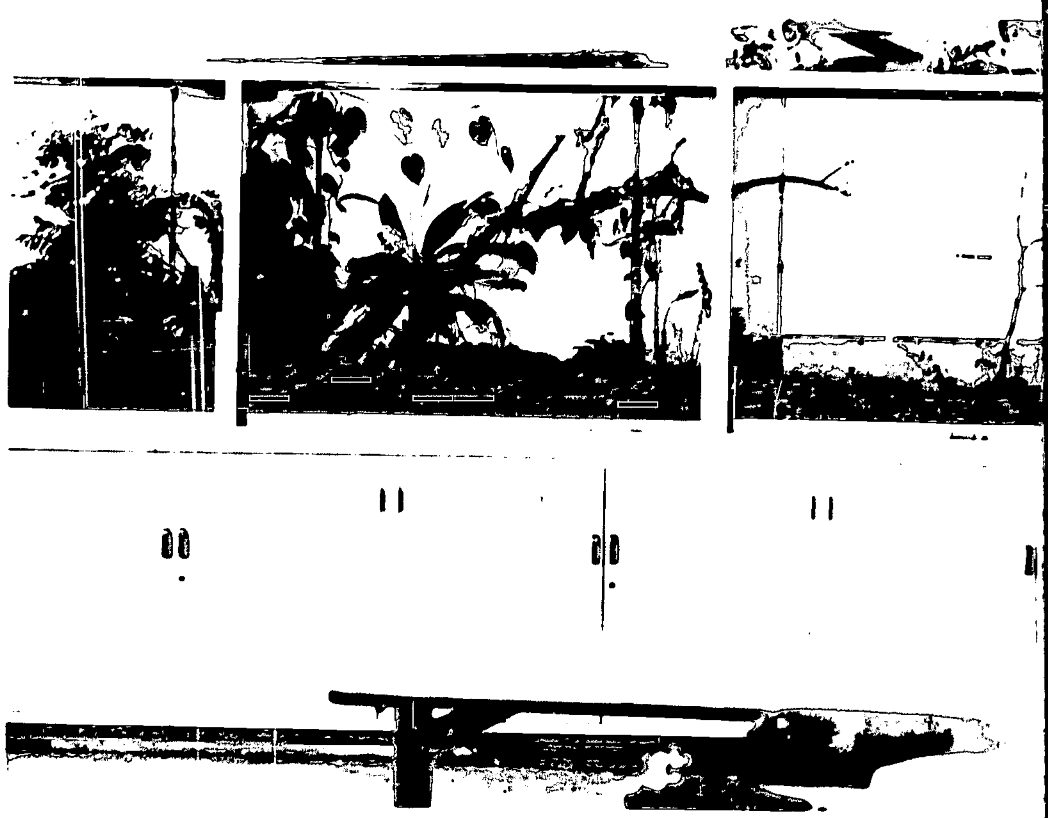


Fig. 26. Classroom storage case properly used as a teaching display. Oak Park-River Forest High, Ill.

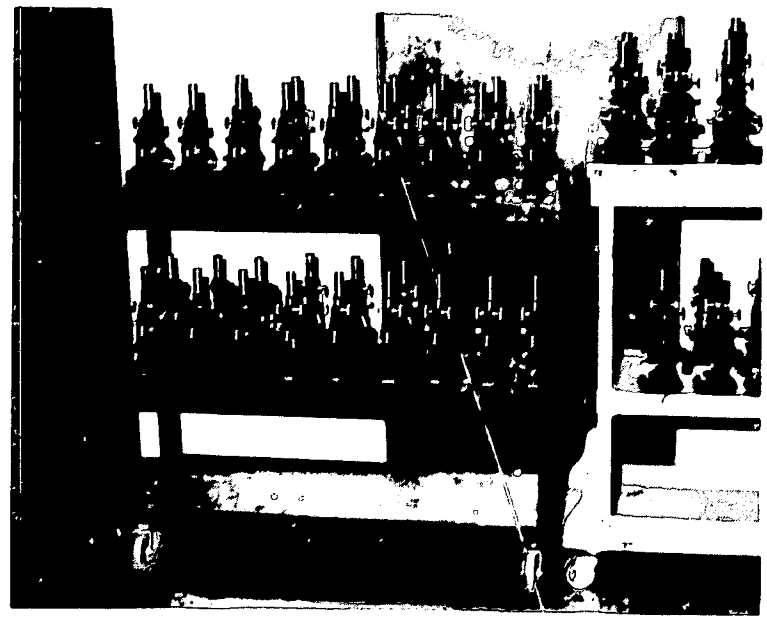
Fig. 27. Movable plant cart equipped with incandescent and fluorescent lights. Menlo-Atherton High, Calif.

Fig. 28. Wall terraria made from display cabinets. Note fluorescent lighting. Granada Hills High, Calif.

Fig. 29. Lab cart equipped for distribution of microscopes. East High, Denver, Colo.

Fig. 30. Microscopes should be stored in dust-proof cases. Huntington High, N. Y.

Fig. 31. Wide variety of storage units needed for a modern biology course. East High, Denver, Colo.



A self-contained biology room which must house all storage, large equipment, living specimens, etc., and which must also accommodate all class and laboratory teaching functions should have floor and wall space utilized to the maximum. However, caution must be used to avoid filling the room with fixed or non-movable furnishings. It is much more important to have movable furniture where space is limited. Equipment can be shifted to meet special requirements and new units may be brought in when changes in the curriculum demand them. The BSCS emphasis upon the use of living plants and animals may require different equipment than is found in many schools. (Figures 7, 27, 28.)

The all-purpose science room in which general science, biology, physics and chemistry are taught presents a special problem. While it is possible to plan such a room for complete in-room storage, it will require carefully designed furniture. Better results will be obtained by planning for maximum in-room storage with a storeroom in addition.

A laboratory cart is frequently used as a storage unit, especially for sets of microscopes that must be used in several classrooms. The microscopes are housed permanently on a cart which can be wheeled from one room to another. Movable carts may be equipped for a variety of purposes such as portable units for growing trays, animal cages and chemical supplies. It can also be used as a tote-tray unit or as a special supply unit for particular experiments or laboratory blocks. (Figure 29.) Laboratory carts provide a highly flexible storage unit, and, because of their mobility, they can place needed materials at the center of a work area, thus minimizing student traffic and reducing the time students need to get the materials of the day. Several supply carts well placed around the room may be the most efficient arrangement for distributing materials in large classes.

Whatever the arrangement for storage, some of the units must be lockable. The storage place for microscopes should be dustproof, and chemicals must be stored in a safe manner. Whether the storage facilities will meet the needs of the course or not depends upon the proposed curriculum and the style of teaching that is to be used. (Figures 30, 31.)

THE CENTRAL STOREROOM. The trend in larger schools is toward a common storage area for the various sciences. Central storerooms or storage halls are used to house most of the school's science supplies and they are arranged with an access from each science room. BSCS Biology requires the use of more glassware and chemicals than do traditional courses. Typically, these materials are available in the school but they are not always easily accessible, particularly if they are scattered about the school in individual storerooms. There are supplies and equipment used in all science classes upon occasion and these should be located in a central supply area. (Figures 32a, 32b, 33.)

Fig. 32a. Common storage area for all sciences. Eight science classrooms and labs open from this central storage and preparation area. Homestead High, Cupertino, Calif.

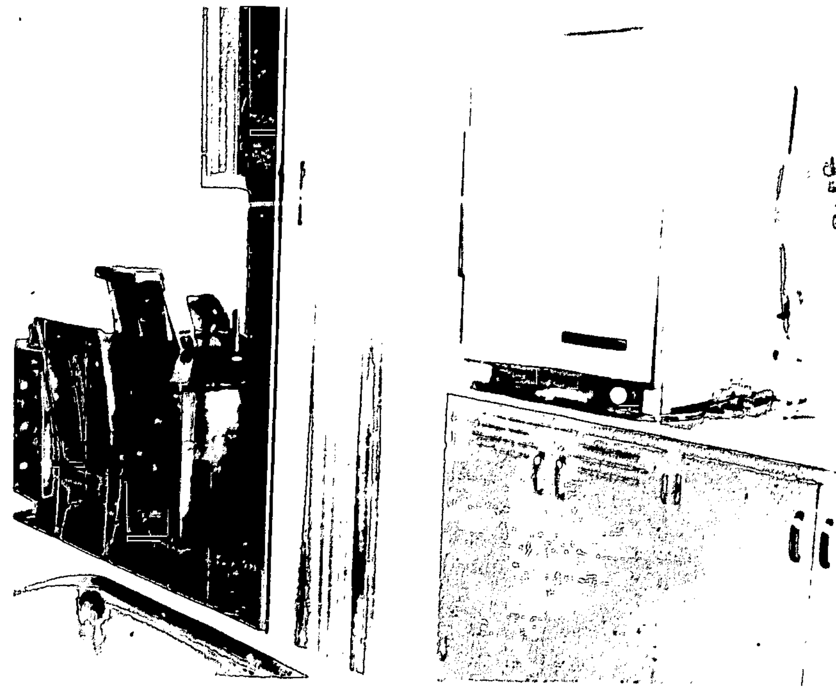
Fig. 32b. Extension of a central storage area for a science department. Note series of lockable storage cabinets. Homestead High, Cupertino, Calif.

Fig. 33. Central storage area for science department. Mills High, Millbrae, Calif.

Central storage areas are used to keep such large-sized equipment that is not in daily use as: refrigerators, stoves, dishwashers, incubators, ovens, autoclaves. Equipment frequently used by the biology classes is placed in a section of the storage area that is most convenient to the biology classrooms. (Figures 34a, 34b, 34c, 34d, 34e, 34f, 34h.)

The preparation area is frequently a part of the central storeroom, but some teachers prefer to separate the storeroom and preparation room while keeping them connected. Another possibility is to screen off a section of the storeroom as a closed area. In this section are kept such materials as poisonous chemicals, radioactive isotopes and expensive equipment. Whatever the arrangement, it is imperative that some storage units be lockable. (Figure 32b.)

To keep the central storeroom as flexible as possible in order to meet changing needs, the divisions of space should be managed through movable storage walls rather than load-bearing walls. All doorways and aisles should be wide enough to accommodate standard-size laboratory carts. In planning the storeroom furniture arrangements, consideration should be given to the problem of providing adequate supervision of students.



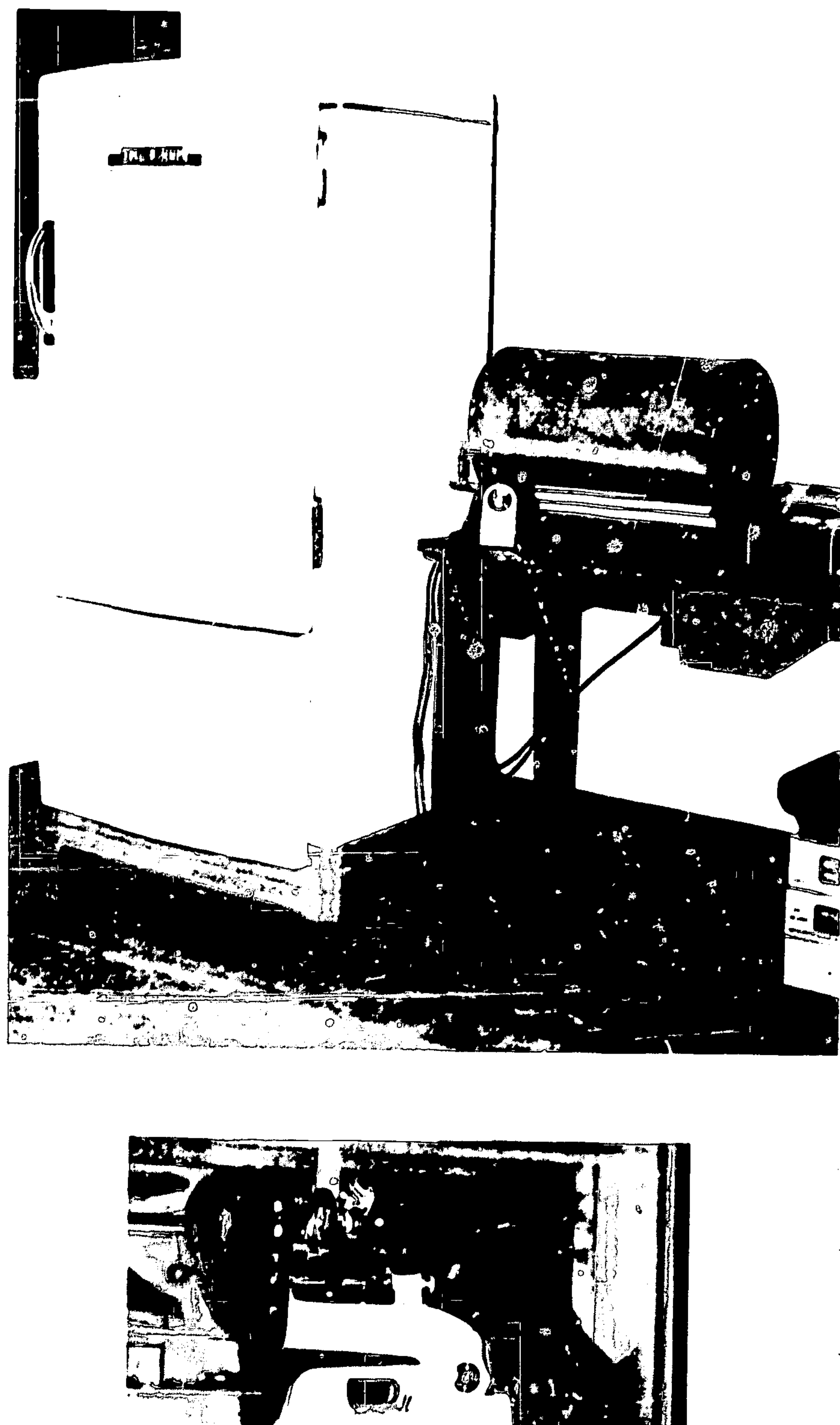
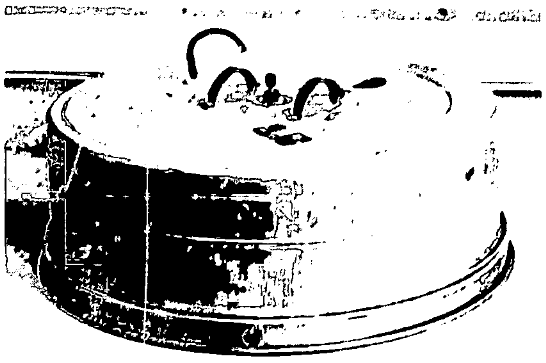


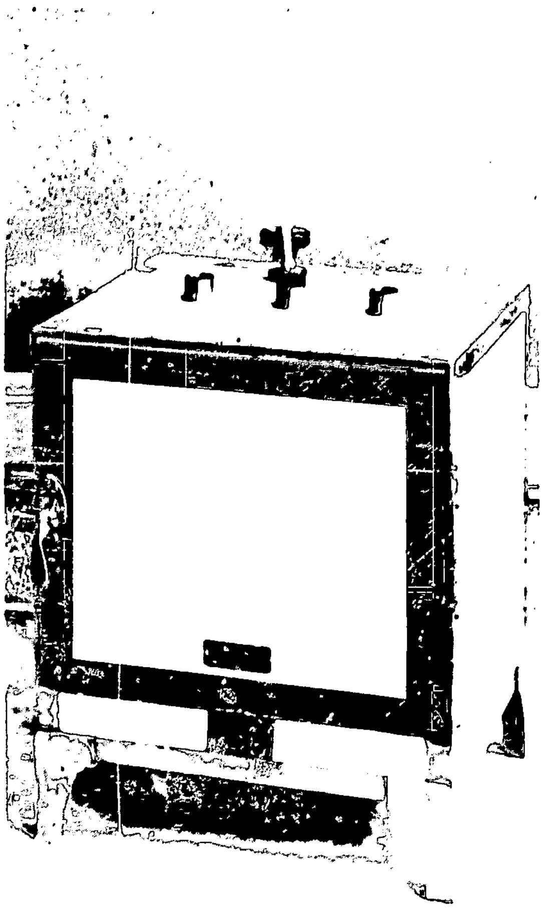
Fig. 34. Modern biology requires use of a variety of instructional equipment—micro-projectors, ovens, sterilizers, refrigerators, incubators, aquaria, models —requiring space for use and storage.

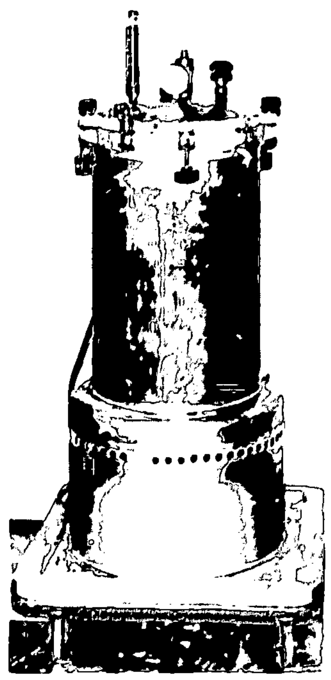
a. Preparation room showing one side of office. East High, Cheyenne, Wyo.

b. Refrigerator and photocopy apparatus. East High, Denver, Colo.

c. Microprojector. North High, Denver, Colo.







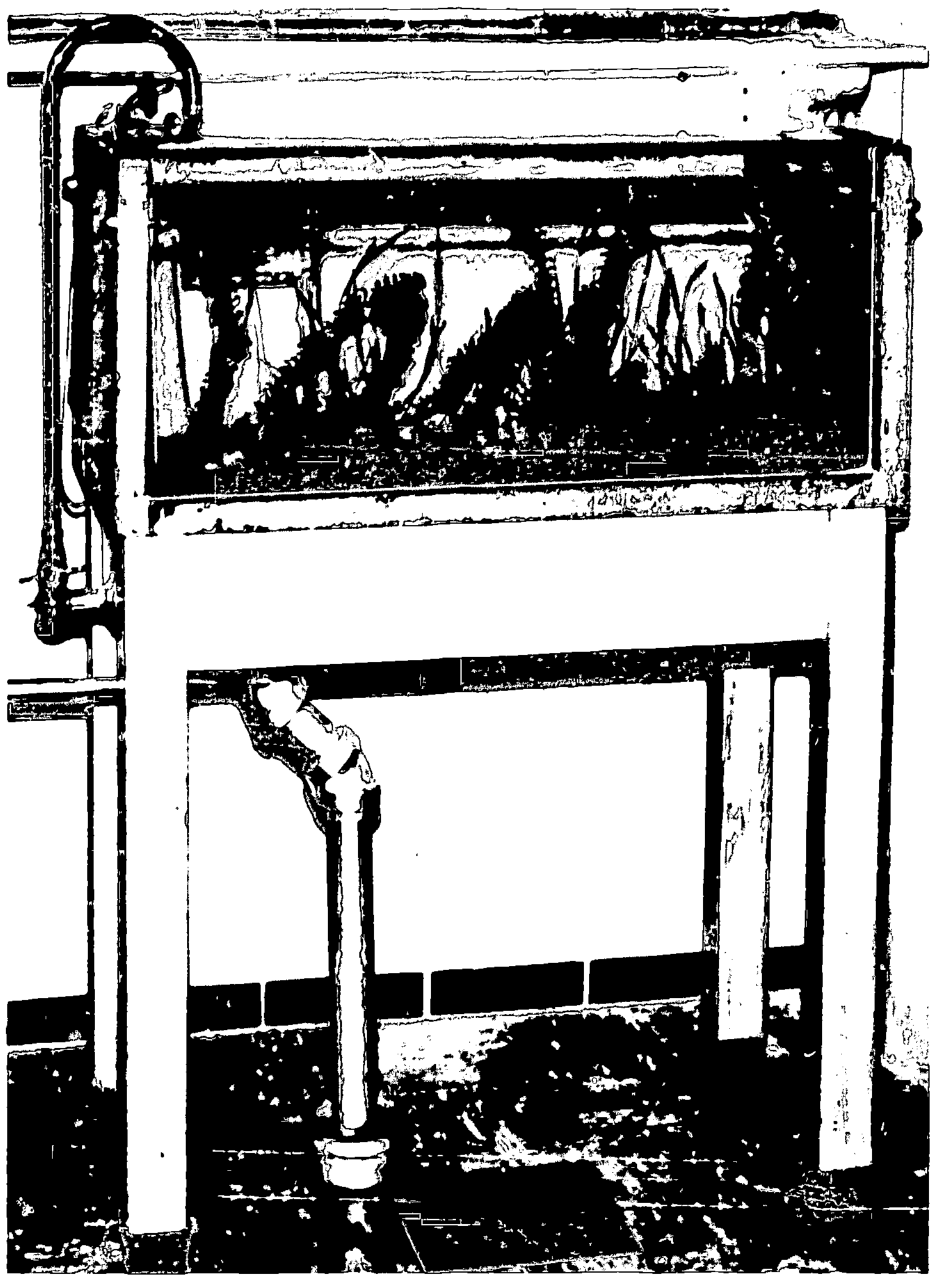
d. Incubator—100-egg capacity. Wichita High Southeast, Kan.

e. Autoclave with movable cart, constructed by the shop class. Wichita High Southeast, Kan.

f. Drying oven. Wichita High Southeast, Kan.

g. Charts labeled and stored in special cabinet. Laboratory School, Greeley, Colo.

h. Permanent installation aquarium (18" x 32" x 15" deep). Wichita High Southeast, Kan.



STOREROOMS. The most common practice for out-of-room storage is a storeroom adjoining the classroom. Where there are adjacent classrooms, one storeroom may serve two biology rooms. In school construction, the practice of planning rooms all in a line on either side of a hallway limits the management of out-of-room storage.

The inadequacy of storage space is a major complaint of biology teachers. There is need for an ample number of drawers to accommodate many small items, for open and enclosed shelving, for table space and for at least some free wall space against which large items of equipment may be placed.

The storeroom is best located with the door near the teacher's station in the classroom. This makes it easier for the teacher to secure equipment and materials for demonstrations and at the same time to supervise the entrance to the storeroom. (Figures 35, 36.)

PREPARATION ROOM. Preferably, preparation space should adjoin and open into the storeroom. Typically, a divider of cabinets provides two spaces within a single large room.

The equipment of the preparation area includes gas, electricity and hot and cold water. One of the sinks should have a sand trap and a garbage-disposal unit. Space for several laboratory carts is essential. Germination beds and a place for animal cages are needed, if not provided for elsewhere. It would be advantageous if the room contained a shop workbench equipped with a vise and tools. A two- or three-burner stove with an oven, refrigerators, freezer and a water still are also needed. A fume hood that may also function as a sterile transfer chamber is desirable.

Work stations with tables and chairs are needed for the laboratory or instructional assistants. While it is not the most desirable arrangement, the preparation area is frequently equipped to serve as a teacher's office. (Figures 37, 38, 39, 40, 41, 42.)

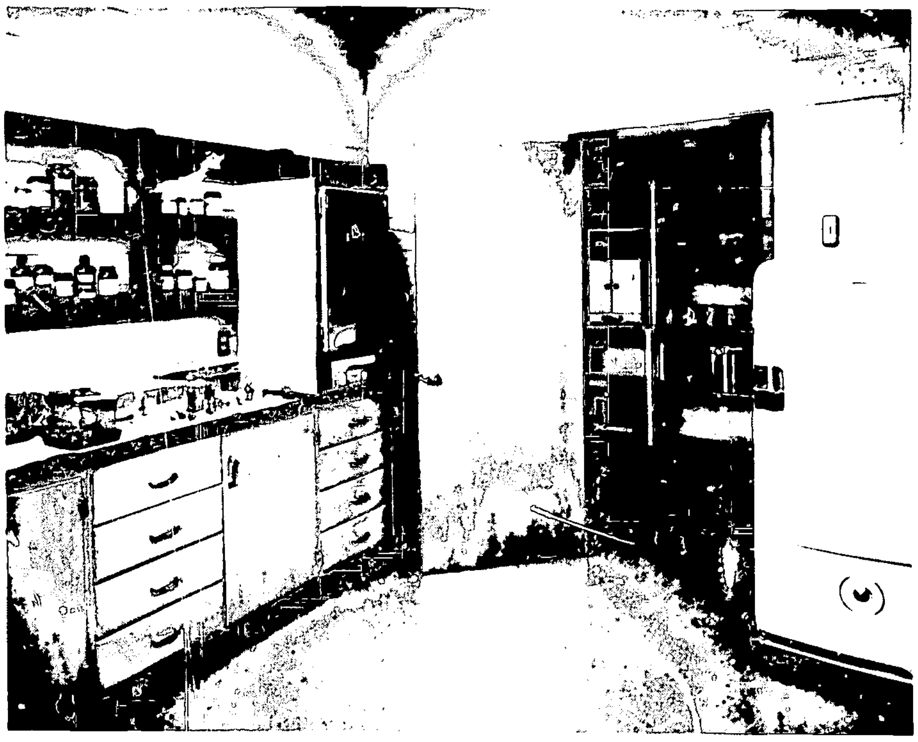
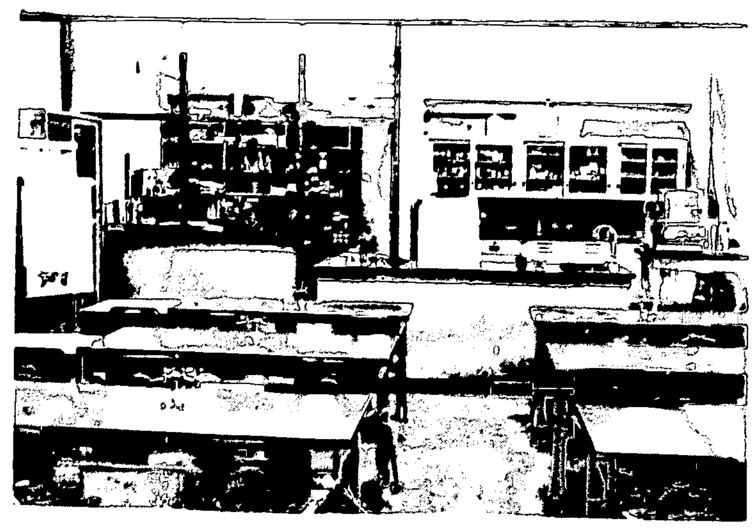
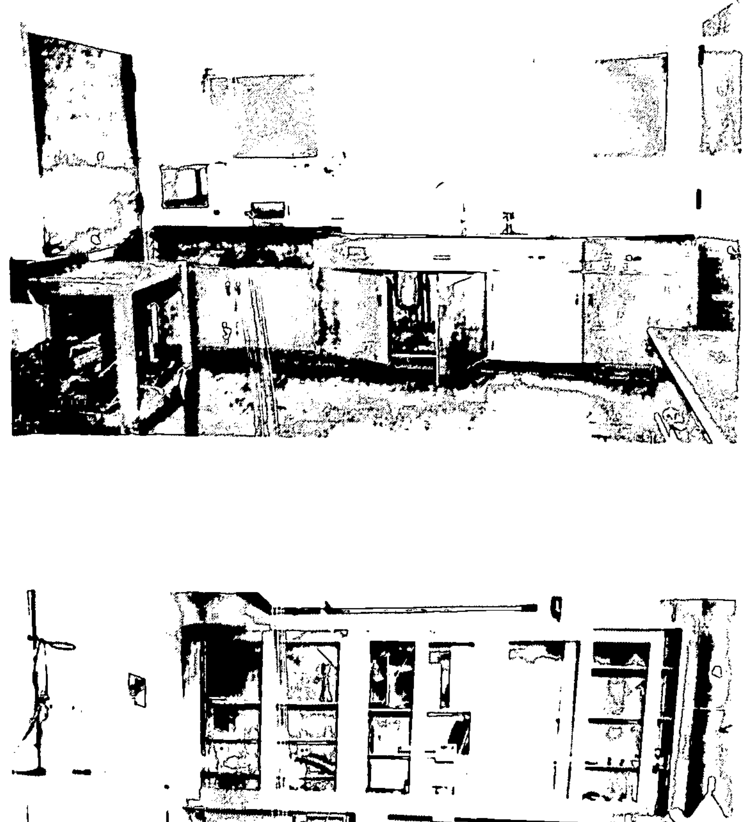


Fig. 35. Preparation (14′ x 12′) and storage areas (12′ x 8′) in separate but connecting rooms. Mercy High, Baltimore, Md.

Fig. 36. Biology storeroom 40′ x 36′. Sunset High, Beaverton, Ore.

Fig. 37. Preparation room opening onto the lab area in rear of classroom. Wilson High, Portland, Ore.





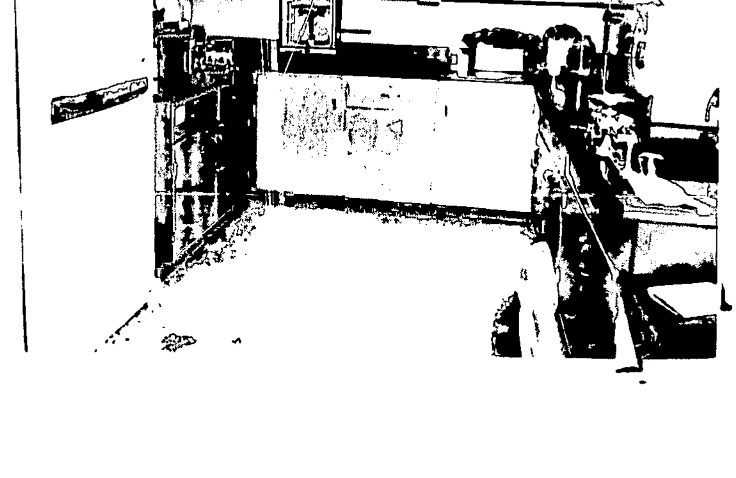


Fig. 38. Preparation area in project room. Refrigerator with freezing unit is located at right of counter. Menlo-Atherton High, Calif.

Fig. 39. Preparation room. Note built-in electric heating units. Riverview High, Sarasota, Fla.

Fig. 40. Preparation area is an integral part of demonstration center. Teacher's office is at the left. Brookfield Central High, Wis.

Fig. 41. Preparation area. Note garbage disposal unit with sink. Abraham Lincoln High, Denver, Colo.

Fig. 42. Preparation room. Melbourne High, Fla.

PROJECT ROOM. The need for a project area has developed as a result of the demand for more worthwhile laboratory experiments. The best of these experiments may require working with organisms that grow, develop and react. Since it takes days—even weeks—for plants and animals to develop, there is need for a place where experiments can be left set up without disturbance. The need is even greater when five or six classes per day use the same room and every class is developing continuing experiments.

The BSCS *Research Problems in Biology* series contains individual research projects that students may engage in. These investigations require that students have a work space for their equipment and supplies, where they may work during odd hours. The BSCS laboratory blocks experiments as well as science fair projects, also require the continued use of space, and it is not feasible to attempt to house all of these activities in the laboratory-classroom.

A project room is designed as a laboratory room, with tables equipped for gas, water and electricity, and with drawers for the storage of project materials. It also includes considerable storage space and ample work surface. Some of the laboratory tables should be movable. A shop table with tools is an important part of the furnishings if not available elsewhere in the science suite. The arrangement of furniture and equipment should be highly flexible to accommodate the variety of projects that will be developed within the room.

A common arrangement is to combine the preparation room, the project room and the storeroom into one large room, with "centers" in the room for project activities, preparation, storage and clean-up. (Figures 43a, 43b, 44, 45a, 46b, 47.)

THE CLEAN-UP AREA. Either within the classroom-laboratory itself or as a part of the preparation room, a cleanup center is needed. Typically, the equipment for the area includes a dishwasher and sink, both equipped with *hot* water as well as cold. The sink should contain a garbage-disposal unit. Disposal crocks, drain boards, glassware pegboards and storage shelves should be close at hand. There should be enough space around the cleanup center to accommodate laboratory carts and for the free movement of students and laboratory assistants. (Figure 46.)

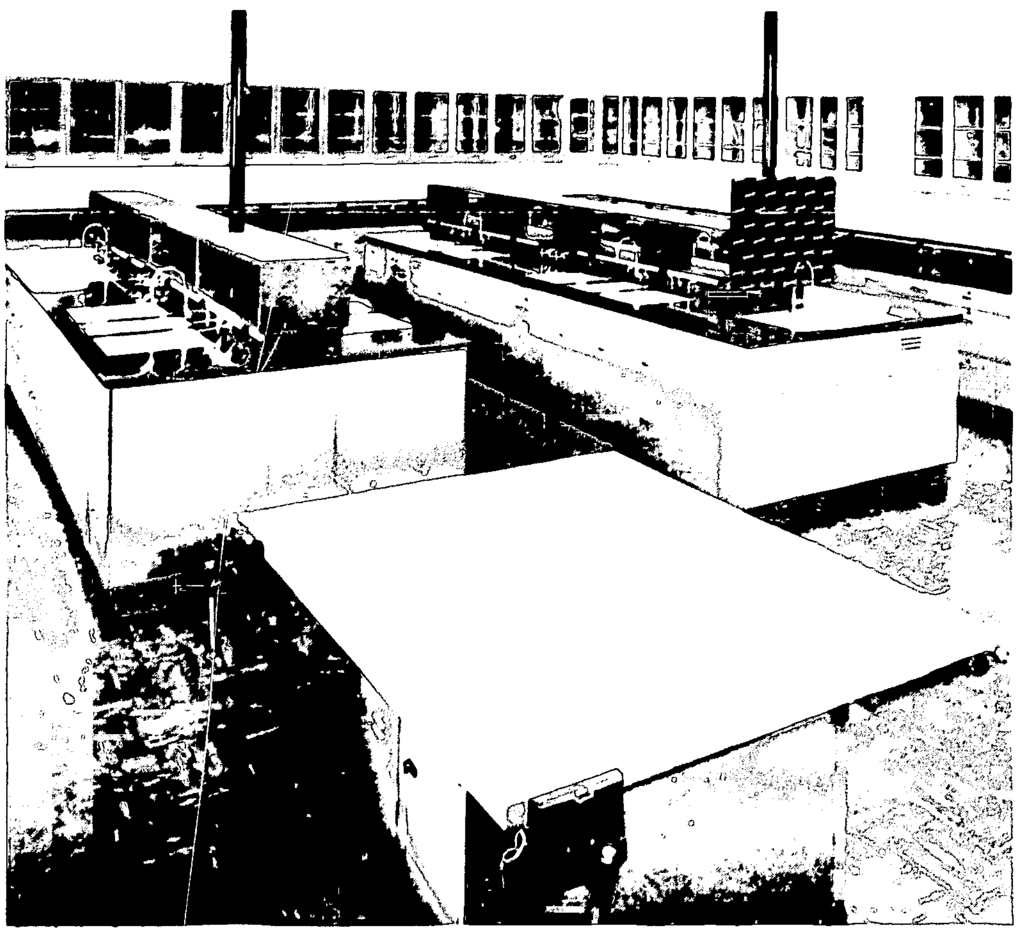


Fig. 43a,43b. Student project room. Note shop table and clean-up station. Room is not used by regular classes. Menlo-Atherton High, Calif.

Fig. 44. Biology project room. Richfield Senior High, Minn.

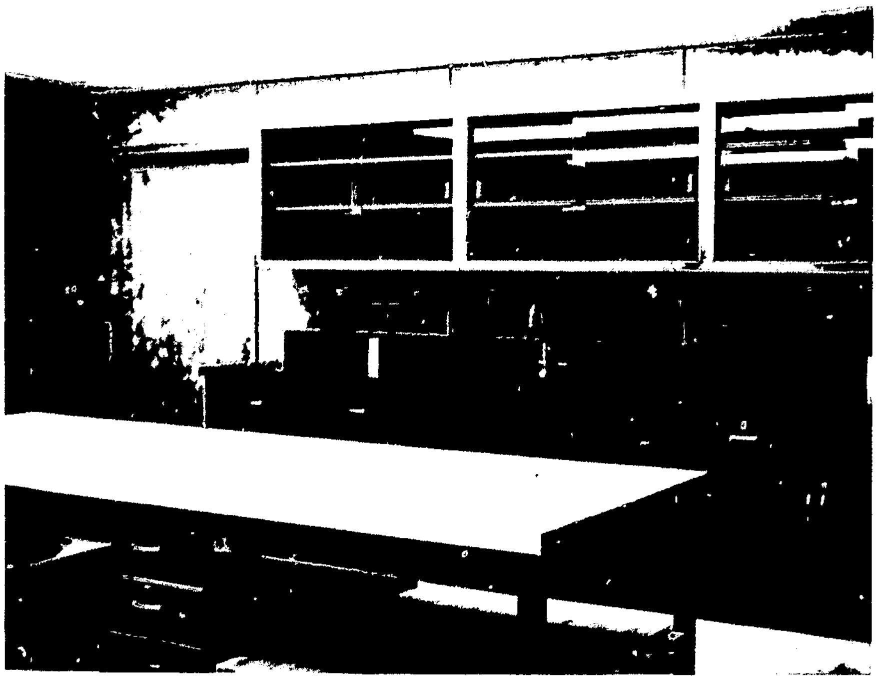
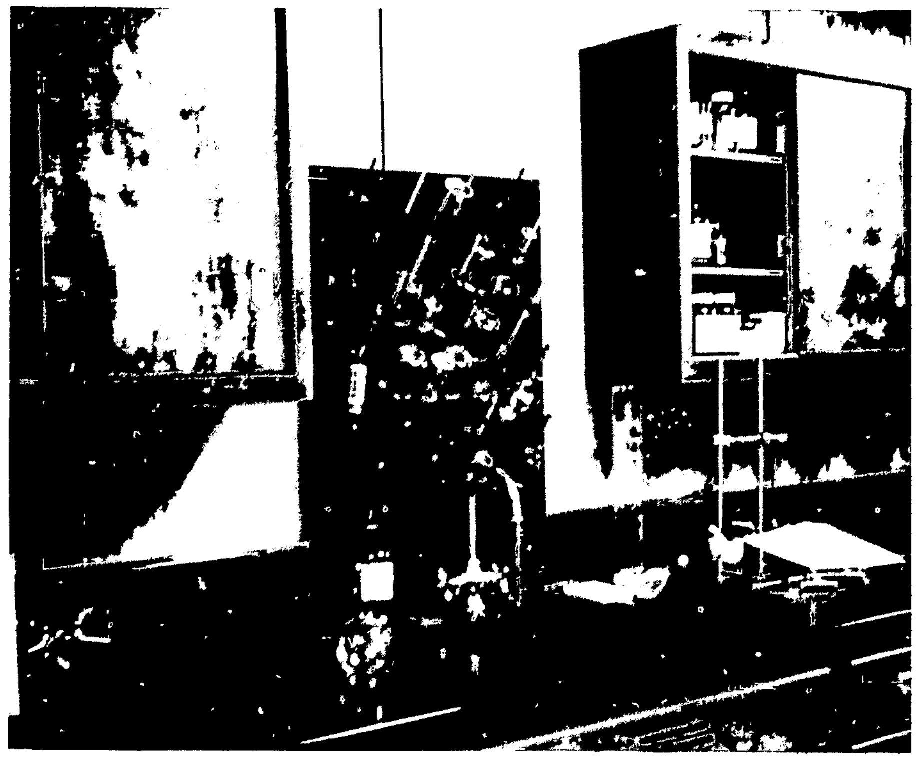
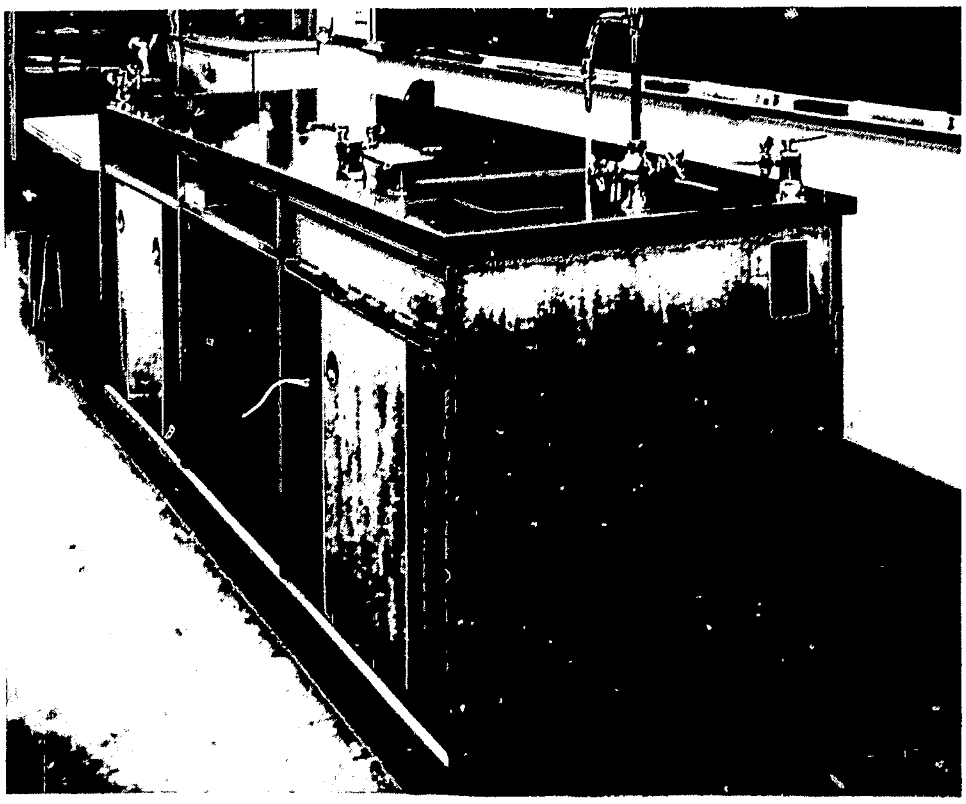


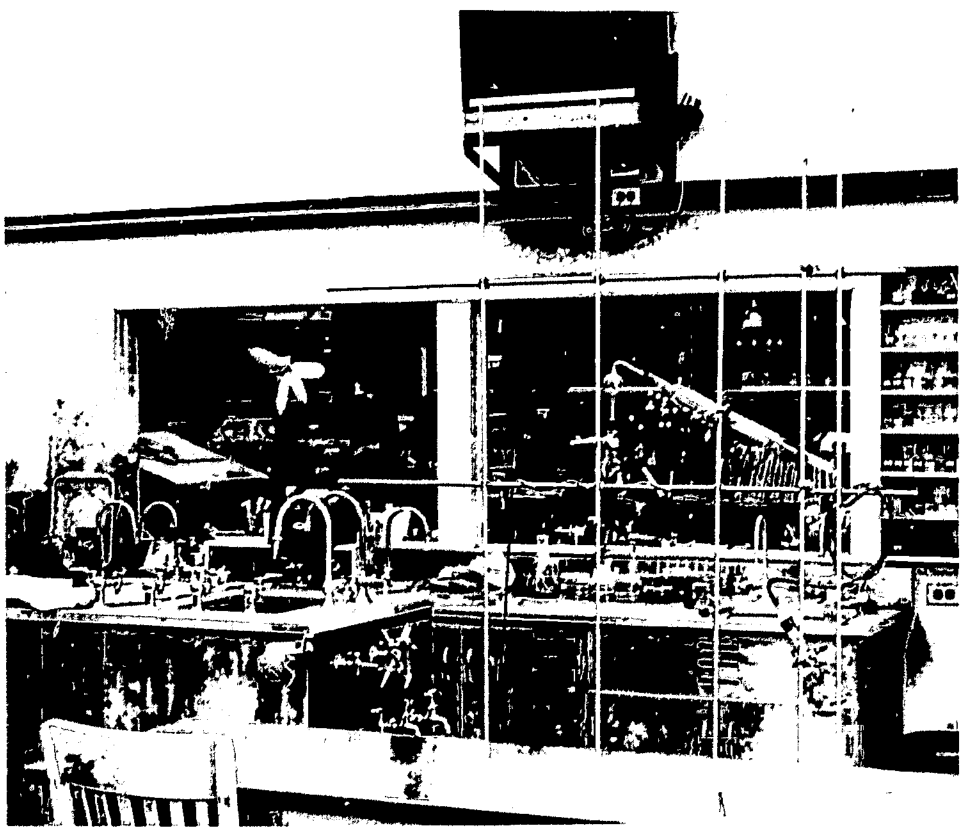
Fig 45a,45b. Student project room, with vision strip allowing supervision from faculty office area. Homestead High, Cupertino, Calif.

Fig. 46. Clean-up area in preparation room. Homestead High, Cupertino, Calif.

Fig. 47. Student project room. Storage and preparation rooms located across hallway. Alamo High, San Antonio, Tex.







DEMONSTRATION AREA. The instructor's demonstration table at the front of the room is a standard feature of biology classrooms. Equipment for the desks may be obtained in many combinations but typically includes hot and cold water, a sink with a garbage-disposal unit (if not available elsewhere in the laboratory), receptacles for upright rods, electricity, gas and a variety of drawers and cupboards. (Figures 48, 49.)

The length of the demonstration table is a matter of preference, since movable laboratory carts that match the table in height and width are available, and can be moved in to increase work surface as needed. This arrangement is preferred by some teachers, because laboratory carts can be "set up" in the preparation room and brought in as needed. This arrangement provides a means of having a portable demonstration table that may be used in other sections of the room. (Figures 49, 50.)

In laboratories without separate storerooms, an effort should be made to provide ample storage space close to the demonstration area. Shelving can be placed behind a sliding chalkboard, chart storage placed under the chalkboard and storage cases located nearby. A permanently mounted projection screen, a chart rail and display units should be near the demonstration center. A tilted projection screen angling away from the wall will improve the picture from an overhead projector. This area is often the location of the teacher's desk and most manufacturers offer a combination teacher's desk and laboratory table. (Figures 51, 52.)

Fig. 48. Demonstration table has storage sections on sides and a garbage disposal unit; master switch on side of demonstration table controls electricity at student stations. Oak Park-River Forest High, Ill.

Fig. 49. Demonstration center in lab-classroom. Note small movable demonstration table, access to supplies at rear of tables, and placement of the television receiver. Evanston Township High, Ill.

Fig. 50. Movable demonstration table. South High, Denver, Colo.

Fig. 51. Overhead projector allows drawings to be prepared in advance. Note projection screen mounted away from the wall and hooked back at the bottom to correct parallax. Brattleboro Union High, Vt.

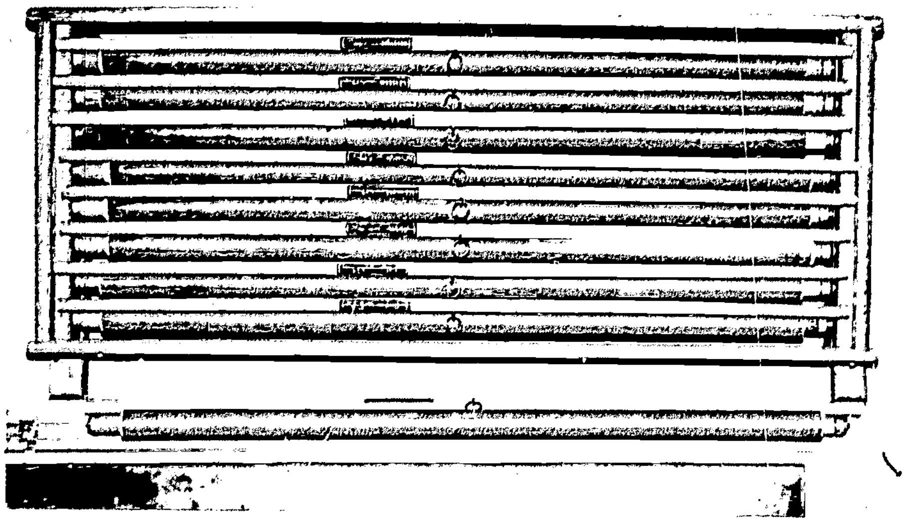


Fig. 52. Charts mounted in wall rack at front of room. Wichita High Southeast, Kan.

Provision should be made for the location of the projection table and the needed electrical outlets. A permanently mounted speaker and a remote control for the projectors are also desirable..

Many science teachers prefer that the master shut-off valves and switches controlling the services on student tables be located near or at the demonstration table. Whatever the location of the master controls, they should be close to the work areas of the teacher.

STUDENT STATIONS. At the area where students are expected to carry out experiments, there should be electrical outlets placed where they will not interfere with the work surface. Gas or other heating source should be available at regular intervals. The same is true of water and sinks. Each student should have his own storage space, which may be provided by means of desk drawers, tote trays or cabinet space. The table tops should be resistant to chemical stains, and easy to clean and maintain.

The arrangement of student desks should make it possible for a squad of three or four students to work together. The need for laboratory stools will depend upon the choice of furniture. Stools are most likely to be needed when the classroom and laboratory work areas are separate units. (Figures 9, 11, 14, 25.)

THE DISPLAY AREAS. Displayed materials are intended primarily to increase interest, raise questions, arouse curiosity and in other ways motivate students toward the study of biology. A properly planned display may become a teaching device illustrating a biological principle, an ecological setting or a taxonomic grouping. Hall displays should be specially planned as teaching demonstrations. (Figures 53, 54.)

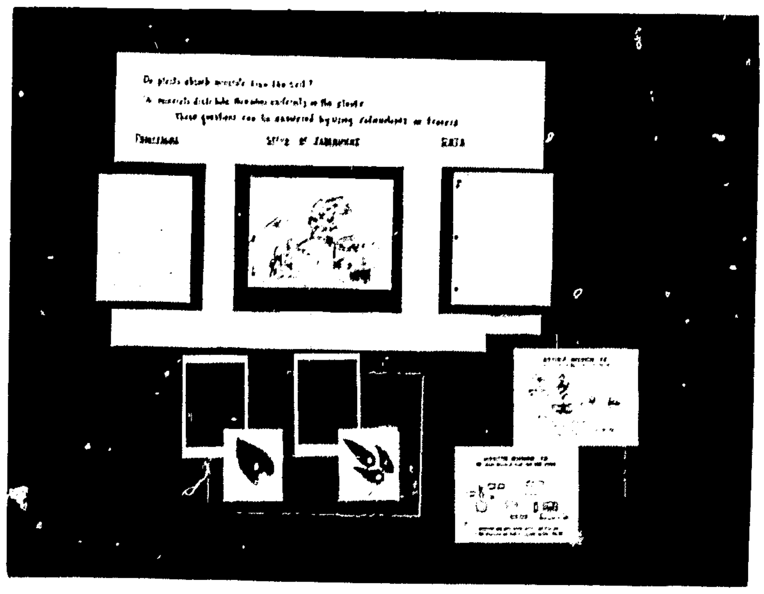
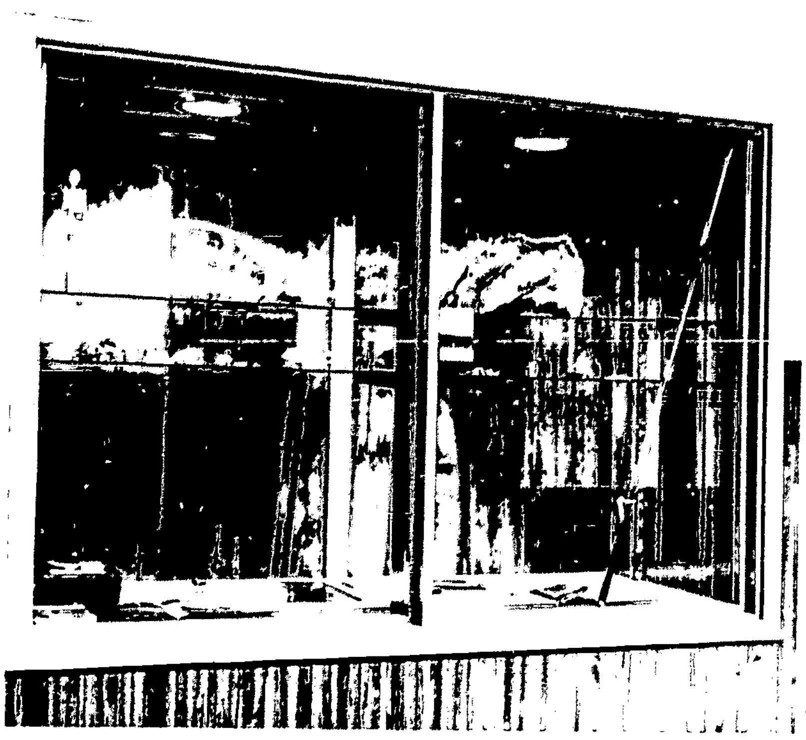


Fig. 53. Walls that teach. East Brunswick High, N. J.

Fig. 54. Hall display cases well lighted and equipped with adjustable shelves; sliding back panels open into classroom. Sunset High, Beaverton, Ore.

Fig. 55. New books for the biology library. North High, Denver, Colo.



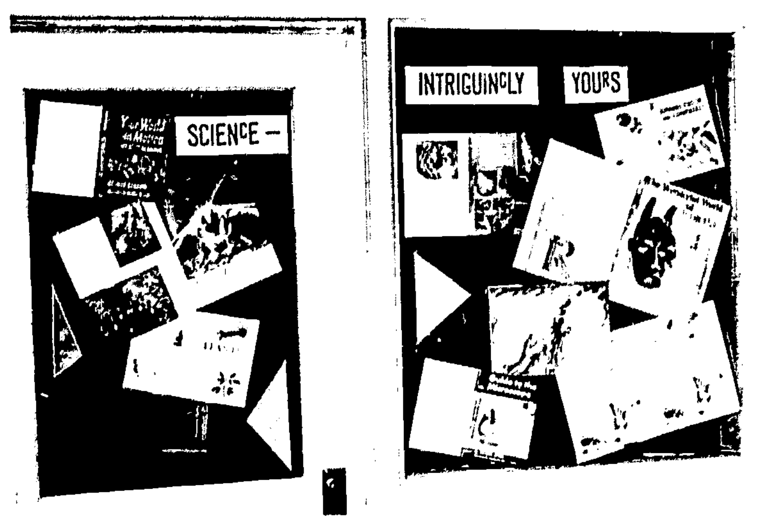


Fig. 56. Plant room with pools. Note storage bins. Yuba City Union High, Calif.

The aquaria, library center and the plant material in a room can be organized as displays for learning as well as serving their usual purposes. The new BSCS Pamphlets and recent books should be featured as a display for a week or so after their arrival. Specimens stored on open shelves or in glass cases should be arranged in the manner of a teaching exhibit rather than as dead storage. (Figure 55.)

Cases intended primarily for display are more useful if equipped with museum-type glass doors and with electrical outlets. Live animal and plant display units should be planned to provide the appropriate conditions for healthy maintenance. (See sections on facilities for plants and animals.)

Tackboard and pegboard units are best distributed throughout the laboratory-classroom. Cabinet doors and the backs of certain display furniture can be obtained with a cork surface for displaying pictures, charts, etc. A portable easel and a mobile table are useful display accessories. With proper design and management, a considerable fraction of the wall and counter space in a biology room can become instructional devices.

LIFE AREAS. The proper teaching of biology requires that young people have many opportunities to work with living plants and animals of many kinds.

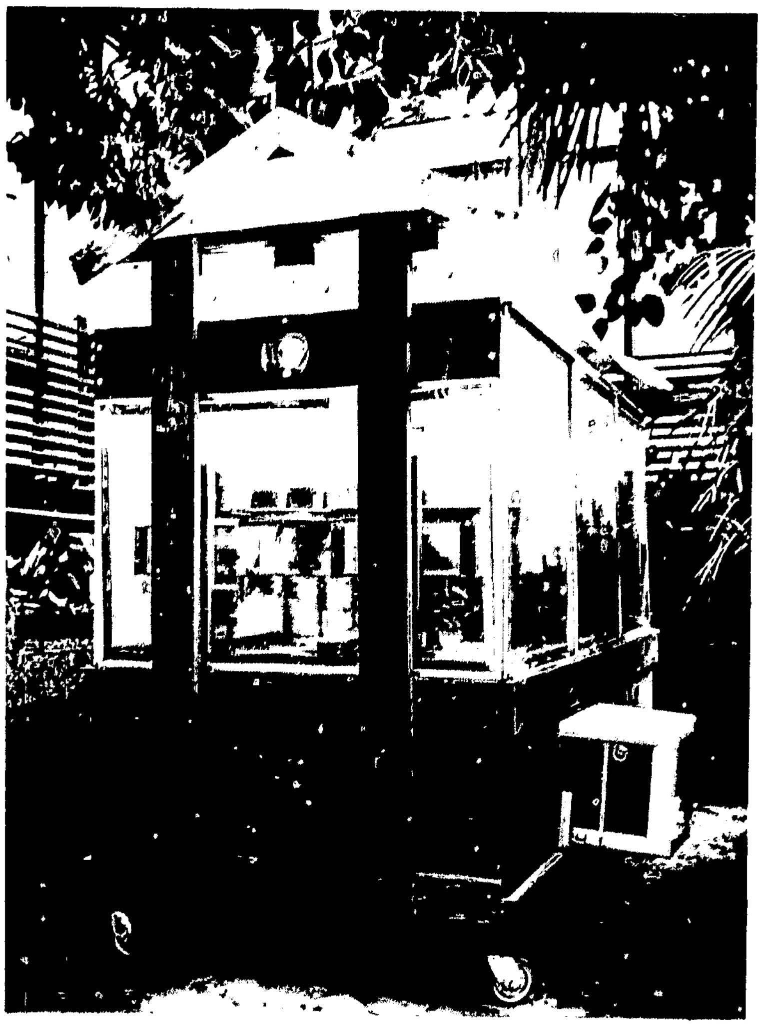
To keep certain plants and animals alive and healthy in a classroom, special environmental conditions may be needed. A biology room is essentially a learning laboratory without walls; the school grounds, vacant lots, parks, ponds—in fact any place where life exists—should be viewed as an instructional resource for the teaching of biology.

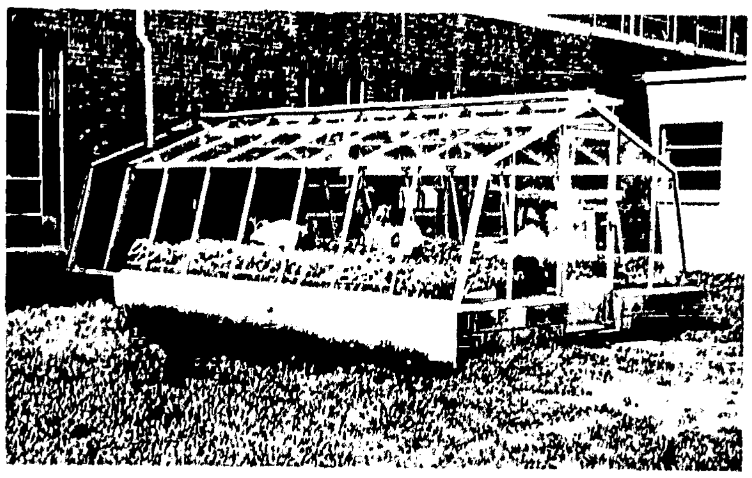
Aquaria. One 30-50 gallon, permanently mounted aquarium and several smaller, movable aquaria should be available. A salt water aquarium will require special equipment for water circulation and cooling. A shallow, aquatic table four to five inches deep is useful for the rearing of frogs, turtles, salamanders and aquatic invertebrates (Figures 34h, 56.)

Germination and small plant units. There is a wide variety of terraria, vivaria and soil units available through commercial companies. These are small units suitable for seed germination and the growing of plants that do well under the usual temperature, humidity and light conditions of a classroom. Portable units that will hold horticultural flats or flower pots and are equipped with a light source can be made or purchased. (Figure 27.)

Growth chambers. A growth chamber is a mobile classroom greenhouse. The soil trays are enclosed by a glass or plastic housing, and it is possible to vary environmental conditions to meet the requirements of an experiment. The intensity and quality of the light, the humidity, the soil temperature and the circulation of air in the growth chamber can be regulated automatically. (Figure 57.)

Greenhouse. Schools where several classes of biology are scheduled should consider installing a greenhouse. To obtain the best results from experiments involving living organisms, they should be raised and maintained under optimum environmental conditions. Quite properly, the class and laboratory rooms in a school are not planned to provide th: best living conditions for plants and animals. Greenhouses are designed to provide conditions in which light, temperature, humidity and air circulation may be regulated. The more precise the control of these conditions, the more costly the greenhouse. In BSCS courses and laboratory blocks, the range of living organisms is not so great as to require a highly expensive unit. (Figures 58, 59, 60, 61.)





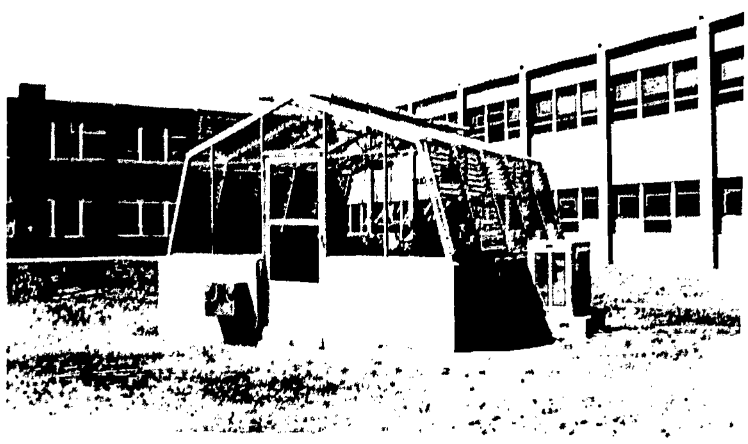


Fig. 57. Prototype high school plant growth chamber, developed under a National Science Foundation grant, by Wray Darr in consultation with F. W. Went, Director, Missouri Botanic Garden, St. Louis.

Fig. 58. Greenhouse entered from biology classroom and out-of-doors. Brattleboro Union High, Vt.

Fig. 59. Detached greenhouse. Laboratory School, Greeley, Colo.

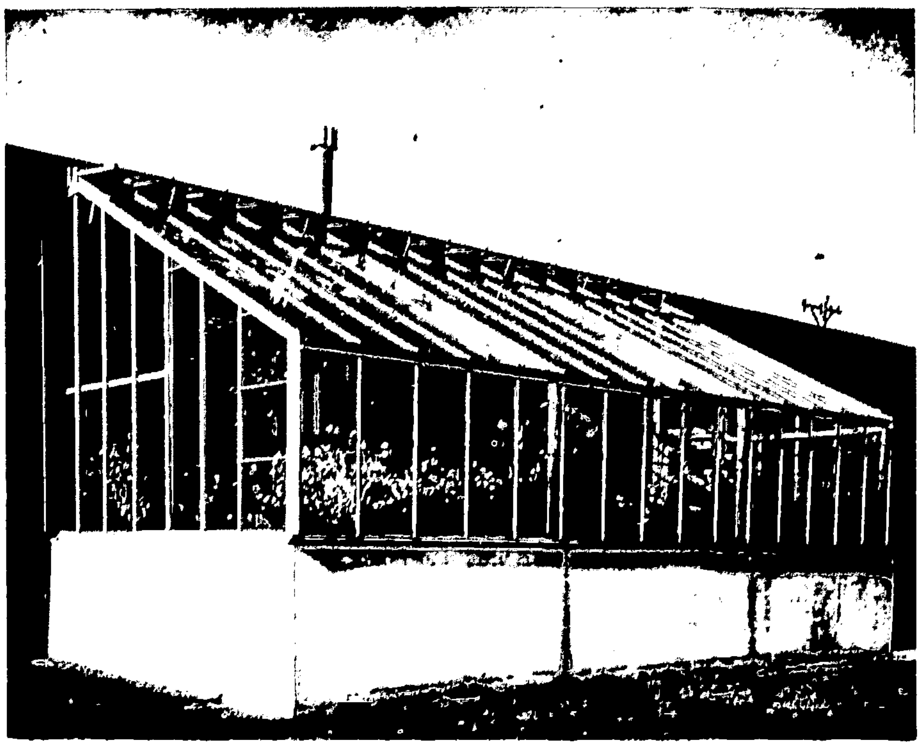


Fig. 60. Greenhouse connects with classroom. Note ventilation facilities. Wichita High Southeast, Kan.

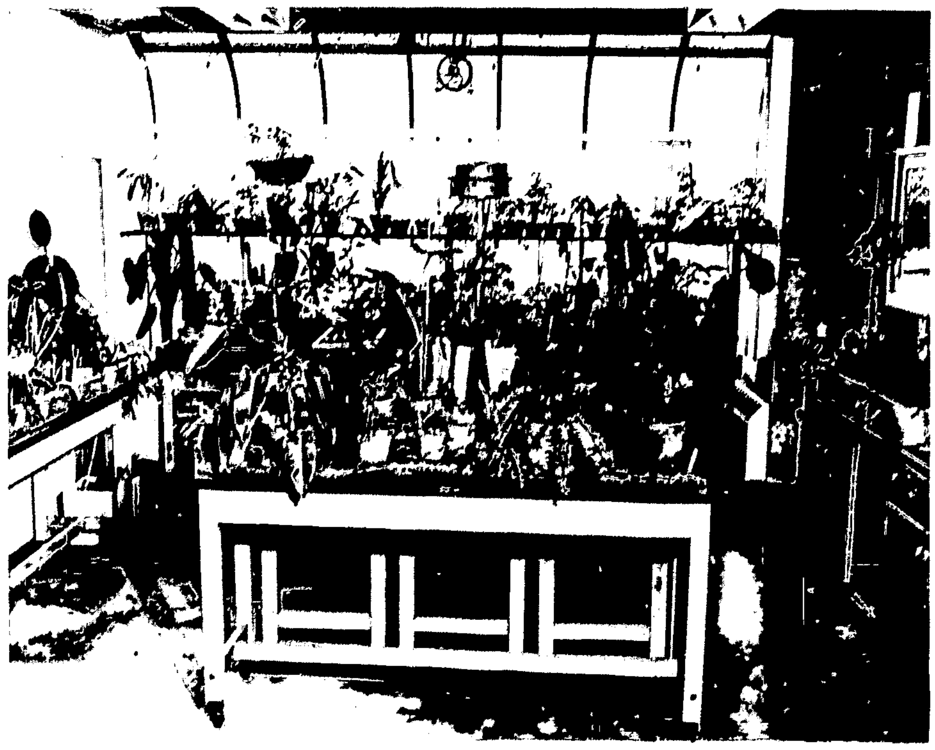


Fig. 61. Plant room. Note lighting arrangement, humidifier and movable terraria. Maine Township High West, Des Plaines, Ill.

A greenhouse is more useful if it is planned to include running water and still water for aquatic plants and animals. It should also include space for on-going experiments in which students are involved, as well as for growing the living things to be used in future experiments. The greenhouse should have space for storage of soil, pots, flats, fertilizers, tools and related materials. The equipment of a greenhouse typically includes a sink with a sand trap, a floor drain, one or more hose bibs, benches, shelves and some means of artificial lighting. The location of the greenhouse will be influenced by climatic conditions and by the design of the school. It is preferable to be able to enter the greenhouse from the biology room as well as from the school grounds.

Living culture area. An alcove in the laboratory classroom or space in the preparation room should be planned as a center for the culture of protozoa, small invertebrates, fungi, algae, bacteria and other organisms. Representative equipment within this area might be aquaria, live insect cages, incubators, culture jars of various kinds, breeding cages, vivaria, live frog tank, oven and similar items. The management of living cultures is more efficient if they are concentrated in one place. The living culture center should evolve in terms of instructional needs, but the space and required services need to be planned in advance. (Figure 43.)

Animal center. Use of live animals in the laboratory carries with it the responsibility for proper care; specific instructions for such care are included in the BSCS teacher and student materials. Whether live animals are to be kept in cages in the classroom or relegated to a special animal room, the conditions for humane care and maintenance are the same. (Figures 62, 63.)

Protozoa, worms, insects and other invertebrates are animals that can be used for a majority of biological experiments. Fish and frogs are widely used for experiments and are not difficult to maintain in the laboratory. White rats, mice, hamsters, guinea pigs and small birds provide an opportunity for studies in behavior, genetics, growth and development, life cycle and nutrition. All of these animals must be kept healthy through proper care. A laboratory animal is a laboratory tool and a very delicate one. Its care must be better than that of a house pet or farm animal from a humanitarian standpoint as well as a

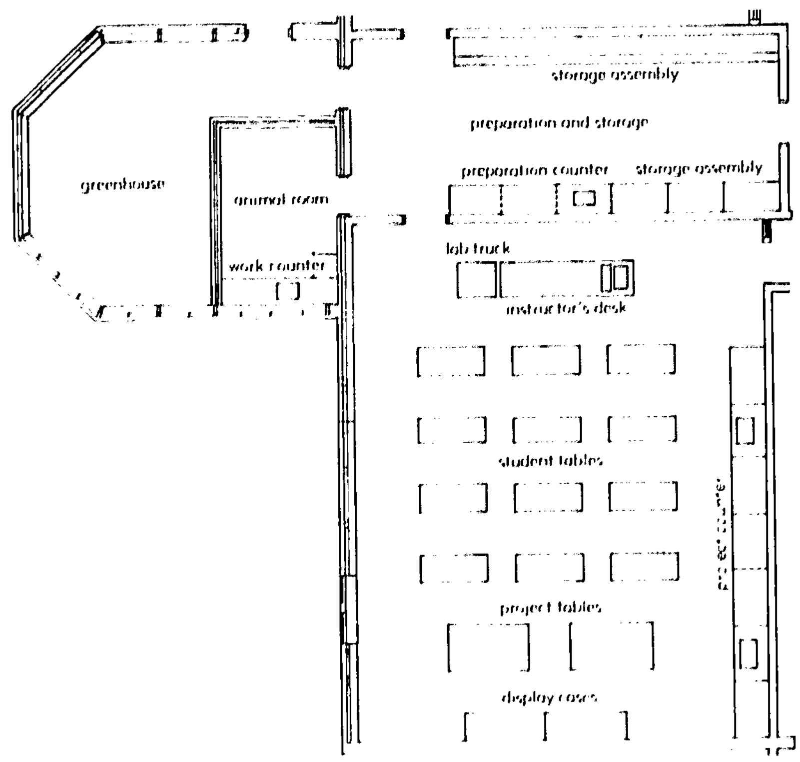


Fig. 62. Animal room. Laboratory School, Greeley, Colo.

Fig. 63. Biology suite showing arrangement of facilities. Note plant and animal rooms are distinct units. Lilly Road High, Brookfield, Wis.

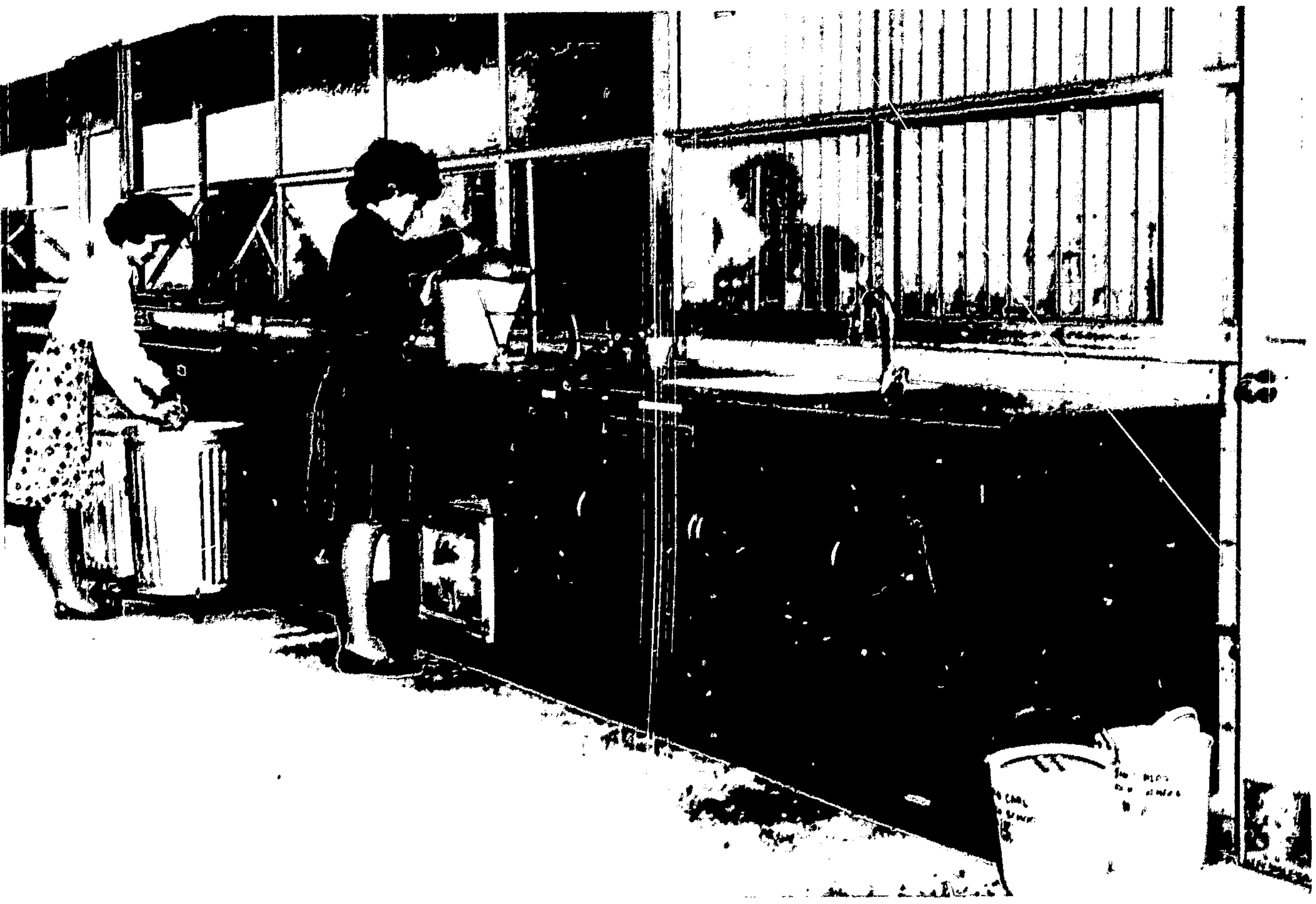
scientific standpoint. The desirable environmental conditions in the animal room are:

1. clean and sanitary
2. controlled temperature (72-75° F), humidity (50-55%) and lighting
3. adequate ventilation
4. freedom from excessive noise, movement and other conditions likely to cause nervous stress in animals
5. a vision strip between the laboratory and animal room

Outdoor laboratory. An outdoor biology laboratory provides a place to raise plants and keep animals under the normal environmental conditions of the region. The area is frequently located next to the biology room and this is most desirable whenever conditions permit. The oudoor laboratory can have many variations in the way it is designed and used. It may be a garden area with representative native species and horticulture exotics. The area may be divided into representative ecological communities. It may be used for projects and for conservation studies. A greenhouse may be located here. Enclosures for large animals and for birds may be provided. Work tables, water, electricity, storage units and garbage containers are basic items of equipment. The area should be protected from intruders.

In most schools, the outdoor laboratory is used as a facility to increase the opportunities for experimental work in biology. A few schools use this space as a living nature museum, organized and cared for by students. The area is open to all high school students, and elementary school children are encouraged to visit the museum. (Figures 64, 65, 66, 67a, 67b.)

Fig. 64. Biology room should have a direct access to the outdoor lab; note adjacent study pond and forest area. Park School, Brooklandville, Md.



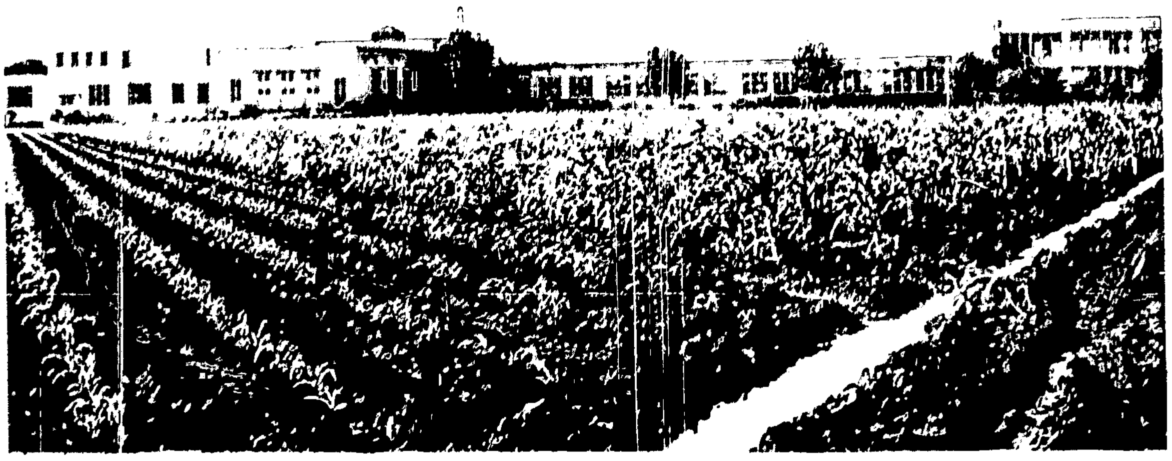
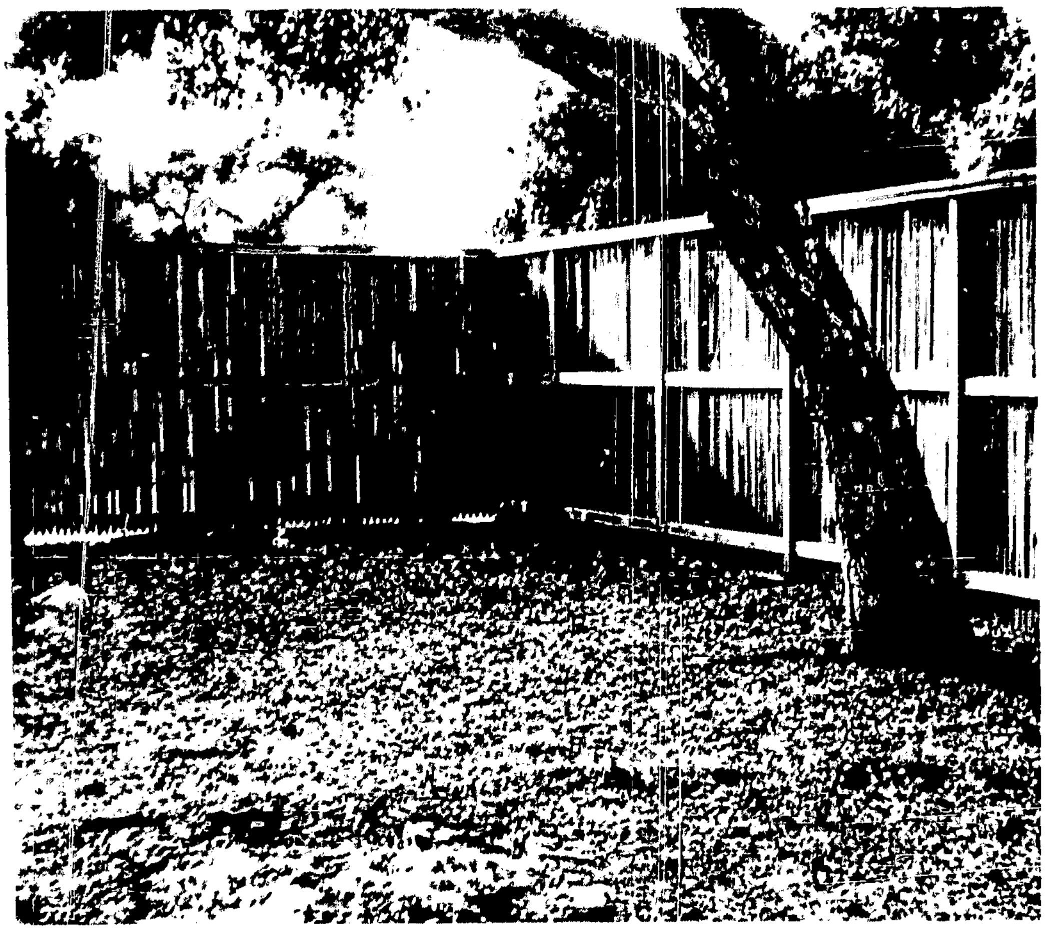
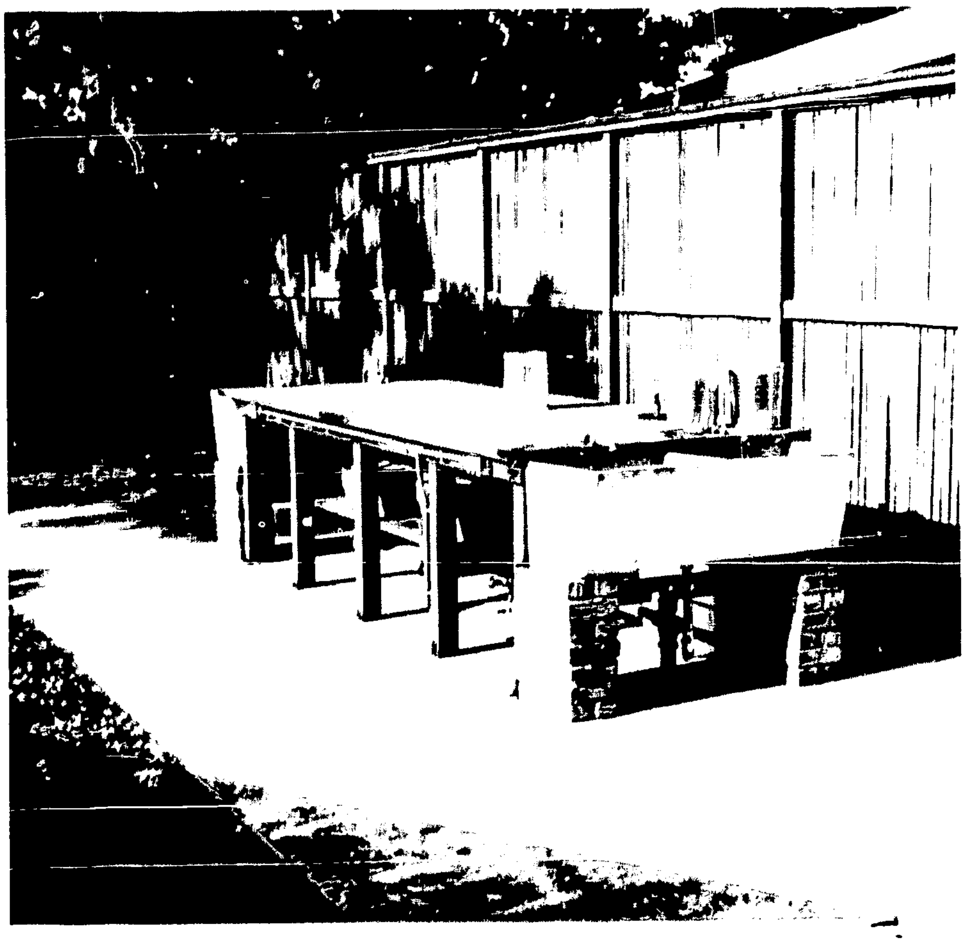


Fig. 65. Outdoor lab for preparation, storage of field trip equipment and experiments adjacent to large, fenced plot. Note entrance to the biology classroom and the darkening blinds. San Carlos High, Calif.

Fig. 66. School farm used for biology studies. Burbank Senior High, San Antonio, Tex.

Fig. 67a,67b. Area of the outdoor lab planned for permanent display of plants useful for instructional purposes, and area where experiments may be conducted; note protective fence. Preparation area of outdoor lab; note preparation table, sinks, storage shelves, electrical outlets and paved work area. Menlo-Atherton High, Calif.





School grounds. The school grounds can be developed into a biology teaching resource, with careful planning. Many plant types may be used in the school's landscaping without violating good landscaping principles. The open areas of the school grounds and the space around buildings represent a variety of microclimates capable of supporting diverse kinds of trees and shrubs. In a park-school type of development, the possible range of plants is even greater. Ponds, pools, streams and artificial lakes further increase the kinds of living organisms to be found on the school grounds. Nature trails can be developed around the materials available and modified according to changes in the seasons. (Page 8 and Figures 68, 69, 70, 71.)

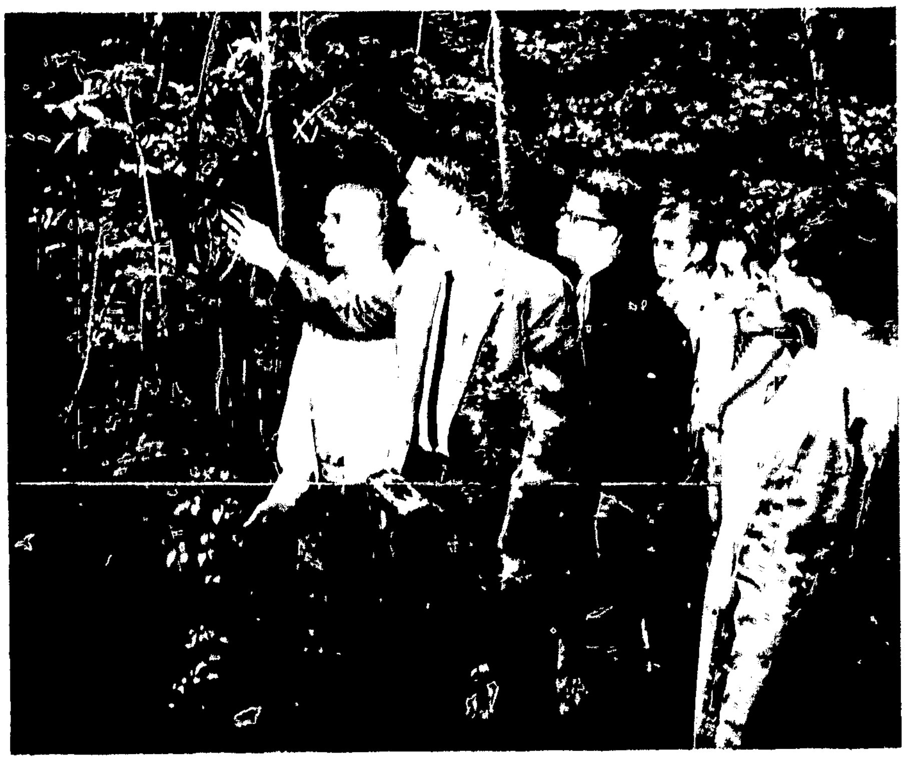
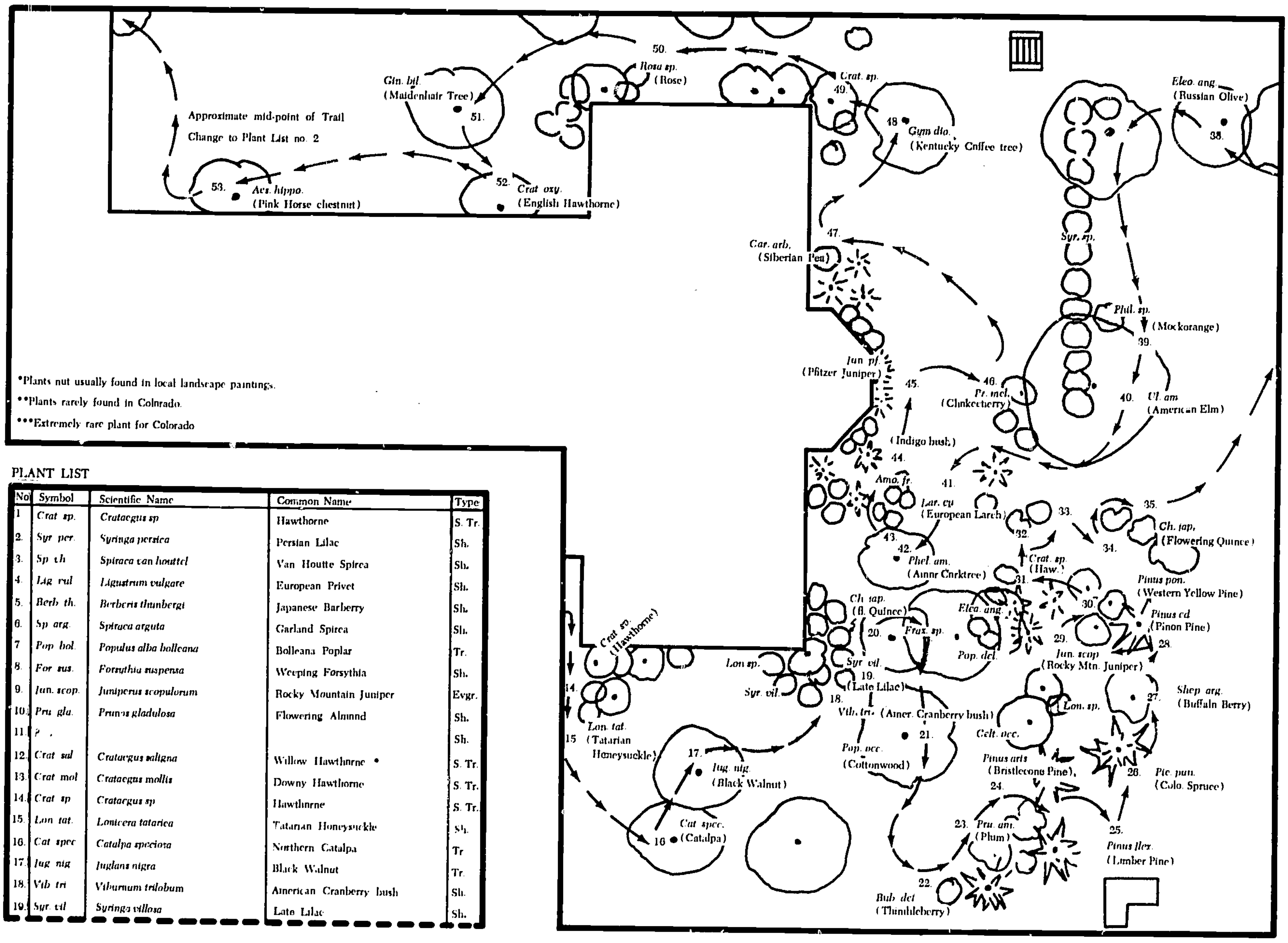


Fig. 68. The pond, a valuable teaching resource for biology. Brattleboro Union High, Vt.

Fig. 69. Station "30" on nature trail at Forest Park, Cleveland High, Portland, Ore.

Fig. 70. Desert area used for the study of biology. Highland High, Albuquerque, N. Mex.



*Plants not usually found in local landscape paintings.

**Plants rarely found in Colorado.

***Extremely rare plant for Colorado

PLANT LIST

No	Symbol	Scientific Name	Common Name	Type
1	Crat sp.	Crataegus sp	Hawthorne	S. Tr.
2.	Syr per.	Syringa persica	Persian Lilac	Sh.
3.	Sp. vh	Spiraea van houttei	Van Houtte Spirea	Sh.
4.	Lig vul	Ligustrum vulgare	European Privet	Sh.
5.	Berb th.	Berberis thunbergi	Japanese Barberry	Sh.
6.	Sp arg.	Spiraea arguta	Garland Spirea	Sh.
7	Pop bol.	Populus alba bolleana	Bolleana Poplar	Tr.
8.	For sus.	Forsythia suspensa	Weeping Forsythia	Sh.
9.	Jun. scop.	Juniperus scopulorum	Rocky Mountain Juniper	Evgr.
10.	Pru gla.	Prunus gladulosa	Flowering Almond	Sh.
11.	? .			Sh.
12.	Crat sal	Crataegus saligna	Willow Hawthorne *	S. Tr.
13.	Crat mol	Crataegus mollis	Downy Hawthorne	S. Tr.
14.	Crat sp	Crataegus sp	Hawthorne	S. Tr.
15.	Lon tat.	Lonicera tatarica	Tatarian Honeysuckle	Sh.
16.	Cat spec	Catalpa speciosa	Northern Catalpa	Tr
17.	Jug nig	Juglans nigra	Black Walnut	Tr.
18.	Vib tri	Viburnum trilobum	American Cranberry bush	Sh.
19.	Syr. vil	Syringa villosa	Late Lilac	Sh.

Fig. 71. Portion of guide to the nature trail, featuring plant varieties in the school's landscaping. East High, Denver, Colo.

THE TEACHER'S OFFICE. To do the best kind of biology teaching, a teacher needs a place he can call his own. A major cause of unhappiness and dissatisfaction among science teachers is the lack of any place in the school building where one can find privacy and work at his job of preparing to teach undisturbed. To hire professionally trained teachers and then fail to provide them with the physical resources which they need to carry on their work is the poorest kind of economy. Teachers have papers to grade, lessons to create, tests and laboratory experiments to devise, reports to do and supplies to order. Good lessons are not fortuitous; they are the result of careful thinking and planning, and they require time to perfect. It is necessary to refer to books and manuals in preparing a lesson, and these should be close at hand.

Office space for biology teachers may be provided in several ways as:

1. an individual office adjoining the classroom and preparation area
2. a science department office located in the science wing, with individual desks or cubicles for each teacher, and having access to a central preparation room
3. a desk in the storeroom or preparation room is adequate but not too desirable, due to poor environmental conditions
4. a desk in the biology classroom with the room unused one or more periods per day so that the teacher may have privacy. This obviously is a very costly arrangement, and less desirable from the teacher's standpoint.

Fig. 72. Biology department office; note typewriter, duplicating equipment, files and library. Edmondson High, Baltimore, Md.

Fig. 73. Biology departmental office combined with preparation room. Edmondson High, Baltimore, Md.

Fig. 74. Teacher's office and professional library; two teachers share office. Laboratory School, Greeley, Colo.

Office equipment should include a desk and a comfortable chair, a lockable file, bookshelves, a bulletin board and storage space. Departmental office equipment usually includes a special typewriter with science symbols, a chalkboard, duplicating machines, work tables, a sink, a telephone and facilities for previewing films. A small science department library is a necessity and typically contains: science equipment catalogs, professional science magazines, books on new curricula and methods in science teaching, source books of experiments and fields studies, curricula guides and copies of new textbooks. In some schools, all the new science books ordered for the school library are first sent to the teachers' library for a limited period of time. (Figures 72, 73, 74, 75.)

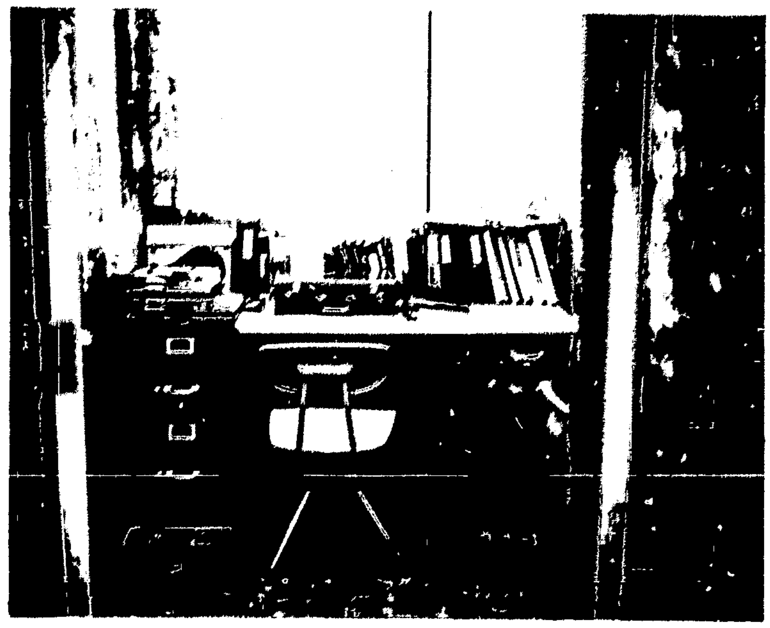


Fig. 75. Individual teacher office. The science teacher offices are in the same area, and close to preparation and project rooms. Homestead High. Cupertino, Calif.

SOME SPECIAL CONSIDERATIONS. The planning of biology facilities cannot be prescriptive. This chapter contains suggestions that may be implemented in a variety of ways and still meet the criteria of adequate facilities for teaching a modern course of biology. The emphasis is on instructional space requirements because they are most critical in terms of supporting the curriculum design and teaching style. In addition, there are other items that merit consideration in the planning of biology facilities.

Lighting. Lighting should be considered in terms of quality as well as quantity. An all-luminous ceiling is common, but maximum light sources are acceptable. There should be supplementary lighting over chalkboards and demonstration tables and microscopes have special provisions. Direct and indirect glare should be avoided through the use of dull surface areas and the proper location of equipment.

Acoustics. Acoustical treatment of science rooms is recommended.

Ventilation. There are state standards and local rulings that must be observed. The control of ventilation will depend upon climate and specific conditions. However, a system which keeps dust accumlation from equipment and surfaces should receive primary consideration. Need for special attention to ventilation in the preparation room, storeroom, animal room and greenhouse are apparent.

Audio-visual. The appropriate location of the overhead, slide, motion-picture and micro-projectors should be determined early in the planning of a room so that electrical outlets can be located at strategic places. Facilities for darkening the room should be a type that will not interfere with materials on the window counters. If open- or closed-circuit television is to be used, consideration needs to be given to wiring requirements. (Figures 76, 77, 78.)

Utilities. Gas, water and electricty should be located at various intervals throughout the room to meet the demands of the laboratory work. Particular attention should be given to an adequate distribution of electrical outlets in the classroom, at work tables and in all auxilliary rooms. If compressed air is available in the science center or shops, a line should be extended to the biology laboratory and preparation rooms.

Floors. The floors in the biology rooms should be easy to clean and to some extent, resistant to chemicals. The floors in the greenhouse should be of a type that is not slippery when wet and that is especially resistant to the growth of algae.

Plumbing. There is a limited use of corrosive chemicals in the biology laboratory, but there is an increase in the number of biochemical experiments being introduced into the course. This suggests that sinks, troughs, drains and waste lines should be planned to meet the standards of a chemistry laboratory. *Hot water is a necessity,* and should be made available in the preparation room, at the demonstration table

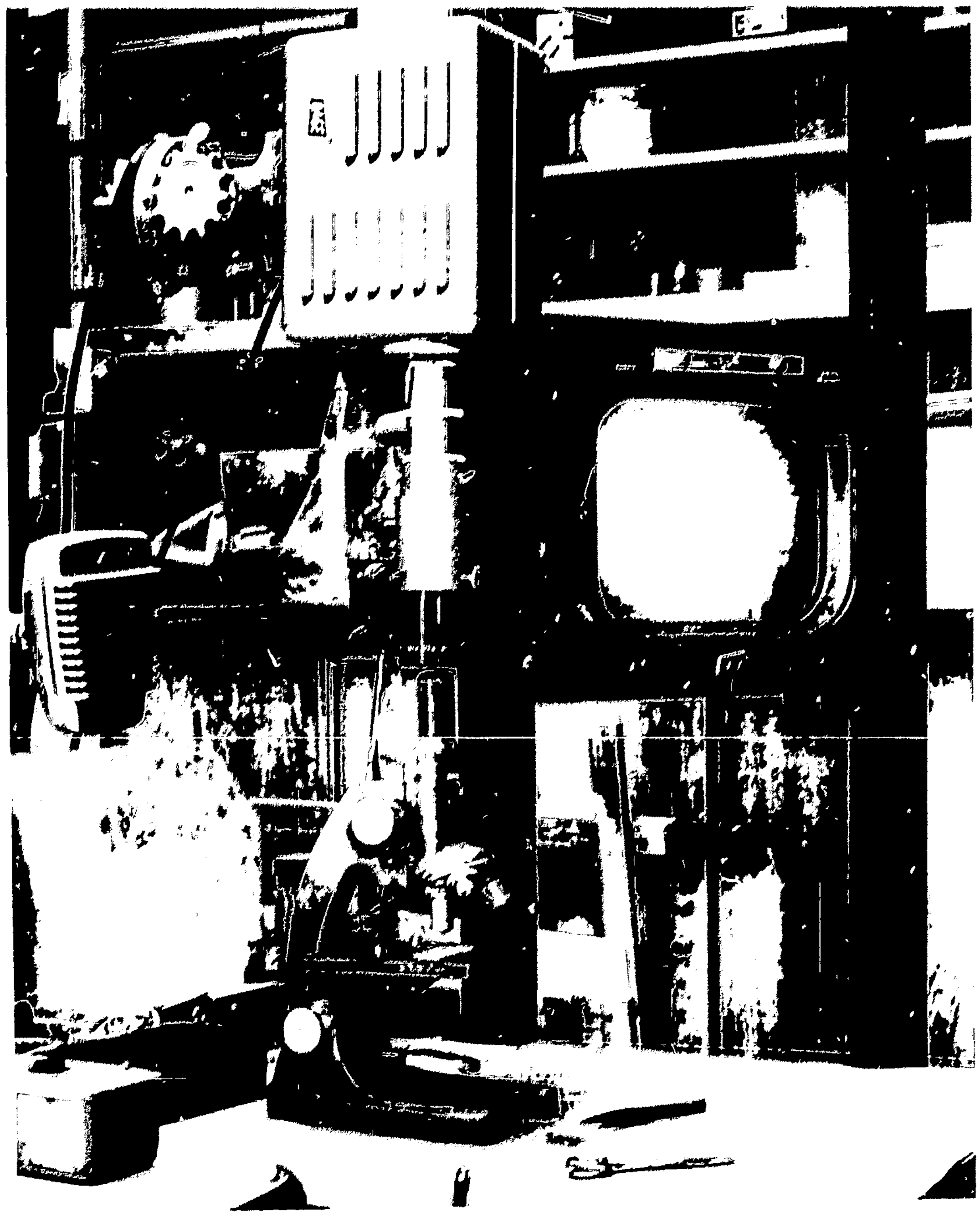
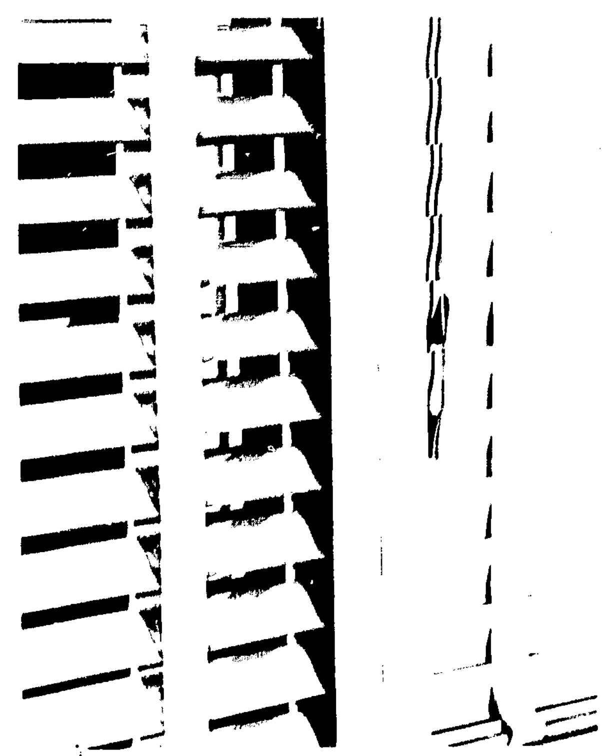


Fig. 76. Closed circuit television used to study living micro organisms with the entire class at one time. Evanston Township High, Ill.

Darkening facilities are essential for a biology lab

Fig. 77 Opaque shades. Wichita High Southeast, Kan.

Fig. 78. Full closure venetian blinds with light shields. Edmondson High, Baltimore, Md.



and at the cleanup station. Plumbing and traps should be easily accessible for maintenance and repairs.

Fume hood. A fume hood opening into the classroom and preparation room should be considered. It may also be adapted for use as a sterile transfer chamber. The locked and ventilated cabinet under the hood provides an excellent place for the storage of fuming or poisonous chemicals.

Vision strips. To provide maximum supervision of students, vision strips should be located between the classroom and preparation room, between classroom and project room, between the preparation and storeroom and/or any other combination of work centers, depending upon the arrangement of rooms.

Wall space. There is a tendency to cover all available wall space in science rooms with cases, counters and cabinets. In the planning, some free space should be allotted for the placement of large pieces of equipment, so that they will be convenient to use and will not interfere with traffic. Some of the larger items frequently used in biology and attached to or located next to walls are: aquaria, autoclave or pressure cooker, stove, incubators (egg and bacteriological), refrigerators, animal cages, centrifuge, ultra-violet ray lamp, projection stands with projectors, water still or bottled water, drying oven, dishwasher, hot plate, balances, growth chamber, laboratory carts, soil bins, terraria, germinating trays, mobile demonstration table, teacher's locker, first aid cabinet, fire extinguisher, soap dispensers, paper towel dispenser, filing cabinet, clock and disposal crocks. If the room is used for more than one science, there are additional items to be considered. It is important to plan for the placement of large equipment at the time the laboratory is being designed. Since it is not possible to anticipate all future equipment needs, movable storage units and some free wall space will help to solve the problem.

Safety. Safety is the result of good architectural design, proper equipment and instruction in the appropriate handling of equipment and supplies. There are state codes which govern structural and equipment specifications, but good classroom arrangement and management are essential for the prevention of accidents. For example, dangerous chemicals, poisonous animals and harmful bacteria, must be properly contained and kept under the supervision of the teacher at all times. First-aid kits, fire extinguishers and other emergency equipment are a part of every science room. Radioactive materials, if they are to be used, should be identified and stored according to recommendations.

Balance table. In the laboratory, the table or counter, where balances are to be used, should be free from the influence of room vibrations. This does not have to be a special item of furniture.

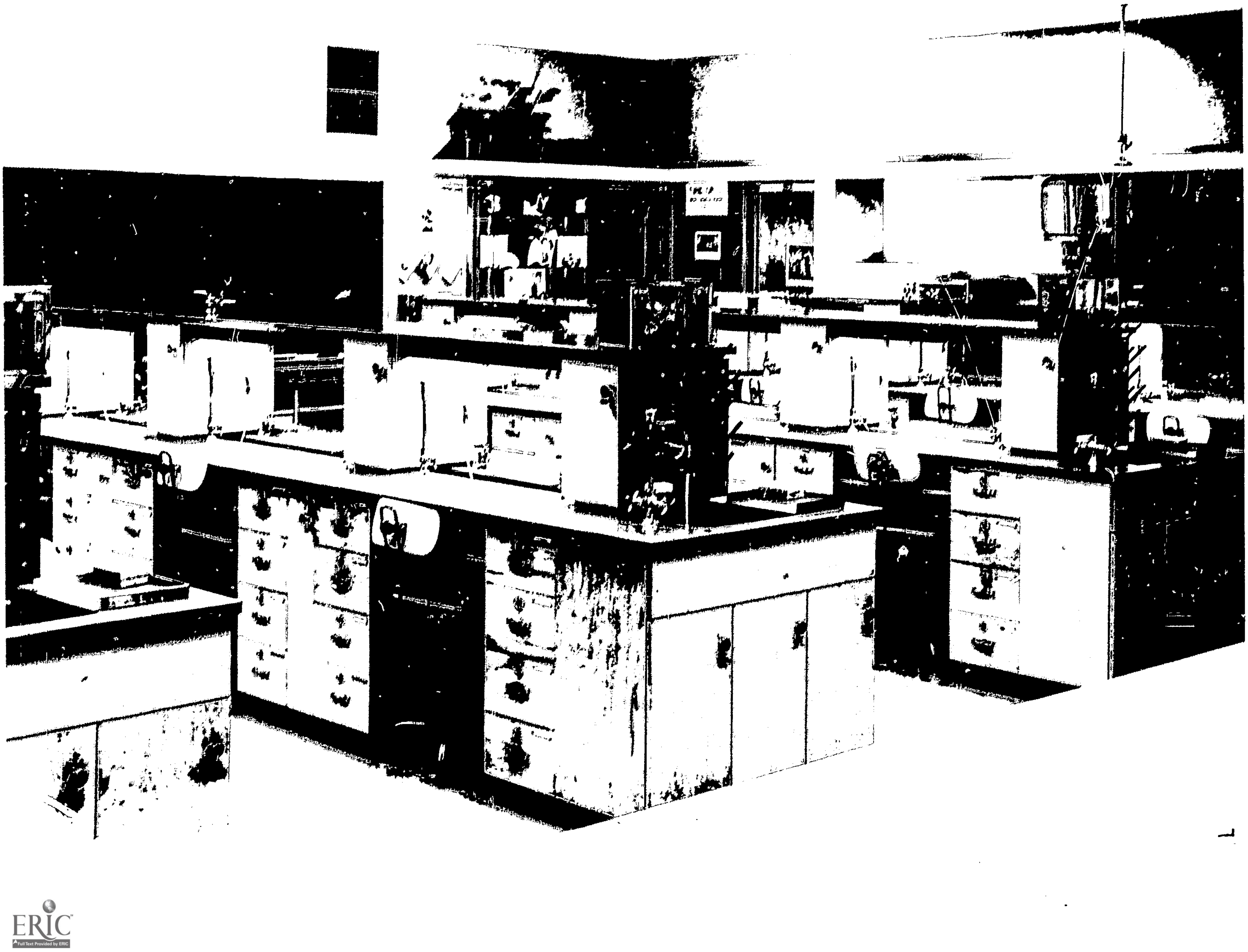
Remodeling. A good biology laboratory does not require a new building. Remodeling is not only practical but can produce a highly efficient laboratory. (Figures 79a, 79b.)

Community Resources for Biology Teaching

A community resource guide is one of the more valuable instructional aids for a biology teacher. Typically, the guide identifies each biological resource as to its location and its potential use in teaching biology. The listings might include: arboretums, aquaria, zoos, test and experimental gardens, aviaries, ponds, lakes, streams, springs, meadows, soil types, examples of erosion, unusual stands of plants, specimen trees, nurseries, Department of Agriculture experimental stations, museums, tide pools, animal trails, conservatories, commercial greenhouses, tree farms, forest and pasture lands, parks, fossil deposits, wildlife areas, soil improvement projects, game preserves, conservation projects, nature trails and many other similar resources. The human resources should also form a part of the guide. These might include biologists in nearby colleges and universities or in industry, the experimental biologists in the county and state agricultural stations, biologists living in the community who may be retired, medical researchers, and others. A section of the guide might well be given over to places in the community where there are collections of biology books and magazines available to students and teachers.

The resources for the teaching of biology are as widespread as life itself. Not all of the resources are convenient for in-school use, but then the student spends most of his time outside of class and his laboratory becomes the world itself, if he has been introduced to it and his observations properly directed (Figures 80, 81, 82, 83, 84, 85, 86, 87, 88.)

Fig. 79a,79b *Old* biology laboratory. Biology laboratory *after* renovation. Oak Park-River Forest High, Ill.



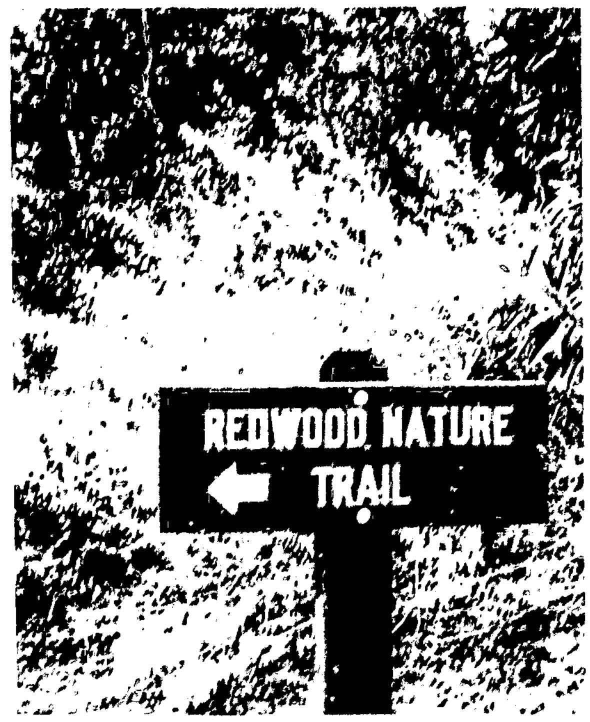


Fig. 80a,80b. Parks often contain special areas of plants unusual to the region. The tree fern dell and nature trail, Golden Gate Park, San Francisco, Calif.

Fig. 81. Diversity among plants illustrated in Golden Gate Park, San Francisco, Calif.

Fig. 82. Collection of dwarf trees and plants, Strybing Arboretum and Botanical Gardens, San Francisco, Calif.

Fig. 83. Museum provides opportunity to study animals from many parts of the world in a natural setting. Habitat group in the Florida State Museum, University of Florida, Gainesville, Fla.

Fig. 84. Conservatory contains many plants native to tropical regions. San Francisco, Calif.

Fig. 85. Museum exhibits develop knowledge and ideas of biology. Denver Museum of Natural History, Denver, Colo.

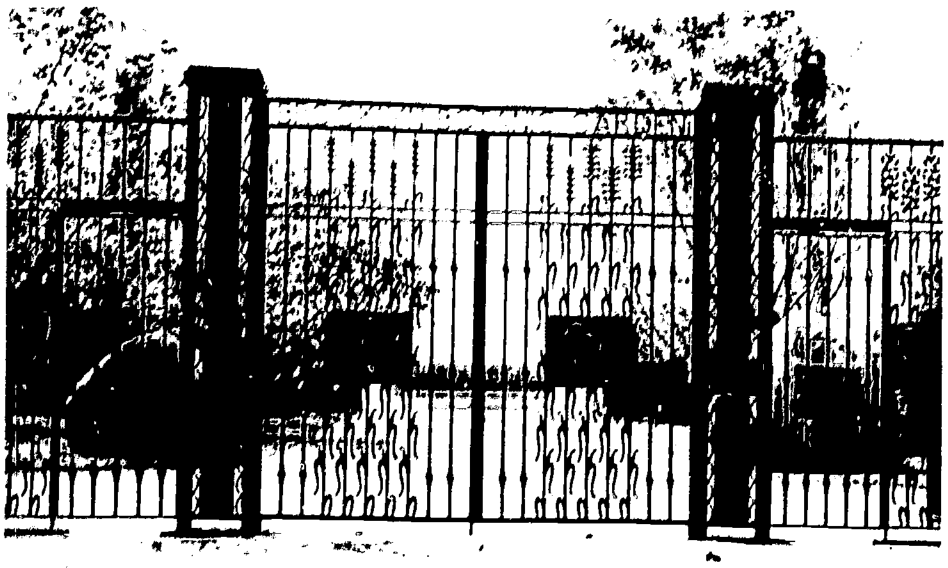


Fig. 86a,86b. Eastern Parkway Gate of the Brooklyn Botanic Garden and view after entering the gate. This is one of five entrances to the Garden. It is the only known ethnobotanical gate to a botanical garden anywhere in the world. One of its explanatory tablets reads as follows:

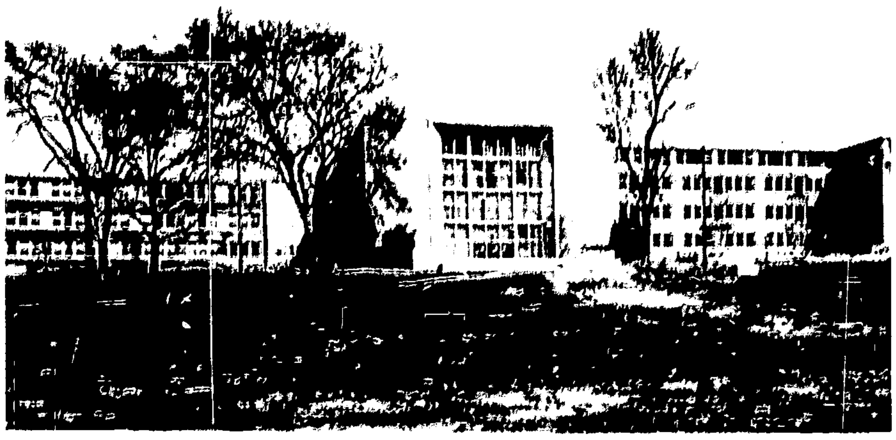
> *Grasses are the theme of the gate. Since ancient times the cereal grasses have supplied the basic foods of three great civilizations. Half of the world's population, living in southeast Asia, depends upon rice. Wheat long has been the chief food of the European and Mediterranean peoples and has been carried around the earth by them. In the Americas, the Indian civilization grew up on maize.*

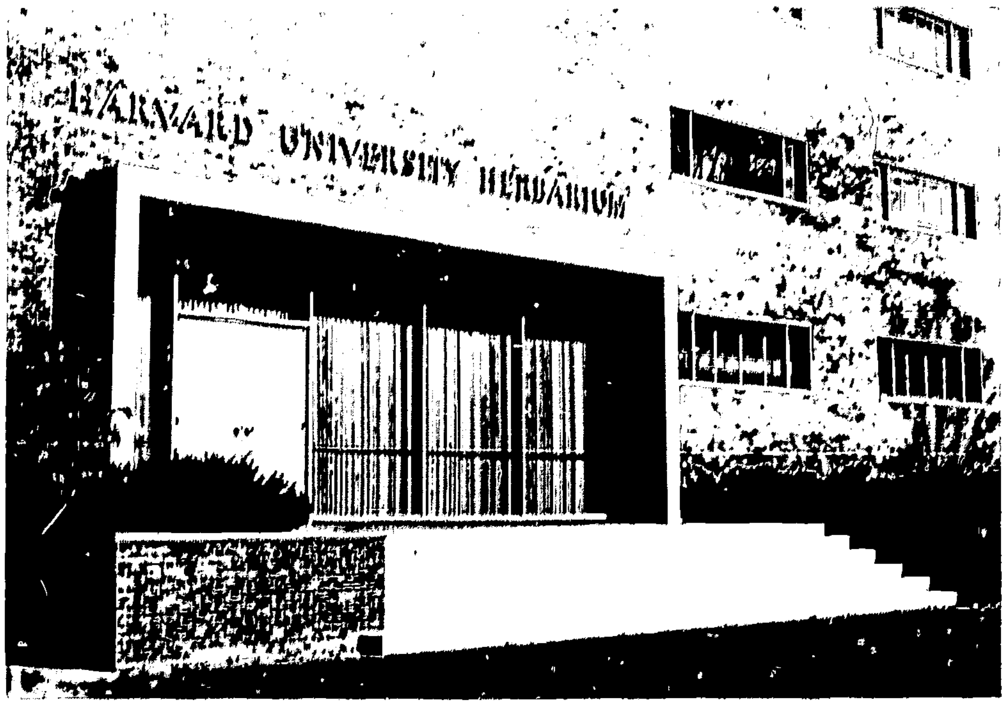
Fig. 87. Botanical gardens have plants from many parts of the world. Strybing Arboretum and Botanical Gardens, San Francisco, Calif.

Fig. 88. Instructional resources for teaching biology are many and varied

San Diego Zoo, San Diego, Calif.

Arboretum and Botanical Garden, San Francisco, Calif.





Morrill Science Center, University of Massachusetts, Amherst, Mass.

San Diego Zoo, San Diego, Calif.

Herbarium, Harvard University, Cambridge, Mass.

Steinhart Aquarium, California Academy of Sciences, San Francisco, Calif.

Botanical Museum, Harvard University, Cambridge, Mass.

STEINHART
AQUARIUM

Summary

An extensive evaluation program has indicated that in the eyes of school administrators, biological scholars and biology teachers, BSCS Biology is worth teaching; and from student test performance, it is clear that students can master the materials. However, the course is more demanding on the teacher. Thus, it is imperative that insofar as possible, administrative arrangements facilitate effective teaching, by providing teachers and students with a suitable learning environment. This includes not only laboratory facilities and text and lab manuals for students, but also reasonably sized classes, adequate class periods, teacher relief from non-teaching duties, and assistance in lab preparation and ordering.

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Summary

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4 ADMINISTRATIVE ARRANGEMENTS FOR BSCS BIOLOGY

Arnold B. Grobman

The scholastic environment of teachers and students is the concern of this chapter. Discussed below are some of the arrangements that have been made in various parts of the nation to improve that environment for BSCS Biology. Here we deal primarily with administrative arrangements and only indirectly with physical facilities which were treated in the previous chapter.

Teacher Preparation for BSCS Biology

Because BSCS Biology is quite different both in approach and content from most of the biology courses previously taught, the BSCS strongly recommends that teachers have some type of special orientation before introducing the course in their classrooms. Many colleges and universities are currently modifying their offerings to provide such opportunities for inservice as well as preservice teachers. Among the most useful types of preparation are those offered by individual school systems or groups of school systems (for example, the City of Baltimore or the Allegheny County, Penn., Regional Committee for Teacher Inservice Education). To assist such groups in arranging inservice teacher preparation programs, the BSCS has prepared a pamphlet—*BSCS Materials for Preparation of In-Service Teachers of Biology*—which is available, upon request, to persons responsible for teacher-preparation activities. Also the BSCS *Biology Teachers' Handbook* and the Teacher's Guide for each version of BSCS Biology are useful sources for the biology teacher planning to teach a BSCS program.

In addition to such standard techniques as workshops and summer institutes, another useful teacher training device is the *Center Meeting*. For the experimental development of the BSCS courses, evaluation centers were established throughout the country to facilitate efficient transmission of feedback information from teachers to the writers. Each center consisted of from 7 to 12 teachers in a commuting area. The teachers in each center met weekly for three to four hours to discuss the progress of the BSCS program and to prepare feedback reports for the BSCS central office.

Although these arrangements were devised primarily for the quick and accurate transmission of feedback, it soon became apparent that the weekly center meetings were ideal teacher improvement programs. Such center meetings provided teachers with an opportunity to discuss biology and the teaching of biology in a professional way that would be impossible in ordinary faculty meetings. Teachers were able to compare their progress with that of their colleagues. As the weekly meetings rotated from one school to another, the teachers were able to visit each other's classrooms and laboratories. They found themselves free to admit to each other that they did not understand certain topics, and they found that one or another of their colleagues was frequently, although not always, in a position to help them. On occasion, when a topic under consideration seemed extremely difficult for all concerned, the members of a center did not hesitate to invite a specialist in the subject from a nearby university to meet with them and explore the matter.

Another factor contributing to the center meeting successes was the fact that all of the teachers in the center were doing approximately the same kind of classroom work at the same time, and so they were rarely discussing things at cross purposes. The center meetings of second-year BSCS teachers were even more sophisticated than those for the first year, although it would seem that a long-range program of this sort would begin to taper off unless new materials for discussion and evaluation were introduced. Many of the centers continued their meetings after the termination of the BSCS evaluation program, because teachers found them so useful.

A further advantage in center meetings is that some of the technical work in preparing for laboratory sessions could be divided up among the teachers so that there would be some specialization of work, resulting in increased efficiency. For example, one teacher could maintain cultures sufficient for all participating teachers. Another teacher could arrange to package chemicals for all of the classrooms. (Many of these chemicals are relatively inexpensive in pound lots, but are extremely expensive to purchase in smaller quantities, though frequently only the smallest amounts may be needed for biological work.)

BSCS center meetings have developed into one of the most important teacher-improvement programs that we have had an opportunity to observe. It is strongly recommended that those teachers in an area who are using BSCS materials be involved in such periodic meetings, without the presence of administrative personnel or others not specifically invited for some special purpose. In general, such meetings should be unstructured and a chairman—one of the teachers—should be free to organize each session according to the needs of the group. While it is difficult to suggest the optimal frequency of meetings and size of the group, it would seem that biweekly meetings of about eight or ten teachers would be within the right range. If it is not possible to reward teachers in other ways for participation in center meetings, it would certainly be desirable for participating teachers to receive credit toward progression on their salary schedules.

Assistants

One way to greatly increase the efficiency of teachers is to relieve them of the responsibility for work that it not utilizing their highest professional skills. It is obviously desirable to use appropriate help to relieve teachers of clerical duties and such non-academic responsibilities as collecting monies from the sale of tickets, monitoring study halls, policing corridors and restrooms, taking attendance, duplicating materials and maintaining records on the distribution of textbooks to students. These are clear examples of the kinds of duties from which good biology teachers, or aspiring good biology teachers, should be relieved. In addition to relief from such chores, there are other kinds of assistance teachers could receive and these are broadly considered here as assistantship help.

For many years, New York City has been using para-professionals to help in the science laboratories, and a program of this nature is also in use in Baltimore. In general, the para-professional assistants (in some systems they are known as *educational assistants*) are required to have a minimum of two years of collegiate work with 15 hours of science, and they are expected to qualify through an examination and interview. Full-time science assistants usually earn about three-fourths the salary of the science teacher. For large schools, the evidence seems to indicate that about three educational assistants per school, for both the junior and senior high schools, would be appropriate in those schools where effective laboratory work is being attempted. In some of the larger high schools, it might be possible to have a laboratory assistant assigned to each subject matter area, so that there would be one specialized for biology. Many of today's science teachers in New York City and Baltimore began their careers as laboratory assistants.

In general, the duties of the science educational assistant are to watch over the facilities, supplies and apparatus, to be sure that the laboratory is in a safe condition and that the stockroom is so organized that materials can be located easily. He sees to it that the apparatus is in working condition and takes appropriate steps to preserve it. He also makes minor repairs or advises the teacher or department head about requisitions for such repairs. In addition to having supplies, cultures and prepared materials available for use in the laboratory when needed, the assistant should maintain careful records so that supplies can be ordered in anticipation of need.

As far as instruction is concerned, one of the first responsibilities of the assistant is to develop a good understanding of the courses with which he is involved. He should be able to help students with their individual laboratory work and be permitted to carry on in the temporary absence of the regular teacher. He is expected to assist the teacher in organizing the laboratory work and in preparing the laboratory room for student use.

Such assistants should not be asked to grade papers. This would seem to be a responsibility of the teacher, since it is one of the important ways in which the teacher can gauge what his students are learning and how effectively the program is developing.

In some school systems, *student assistants* are used in order to free the teacher from routine jobs and, perhaps, to interest some of the better students in careers in teaching. Obviously, the only students who should be assigned to such duties should be those who have already completed the course in which they will assist and who are doing good work scholastically. This raises a problem, since the best students are in demand not only for laboratory assistance but for many other kinds of important activities in the school. Therefore, it frequently happens that the most qualified students are not readily available.

As far as their duties are concerned, the student assistant should not take over classes when teachers are absent nor should they grade the work of other students. They should not be given undue responsibility nor allowed to use expensive equipment without the teacher's direct supervision. But they can be expected to prepare materials for laboratory work and handle the duplicating of laboratory sheets. They can help in supervising the laboratory sessions, take attendance or run errands confined to the school building, collect and maintain live specimens for laboratory experiments and assist in the maintenance of the stockroom. In some schools, as part of their assigned duties, such student assistants also help the high school teacher in his own research program.

There seem to be several patterns with regard to the use of student assistants and remuneration for such work. In Evansville, Indiana, students are paid 75¢ per hour and normally work about five hours a week. In New York City, students work for a similar period of time but are not reimbursed, since the position of student assistant is considered an honor appointment. In other systems, partial academic credit is given for serving as a student assistant, or the assistantship may count as an activity credit. Still another pattern combines a student research project with the student assistantship and awards credit for the joint assistantship-research activity, usually through a course titled "Biology Research" or "Special Problems."

The frequency of the use of student assistants has been increasing in the last few years; about one-half of the schools using the BSCS program during the 1961-62 year had some type of student help. Commonly a teacher with four or five classes might have one or two student assistants and the help they give might range from a mere token to a very substantial amount.

In using either student assistants or para-professional assistants, the teacher must do his planning well in advance in order to use this assistantship help efficiently. Unfortunately this does not always happen. However, the availability of such assistants might encourage the teacher to do more long-range planning and, in the long run, might enable him to conduct a better organized course. An advantage in the use of para-professionals rather than student assistants is that there would be fewer individuals to train, and retraining from year to year is minimized.

An untapped source of good laboratory assistants would seems to be mothers in the community, who have had training as biology majors and could probably work part time. Almost certainly, every city has a share of such capable persons who, because of family responsibilities, would not want to hold down a full-time job but could work half days. It would seem possible to hire several such well-qualified women as laboratory assistants on an adjusted-schedule basis.

Related to these potentialities for improving the teaching environments are the problems of state certification regulations. The use of para-professional personnel is an important measure in improving instructional programs and where outmoded certification regulations prevent tapping such a labor source, the regulations may require reconsideration.

Special Staff Utilization Arrangements

Another way in which biology teachers within a school can provide their own efficiency is to divide up their preparation work. This seems to be done more frequently by BSCS teachers than by traditional biology teachers, possibly because the BSCS courses involve a high proportion of laboratory work. Essentially, the teachers can work as a team, each doing those operations with which he is most familiar. For example, one teacher might make a trip to a lake to collect aquatic organisms, and thereby save other teachers the necessity for making parallel trips. The department chairman (or if the total department were not involved in the BSCS program, then a BSCS chairman) should coordinate the pattern of staff utilization. In essence, each teacher could perform the jobs in which he is most proficient, with a resultant saving in time for all. In addition, the program becomes a good inservice training device in which teachers can observe each other's strengths and students gain because the teachers are working at a higher efficiency level.

Concern with efficient staff utilization may lead to a consideration of team teaching. In a number of schools, the team-teaching arrangement consists of one or two of the most competent lecturers presenting topics to large groups of students, while other teachers handle relatively small classes in discussion and laboratory meetings. (There are many competent and experienced persons who feel that teaching via lectures is contra-indicated for tenth-grade students.) In other team-teaching situations, each teacher presents those materials he is most familiar with, but without a lecture-type presentation. Examples of team-teaching programs in BSCS Biology may be found in Melbourne, Florida; Richfield, Minnesota; Golden, Colorado; and Yuba City, California. In many schools, team-teaching programs are relatively incomplete, although interesting variations are being developed. We do not have enough information at this time to evaluate the effectiveness of team-teaching in BSCS Biology.

District-Wide Central Supply System

There have been frequent discussions about the advantages of a district-wide central supply service to handle ordering and stockpiling of the less common items. Often this is impractical, because the materials needed by teachers for conventional courses may be quite diverse. But, if a substantial number of schools in a district are using BSCS materials, some savings of effort and money might accrue through use of a centralized district supply service. In addition, if such a supply service were staffed with alert and knowledgeable persons, it might be possible to obtain some of the materials locally at a resultant saving in cost. In organizing a central supply system, it should be kept in mind that even within one of the versions of BSCS Biology all teachers will not be using the same lab exercises, so there will be some variation in supplies needed from one teacher to another.[1]

The BSCS does not know of a highly organized central supply system in a district using BSCS materials, but it is our understanding that plans are under way for the development of one in Los Angeles. However, informal cooperative arrangements among BSCS teachers within a district are commonplace.

Class Scheduling

The normal weekly time allotment for biology classes in American high schools seems to be five periods of 55 minutes each. It would appear that a class period of less than 55 minutes is highly inefficient, particularly for laboratory work. While a number of schools have about the same number of minutes per week based on shorter periods—as, for example, seven periods of 35 minutes each—periods of less than 50 or 55 minutes do not seem to permit an effective utilization of time. Appendix D shows the frequency of the number of minutes available per week for biology classes in BSCS ninth- and tenth-grade Blue, Green and Yellow Version experimental schools during the 1961-62 school year.

A few schools have arranged their scheduling in a cyclical pattern. For example, a student is assigned to seven classes but attends only six of these classes in any given day. Thus, one period is skipped each day. The apparent advantage is that a student could take five, instead of the usual four, solid courses in this fashion. However, if he took five courses, he would have only four classes per week per course. Another disadvantage of this kind of program is that it plays havoc with certain kinds of experiments in laboratory classes where observations must be made at regular time intervals. For a laboratory-oriented biology course, it would seem that the advantages of this kind of pattern-scheduling are outweighed by the disadvantages.

[1]Each of the versions contains more laboratory exercises than any class would work on, in order to permit flexibility in presentation of BSCS Biology.

An increasing number of schools have double periods. A common pattern is one double period each week and several schools have two double periods per week. Double laboratory periods are advantageous for biology, especially for the laboratory phase of the instructional program, but they do present some difficulty in scheduling.

In some schools, for good and sufficient reasons, it it not practical to offer more than five periods of biology per week. It is suggested that some experimentation be tried by scheduling the five periods as two double periods plus a single period as is done in Golden High School, Golden, Colorado. There might well be greater efficiency in laboratory instruction if students meet for two double periods instead of four single periods.

In some schools, additional hours of class are being provided for students in laboratory courses. For several years, Denver has made available an extra class period, either the hour before school started or the hour after school ended. Each student was assigned to one such extra period per week. There were virtually no objections from the students. The system was inaugurated at the request of the BSCS teachers, and they received additional compensation for the extra time. This arrangement provides the opportunity for one consecutive double lab period per week for about one-third of the students (those who have a first or last period class in biology).

Other scheduling practices not necessarily specific to biology are gaining currency. For example, there are school systems that have recently cancelled, or greatly reduced, the number of general assemblies, and others that have arranged school schedules so that no athletic events conflict with class hours. Many teachers have suggested that public address systems be used more sparingly, and that fire drills be held during non-instructional periods or at the start of the class period.

Size of Class

Size of class seems related to the quality of work being done in the schools. In the experimental BSCS schools during 1961-62, the tenth-grade biology students in classes with fewer than 30 students performed significantly higher on their final exams than those in classes of 30 or more students.

In some schools, there has been an adjustment in class size between discussion sections and laboratory sections. In most of these cases, an effort has been made to keep the discussion sections as small as possible, and to allow the laboratory sections to increase in size when there is an assistant available *and* sufficient laboratory stations and equipment to provide adequately for students. A minor advantage—and one that is frequently overlooked in having larger numbers of students in laboratory sections—is the greater reliability of pooled data than can be obtained in certain specific types of laboratory experiments.

The average class size now seems to be slightly over 30 in BSCS classrooms. BSCS consultants, who have visited 350 BSCS high school classrooms across the country, think about 28 is optimal for the most effective instruction.

Grade Level

Through an extensive testing program, we have found that the regular BSCS materials can be successfully taught to average and above-average tenth-grade students and, if teacher competence and laboratory facilities are satisfactory, to above-average ninth grade students. They are *not* recommended for use with average ninth grade students.[2]

There are, of course, additional important considerations requiring the attention of a competent administrator who is concerned with the grade-level placement of a BSCS Biology program. For example, if the brighter students are siphoned off into a biology course at the ninth grade, what impact will this have on the performance of the next year's classes made up of the remaining student population?

If the school district is too small to offer a BSCS Biology course at both the junior high and senior high levels, then it seems best to offer it at the senior high level. If the school district can manage to offer biology at both levels, it should not do so until the laboratory facilities, teacher preparation and other environmental factors are adequate at both levels.[3]

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[2]The *BSCS Biology, Special Materials* are currently being prepared and tested for use with below-average students.

[3]For a further discussion of this topic, see: Hulda Grobman, "High School Biology—On What Grade Level Does It Belong?" *The Clearinghouse*, April 1964.

Laboratory Facilities

Although an earlier chapter is devoted to laboratory facilities, an observation about the effectiveness of such facilities may be pertinent here. During the 1961-62 experimental school year, teachers were asked to determine the point-scores of their laboratories by using the BSCS Laboratory Checklist.[4] In 1961-62, the tenth-grade biology classes that scored 200 or more points on the Checklist performed better (significant at 3 per cent level) on the BSCS Comprehensive Final exam than those in classes with a Checklist score of less than 200 points. Thus, it appears clear that improved laboratory facilities are associated with better learning of BSCS Biology.

Teacher Load

In the judgment of BSCS classroom observers, it would seem most desirable if a teacher's responsibilities were limited to four classes of BSCS Biology. However, the average number of classes per teacher now seems to be a little over five. Thus, the general goals would be to reduce the number of preparations per teacher and reduce the number of extraneous responsibilities. Such a reduction would permit the good teacher to operate more effectively.

Teacher's Salary

A study was made of the relationships between teacher's salary and student performance in BSCS Biology during 1961-62. Using $6,500 as the dividing line, it was found that there was significant (at the one per cent level) association between teacher's salary and student achievement in BSCS tests. Tenth-grade biology students taught by teachers receiving $6,500 or more annually did better on BSCS final exams than students taught by teachers receiving less than $6,500.[5]

Books

For whatever version of BSCS Biology is used, each student should have a text and a laboratory manual (either bound together or bound in two parts). Since the BSCS courses are laboratory oriented, it is essential that each student have both sections in his possession. Furthermore, the two parts are cross-referenced to each other. It has come to our attention that some schools, possibly for reasons of economy, are purchasing one set of books to be shared among several classes. In other schools, also for reasons of economy, attempts are being made to supply a textbook for every student but only one laboratory manual for every two (or three or four) students. Neither of these procedures will produce good educational results. The value of the BSCS program would be seriously reduced and the resultant economy would be at the cost of a good educational program.

It is recommended without reservation that, if BSCS Biology is to be used effectively, *each participating student have both the text and laboratory manual in his own personal possession for the duration of the course.*

Science Fairs

Teachers should be encouraged—and given time—to work with certain students on projects. Only interested students should be encouraged to work on additional projects and these should be meaningful projects. Insofar as BSCS students are concerned, science fairs do not seem to us to be advantageous when all students are required to prepare projects for a local science fair.

Many persons feel wide participation in science fair projects is desirable because of the close approximation of projects to laboratory experiences. However, well-organized BSCS courses provide students with substantial laboratory experience, and so there does not seem to be special need for BSCS students to participate in science fairs simply to obtain laboratory experience. Therefore, it is our general feeling that the aims of BSCS Biology are not significantly advanced by requiring total student participation in local science fairs. Certainly, science fairs have certain educational values. But for BSCS students, such values can be largely achieved in the BSCS classroom and laboratory.

We feel far more sympathetic to encouraging highly motivated students to enter science talent searches

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[4]See Appendix B for the 1964 Revised Laboratory Checklist.

[5]A report of the statistical analysis of student performance in the 1961-62 evaluation is included in BSCS *Newsletter* No. 19, September 1963.

and activities of this general nature, but we do not feel that such activities should be required for all students.[6]

Testing BSCS Students

In considering student achievement in BSCS Biology, it is important that the administrator and guidance person, as well as the BSCS teacher, consider what type of achievement is desired. The instruments used for measuring progress of BSCS students must be suitable to the desired ends, or the results will be meaningless or even harmful. To expect students in BSCS Biology to achieve high scores on a test measuring the aims or subject matter of conventional courses is unfair to teachers and students. First, it encourages teachers to give an unsuitable emphasis to their BSCS students, through supplementing BSCS Biology with conventional materials which the BSCS authors do not consider part of a modern biology course. And second, students know that what the teacher really thinks is important is what he includes in the test. Thus, the teacher may say that memorizing isolated details is not the purpose of the biology course —that the broad themes of BSCS Biology are important; but if the test does not reflect this, the students will accept the test at face value, and reject the books or the teacher's statements. Thus, through use of improper tests, the best efforts of the teachers and administrators for full implementation of BSCS Biology may inadvertently be defeated.

At the time BSCS materials were being prepared and tested in the schools, no suitable standardized tests were available for measuring the kinds of skills and abilities with which the BSCS was primarily concerned. For this reason, the BSCS prepared tests for each version as well as final examinations suitable for use with students in all versions, and has made these tests available to schools using BSCS Biology. As revisions of standardized biology tests prepared by other organizations become available, these should be examined carefully as to content and basic emphases, before using them with BSCS students.

BSCS Students and College Board Exams

With any radically different curriculum, a question naturally arises concerning effect on college entrance and on success in college. For several years, reports have been coming back from college and university staff members indicating their strong approval of the more sophisticated students coming to college with a BSCS background. In fact, a number of prominent colleges and universities (Amherst, Johns Hopkins, Barnard) are modifying their own biology courses in order to reflect the more sophisticated preparation BSCS students are bringing to college. These and other types of evidence indicate that BSCS students are well prepared for college biology.

Unfortunately, to date it appears that the College Entrance Examinations Board biology tests do not reflect the new emphasis in biology.[7] It was the unanimous opinion of some 20 BSCS writers, teachers and outside reviewers that two recent CEEB Biology tests examined do not provide full opportunity for BSCS students to adequately demonstrate what they have learned.

The BSCS will continue discussions with the CEEB, in the hopes of finding a satisfactory solution in the near future.

Community Relations

Where the BSCS program is in use, the superintendent or principal has a responsibility to apprise the community, including parents and other teachers, about the program. One very successful method has been teacher's letters that have reached homes via the students. An informational film about the BSCS, *The Story of the Biological Sciences Curriculum Study,* can be borrowed from the BSCS for this purpose.

It is extremely important that teachers be well informed on the rationale and approach of the BSCS program, not only for their own needs but to enable them to discuss it in an informed way with parents. Parents quite rightly question courses that depart radically from the patterns they themselves experienced, and the school should furnish its patrons with a reasonable explanation of the rationale behind these differences.

During the early phases of the development of the BSCS program, a few schools introduced BSCS Bi-

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[6]For highly motivated students, the BSCS has prepared suggested research prospectuses, included in BSCS *Research Problems in Biology, Series 1* and *Series 2.*

[7]For a fuller statement, see page 94, Appendix E.

ology throughout the school, but reserved one non-BSCS class for those children whose parents might object to an experimental course. In our experience, such objections have been very rare and were generally based on a failure to understand the background of the new materials. Also, this practice raises some conflicts within the schools. BSCS Biology is an interesting but demanding course for students. While it is within the capacity of average and above-average students, they generally must work harder than is the case in conventional courses. Thus, BSCS students may observe that students in conventional biology classes in their schools are not working nearly as hard and are still receiving comparable grades. This tends to discourage a certain category of students from performing at their best in BSCS Biology. Furthermore, students in traditional courses often think BSCS Biology looks interesting and exciting, but then realize that their own classes are easier and so become complacent about their present situation.

An administrator might wish to have a control group of conventional biology along with BSCS Biology for the first year or so to see how both kinds of programs work in his own school. However, in doing so, it should be recognized that many other sources of variance beyond the choice of textbook enter into the teaching situation; thus test results in so small an experimental group may reflect not the books used, but such other factors as, for example, teacher or composition of student group.

Also, we have found that, in schools where both BSCS and non-BSCS Biology are being taught, the non-BSCS teachers often borrow promising ideas from the BSCS teachers, and so the factor of contamination of the control group enters into such experiments. If the administrator decides to utilize BSCS Biology, he might find it quite desirable to adopt it fully throughout the entire school. It did seem appropriate to have a standard course available in each school while BSCS Biology was still in its experimental stages, but the BSCS books are no longer experimental. Prior to general release in the fall of 1963, they had been more thoroughly tested than any other books had been when made available to the schools.

Two topics are treated in BSCS Biology books which have generally been avoided in the conventional biology texts of the last several decades. One of these, evolution, is a part of the BSCS program because it is one of the great intellectual ideas in man's history. It is felt by the BSCS authors that every educated citizen should be acquainted with this important concept. In the BSCS programs, evolution is not taught as a fact. Nor is it taught with any religious —or anti-religious—connotations. The treatment of evolution in the BSCS books is a straight-forward presentation of a biological concept and has been widely endorsed by lay and clerical educational leaders and teachers throughout the country.

Human reproduction is the other topic which is given some coverage in the BSCS books and is frequently omitted from conventional books. The treatment by the BSCS is *not* sex education, for we do not feel that the social, moral and religious aspects of human reproduction are properly part of a biology course. We do feel that human reproduction itself can best be taught to adolescents in the context of biological reproduction in a biology class.

These "sensitive" areas in biological education have been given the most careful attention by BSCS writers and their presentation of these topics has been subject to testing with 150,000 students and 1,000 teachers over a three-year developmental period prior to release of the books for general use. The BSCS materials have been reviewed by parents, educators, school boards, administrators and specialists of various kinds.

The reception by the schools of these books with "sensitive" topics has been nothing short of outstandingly favorable. In Fall 1963, when the books were first placed on the general market, over 200,000 copies were sold to the schools by the commercial publishers, with only 30 books returned (by a single teacher) because of the assumed conservatism of the community.

Apparently there has been a serious demand for balanced treatments of evolution and human reproduction in the high school biology course. The surprising thing is not the high acceptance of the BSCS books which include these topics, but, rather the fact that this real demand has for so long remained unfulfilled.

In one community, where a reticent teacher pointed out to the school authorities the fact that the books did cover these areas which had not been taught previously, the school superintendent asked a local physician who was on the school board to present the matter to the school board. The board unanimously approved use of the materials. In other communities, an occasional parent has asked the principal about a possible conflict with religious dogma; here again, in almost every instance, the presentation of information on the approval given by review committees as well as the large number of private sectarian colleges of many religious denominations using the material in their teacher preparation programs indicated to the satisfaction of the parents that the BSCS materials did not, in fact, conflict with the tenets of their religion.

It is to be anticipated that in an occasional district there will sometimes emerge an extremist who is against the teaching of evolution or of human reproduction. Giving full publicity to such debates as may emanate seems advisable, as does the procedure of bringing the matter to the attention of the school board for review and deliberation. A representative committee of citizens might be asked to study the matter and report to the school board. Reference might also be made to the kinds of persons who have previously reviewed the books as well as to the high calibre of the authors; both groups are listed in the books themselves.

In a number of communities, such as Madison, Wisconsin, and Houston, Texas, BSCS advisory committees have been established. The BSCS teachers or the superintendents have invited a group of persons (including professors from nearby colleges and outstanding community leaders) to serve as an informal advisory group observing the introduction of the new course. This procedure provides a great many advantages. It helps community leaders become familiar with the new program at the same time that it provides a means of communication between the community and the school on a constructive activity. This would seem to be an especially helpful device in the introduction of new courses which may be quite different in character from those familiar to the parents of the current students.

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APPENDIX A

LIST OF BSCS PUBLICATIONS AS OF SEPTEMBER 1964

Publications currently available through commercial publishers

BSCS High School Biology

Blue Version–Biological Science: Molecules to Man: Houghton Mifflin Co., Park St., Boston, Mass.
Green Version–High School Biology, BSCS Green Version: Rand McNally Co., P.O. Box 7600, Chicago 80, Ill.
Yellow Version–Biological Science: An Inquiry Into Life: Harcourt, Brace & World Co., 757 Third Ave., New York 17, N.Y.
BSCS Version Quarterly Tests are available through the version publishers. (For classroom use only; no samples available.)
BSCS Comprehensive Final Exam for all versions: The Psychological Corp., 304 E. 45th St., New York 17, N.Y. (For classroom use only; no samples available.)
Laboratory Blocks (teacher and student books)–*Plant Growth and Development* by Addison Lee; *Animal Growth and Development* by Florence Moog; *Microbes: Their Growth, Nutrition and Interaction* by Alfred Sussman; *The Complementarity of Structure and Function* by A. Glenn Richards; *Field Ecology* by Edwin Phillips; and *Equipment and Techniques for the Biology Teaching Laboratory*, by Richard E. Barthelemy, James R. Dawson, Jr., and Addison E. Lee: D. C. Heath and Co., 285 Columbus Ave., Boston, Mass.
Teacher's Handbook–Biology Teachers' Handbook: John Wiley & Sons, Inc., 605 Third Ave., New York 16, N.Y.
Biological Investigations for Secondary School Students–Research Problems in Biology: Investigations for Students, Series One and *Series Two*: Doubleday & Co., 575 Madison Ave., New York 22, N.Y.

Biological Techniques Films — Thorne Films, Boulder, Colo; 8 mm. Ealing Corp., Cambridge, Mass.

Genetics: Techniques Handling Drosophila
Bacteriological Techniques
Removing Frog Pituitary
Weighing Techniques
Measuring Techniques
Growth of Slime Plasmodium
Paper Chromatography
Neurospora *Techniques*
Smear and Squash Techniques

BSCS Pamphlets — D. C. Heath and Co., 285 Columbus Ave., Boston, Mass.

Guideposts of Animal Navigation, by Archie Carr
Biological Clocks, by Frank A. Brown, Jr.
Courtship in Animals, by Andrew J. Meyerriecks
Bioelectricity, by E. E. Suckling
Biomechanics of the Body, by E. Lloyd Du Brul
Present Problems About the Past, by Walter Auffenberg
Metabolites of the Sea, by Ross F. Nigrelli
Blood Cell Physiology, by Albert S. Gordon
Homeostatic Regulation, by Thomas G. Overmire
Biology of Coral Atolls, by Richard A. Boolootian
Early Evolution of Life, by Cyril Ponnamperuma and Richard S. Young
Population Genetics, by Bruce Wallace
Slime Molds and Research, by C. J. Alexopoulos and James Koevenig
Cell Division, by Daniel Mazia
Photoperiodism in Animals, by Donald S. Farner
Growth and Age, by Lorus J. Milne and Marjorie Milne

Publications currently available through the BSCS

BSCS Bulletin Series

No. 1, Biological Education in American Secondary Schools 1890-1960, by Paul DeH. Hurd
No. 2, Teaching High School Biology: A Guide to Working with Potential Biologists, by Paul Brandwein, Jerome Metzner, Evelyn Morholdt, Anne Roe and Walter Rosen
No. 3, BSCS Biology–Implementation in the Schools, by Arnold Grobman, Paul DeH. Hurd, Paul Klinge, Marga[illegible] McKibben Lawler and Elra Palmer

Special Publications Series

No. 3, BSCS Materials for Preparation of In-service Teachers of Biology, Ted F. Andrews, Editor

BSCS NEWSLETTER

No. 17, 19, 20, 21, 22

BSCS Biology, Laboratory Blocks, experimental edition (teacher and student books)

Genetic Continuity, by Bentley Glass
Life in the Soil, (rev. exper. ed.) by David Pramer
Metabolism, (rev. exper. ed.) by Peter Albersheim, Johns Hopkins III, John Dowling
Physiological Adaptability in Animals, by Earl Segal

5 THE CCSSO PURCHASE GUIDE AND BSCS BIOLOGY

Paul Klinge

The Purchase Guide and BSCS Biology[1]

Anyone who orders scientific equipment and supplies has felt a need for some type of guide in determining appropriate quantities and types of these materials and their suitability for the job at hand. The administrators who most often must rely upon the science teachers to supply a list of needed equipment and supplies must have wished for carefully prepared criteria to help them judge the appropriateness of the request. Such an instrument exists in the form of the *CCSSO Purchase Guide*. This serves to assist administrators in making the wisest use of school funds for the purchase of materials, apparatus and equipment for the improvement of science instruction as well as for foreign languages and mathematics.

The use of the *Purchase Guide* by administrators will discourage the routine ordering of miscellaneous catalogue items which may turn out to be obsolete, and it may even discourage the purchase of materials which are unnecessary in the quantities indicated by the request. However, the *Purchase Guide* has still another value. Hopefully, it has reduced the sales of shoddy, uneconomical or inappropriate items, so that reputable manufacturers may produce products of high quality and usefulness which can be sold at reasonable prices. In other words, it enables the school administrator to resist the high pressure sales tactics for flashy items of equipment, which may be totally inappropriate for the school science program.

Thus, the *Purchase Guide* may become a highly usable item for all school administrators in the ordering of scientific materials, apparatus and equipment. Yet, the *Purchase Guide* should not be considered as an absolute authority when new items of equipment and materials are being made available by many manufacturers who are attempting to produce more appropriate items for such new programs as BSCS Biology. But, when items are requested for purchase which are not included in the *Purchase Guide*, the administrator should insist on a justification of these purchases.

The value of the *Guide* for BSCS Biology is to serve as a fundamental guide in the purchasing of materials for *any* good program in biology. If the BSCS course to be taught requires items not in the *Guide*, then justification may be found in the BSCS Laboratory Checklist and equipment and supply list.[2] But the *Guide* is a good starting place for checking the purchase order.

Genesis of the Purchase Guide

Upon the passage of the National Defense Education Act (NDEA) by Congress, it was immediately apparent that Title III enabled school authorities to purchase a great deal of apparatus and equipment for use in schools in a manner that could easily have led to a wholesale stocking by school systems of use-

[1] *CCSSO Purchase Guide*, $3.95, Ginn and Co., 1959. *Supplement to the Purchase Guide*, $1.25, Ginn and Co., 1961.
Editor's Note: A 1964 edition of the *Purchase Guide* is being issued currently through Ginn and Co. This is in the same general format as the earlier edition and supplement, and information on the 1959 edition and supplement is pertinent to the new volume. The 1964 edition is entirely consistent with the BSCS philosophy and it would be a valuable adjunct to schools in implementing the BSCS program.
[2] See Appendices B and C.

less and inappropriate—and in many cases totally outdated—types of equipment which manufacturers might wish to unload. Thus, the Board of Directors of the Council of Chief State School Officers (CCSSO) saw that the formulation of a guide setting up appropriate criteria for purchasing of materials and equipment under the NDEA was a most appropriate project for them.

The Educational Facilities Laboratories, Inc., was approached to help finance the project, and it supplied the major portion of the necessary funds for implementation. The Scientific Apparatus Makers Association supplied funds for a special staff in the National Bureau of Standards to work out specifications for the materials to be included in the *Guide*.

Other agencies and organizations contributed significantly. The U. S. Office of Education contributed professional manpower. The National Bureau of Standards provided technical expertise which was invaluable in the successful completion of the project. Various library and publishing organizations—such as the American Library Association, the American Association of School Librarians, the American Book Publishers Council, and the American Textbook Publishers Institute — made available the services of a skilled secondary school librarian for the preparation of the bibliography included in the *Guide*.

A Committee of Seven was organized to review critically all of the items to be included in the proposed *Guide*. The Committee represented many types of professional societies, including the American Chemical Society, the Modern Languages Association, the American Institute of Physics, the American Institute of Biological Sciences, the American Association for the Advancement of Science, and a host of skilled personnel was recruited from various agencies and schools to assist in preparing the appropriate lists from available catalogues.

The entire project was conceived and organized by Dr. Edgar Fuller, Executive Secretary of the Council of Chief State School Officers, and his careful direction of the project has produced a very admirable and useful guide for all school administrators.

The Use of the Purchase Guide

To use the *Guide* most efficiently, the administrator should put it into the hands of the BSCS teacher who makes up the list of necessary equipment, apparatus, materials and supplies for teaching BSCS Biology.

First, administrators should insist that the BSCS teacher make a careful inventory of present equipment and materials, so that this information may be available for the benefit of both teacher and administrator. The teacher's next task is to plan for the next five years, to project his BSCS Biology teaching over that period. Of course, the factors of space, numbers of students and the projected budget permitted for this purpose must be carefully considered in making the purchase plans.

In other words, the teacher has the task of justifying the purchase of new materials and equipment on the basis of the present inventory, the budget and the projected enrollment as well. For instance, in the purchase of microscopes, the school budget may not be able to cover the purchase of microscopes in an optimum quantity for BSCS Biology. But, the projection may be made on the basis of the *Purchase Guide* recommendations, so that there will be a regular plan for purchase of materials and equipment in order to reach the optimum quantity for the teaching of BSCS courses. Such projection work by the teacher will help him recognize the value of careful planning in ordering. Possibly a teacher who is unable to do this may be a very ineffective teacher of BSCS Biology, for one of its requirements is an extremely efficient use of time, resources and room in the maintenance of a BSCS laboratory.

Organization of the Purchase Guide

The group of items listed under Biology, of course, is most important in any discussion of the use of the *Purchase Guide* for BSCS Biology. Each item listed has been numbered, and this is in a sequence which should be valuable in finding the appropriate item if cross-indexed with manufacturers' catalogues. A complete list of the items included under Biology is stated in the beginning of the *Purchase Guide*. However, in the bulk of the book, all of the items are fully described, with appropriate specifications, in an alphabetical arrangement combining items from all of the sciences, mathematics and foreign languages.

Each of the items listed has been coded under three general headings. The *basic* list includes items which are required for the absolute minimal program in biology. In other words, the *basic* items should be found in every modern classroom and laboratory for biology instruction whether or not BSCS instruction is contemplated. The list includes equipment for demonstration purposes, as well as for individual and group laboratory work.

The *standard* list consists of items which, when added to the *basic* items, give an "enlarged opportunity and greater scope for developing a modern instructional program." These items are considered to be fine additions for building up an excellent biological laboratory inventory.

The third list is designated as *advanced* and consists of items which are in addition to the *basic* and *standard* items. As the term implies, these are recommended for advanced work or for selected, specialized projects by students at all levels. However, it should be pointed out that *advanced* items should only be added to the inventory after the *basic* and certain *standard* items are available in the quantities which are considered optimal. Certain types of unusual courses are considered under the *advanced* category.

All items are listed so that the quantity desired in each of the three categories, *basic, standard* and *advanced,* is stated in the description. Therefore, under the term "microscope," the *basic* list designates as the optimum quantity, one for each two students, and on the *standard* list, one for each student. These designations were arrived at after long and careful discussion on the part of all of the consultants involved in the preparation of the *Purchase Guide* and represent the very best thinking of the group. In deciding on the quantity listing for each item, the consultants had in mind budgetary limitations, as well as the limitations on teacher time and background. These, therefore, represent very skilled judgments in which the administrator can have confidence.

In addition, there is a bibliography of desirable books that should be found in the high school biology library. This is a carefully selected list which is short and yet would be quite effective in biology laboratories. The *Purchase Guide* also includes essays on the topics of "Remodeling for High School Biology Laboratory," and "Outdoor Laboratories and Equipment for Biology."

How to Use the Purchase Guide

The preface of the *Purchase Guide* gives succinct advice on the most useful way to use the *Purchase Guide* after the science faculty has been organized and notified of the steps to be taken. To paraphase:

1. Plan the purchases by referring to the subject lists.
2. Examine the selections carefully in terms of the course of study.
3. Add to the order—from such other subject lists as the BSCS list—items which are particularly needed for modernizing and improving the course of study.
4. Eliminate from the revised list items which are already present in the inventory.
5. Examine catalogues and contact suppliers, listing the quantities needed according to the school situation.
6. Select appropriate books and other materials using the *Purchase Guide.*

After the bid requests and orders have been made up, they should be examined and approved by the purchasing agent of the school. Upon delivery, each item should be checked against the specifications of the order. This involves testing some of the complex and sensitive apparatus by technical use.

The 1961 *Supplement to the Purchase Guide* has several essays on the improvisation of biology equipment, safety precautions for the laboratory and the emphasis which must be placed on the laboratory in teaching modern biology, especially BSCS Biology. In addition, there is a heavy emphasis on some of the newer items of equipment in biology which reflect the trends and recommendations from the BSCS. Therefore, both the original *Guide* and its *Supplement* should be used together.

Relation to the Laboratory Blocks

The BSCS Laboratory Blocks often require types of equipment which may not be found in the *Purchase Guide.*[3] However, each of the Laboratory Blocks, with its supplementary teacher materials, gives a great deal of helpful advice as to how some of

[3]Appendix C includes the list of supplies and equipment for six of the blocks.

the materials may be improvised by the teacher. Also the BSCS *Innovations in Equipment and Techniques for the Biology Teaching Laboratory* gives detailed instructions for making many items of equipment.[4] Several companies are now issuing materials which meet some of the specifications and needs of the Laboratory Block approach. However, the *Purchase Guide* catalogues some of the items which may be considered essential to efficient instruction in using the BSCS Laboratory Blocks.

BSCS Laboratory Checklist

BSCS *Newsletter* No. 21 is devoted to the equipment and supplies for the 1963 editions of BSCS Biology and includes a listing of some of the sources from which these can be obtained. Therefore, in ordering materials, equipment, apparatus and supplies for BSCS Biology, the *Purchase Guide,* together with Appendices B and C and BSCS *Newsletter* No. 21, constitute the effective beginning for the process of equipping the biology laboratory, both in general and in specific terms, for the type of instruction in biology which is now recommended as modern biology.

Summary

Thus, all administrators will find helpful allies in the *Purchase Guide* and the BSCS *Newsletter* No. 21 in carrying out the task of efficiently using funds for the purchase of scientific equipment and supplies. In fact, these may be considered as the absolute starting point for all purchasing procedures. Yet it must be noted that while administrators have the final responsibility in this matter, their first task is to insist their biology teachers use these sources in the preparation of purchase requests formulated on the basis of budgets as well as these two published criteria.

If the *basic* items in the *Purchase Guide* are present in the recommended quantities in a school, the minimal apparatus, equipment, materials and supplies then exist for any *good* course in biology. When the school is ready for the installation of BSCS Biology, then the use of BSCS *Newsletter* No. 21 and other BSCS aids is indicated for the ordering of supplementary material to make BSCS Biology possible. The administrator will soon note that BSCS Biology requires really very little in addition to the *basic* items in the *Purchase Guide*—thus, first the *Guide* and then the few specialized items called for by BSCS. If BSCS is not used, the school will still be well equipped to teach *any* good biology course.

For the first time, school administrators now have standard criteria prepared by very thoughtful persons, knowledgeable in school and scientific affairs, which may be used in effectively evaluating the requests for purchases which come from the science teacher. It is difficult to understand how efficient administrators can do without these guides, and the school administrator must use them if BSCS Biology is to become an important and valuable part of the total science program.

[4]Schools should realize that, while construction of some types of equipment may be a useful way for the teacher to spend his time, the time he spends on making equipment should not be to the detriment of his primary educational activities.

6 THE BSCS AND THE NATIONAL DEFENSE EDUCATION ACT.—(NDEA)*

Margaret McKibben Lawler

The National Defense Education Act—NDEA—(Public Law 85-864) was enacted by the passage of the Hill-Elliot Bill in the closing days of Congress in 1958. The Act was twice extended by the Congress and is now effective until June 30, 1965.

The intent of Congress is clearly expressed in Title I, which outlines the general provisions of the Act, as follows:

> It is therefore the purpose of this Act to provide substantial assistance in various forms to individuals, and to States and their subdivisions, in order to insure trained manpower of sufficient quality and quantity to meet the national defense needs of the United States.

Section 101 spells out the national defense needs in the first three paragraphs as follows:

> . . . the security of the Nation requires the fullest development of the mental resources and technical skills of its young men and women. . . .
>
> . . . The defense of this Nation depends upon the mastery of modern techniques developed from complex scientific principles. It depends as well upon the discovery and development of new principles, new techniques and new knowledge. . . .
>
> This requires programs that . . . will correct as rapidly as possible the existing imbalances in our educational programs which have led to an insufficient proportion of our population educated in science, mathematics, and modern foreign languages and trained in technology. . . .

Congressional intent to improve education in science and technology is expressed or implied in each of the titles of the Act. A reexamination of the Act five years after its passage might result in a renewed emphasis on improvement of science, mathematics and technical education.

The purpose of this chapter is to indicate how the several titles of the **NDEA** are related to the improvement of science education in general and to the Biological Sciences Curriculum Study in particular.

Titles Having Implications for Improvement in Science Instruction

Title III—Financial Assistance for Strengthening Science, Mathematics and Modern Foreign Language Instruction—has strong implications for improvement in science instruction in elementary grades and secondary schools in public and nonpublic institutions. Other titles which also relate to science instruction are: II - Loans to Students in Institutions of Higher Education; IV - National Defense Fellowships; V - Guidance, Counseling and Testing: Identification and Encouragement of Able Students; VII - Research and Experimentation in More Effective Use of Television, Radio, Motion Pictures and Related Media for Educational Purposes; VIII - Area Vocational Education Programs; IX - Science Information; and X - Improvement of Statistical Services of State Educational Agencies.

The Act now extends to the 50 states, Puerto Rico, the District of Columbia, the Canal Zone, Guam, American Samoa and the Virgin Islands. Authority for implementing Title IX is vested in the National Science Foundation; the remaining titles, in the U.S. Office of Education.

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*Dr. Lee E. Wickline, Science Specialist, Instructional Resources Branch, U.S. Office of Education contributed his services in bringing this chapter up to date as of February 1964, so that it reflects the most recent changes in NDEA legislation.

TITLE II. Title II is concerned with loans to needy, full-time students in institutions of higher education. Through the six fiscal years ending June 30, 1964, the Congress has appropriated over $413 million in support of this program, and a maximum appropriation of $135 million has been authorized for fiscal 1965. Present legislation provides that no loan may be made after June 30, 1965 to any student who has not already borrowed on or before that date.

To establish a student loan fund, an institution entering into an agreement with the federal government must deposit in the fund an amount not less than one-ninth of the federal contribution. Special consideration is given to (1) students with a superior academic background wishing to teach in elementary and secondary schools, and (2) those evidencing superior ability in science, mathematics, engineering or a modern foreign language. The maximum loan during any academic year is $1,000. Interest at three per cent does not start to accrue until one year after the borrower has completed his studies, and a ten-year repayment period is provided. Up to half of the loan of a person entering a full-time teaching position in a public school will be cancelled at the rate of 10 per cent for each year of service. During 1962-63 some 5,500 students receiving loans under Title II declared their intention to become high school science teachers. The number of future biology teachers in this group is unknown, but it is undoubtedly considerable.

TITLE III. Title III provides financial assistance for strengthening science, mathematics and modern foreign language instruction. There are two separate programs under this title. The first provides for grants to state departments of education for the acquisition of equipment and materials and for the minor remodeling of laboratory facilities for teaching science, mathematics and modern foreign languages under a federal-state and/or local matching plan.

These acquisition funds may be used only by local school districts. State departments of education, however, receive funds for strengthening their supervisory and related services in science, mathematics and modern foreign languages and for administering the State Plan. Matching funds for supervisory and related services and for administration must be matched with state department of education funds. In most instances, the matching of acquisition funds was done by local and not state units. During the first four years of the Act, a total of $275 million of federal funds was spent for purchase of science equipment and materials and for minor remodeling of science facilities. During this same period nearly $8 million of federal funds were spent for supervisory and related services and for administration.

Most states have found that matching the acquisitions money at the local level is easier than matching the supervisory and related services at the state level, since the latter usually requires action by the state legislature. Over 80 per cent of the federal funds available for acquisitions of equipment and minor remodeling have been matched, while about 60 per cent of the funds available for state level supervisory and related services have been matched. Prior to December 18, 1963 these unmatched federal funds could not be reallotted. Enactment of P.L. 88-210 on that date, among other things, authorized the U.S. Commissioner of Education to reallot to other states any unmatched portions of state allotments. This permits states that are now completely matching their total allotment to request additional federal funds, both for the acquisition program at the local level and for the supervisory and related services program at the state level.

As a result of Title III of NDEA, most state departments of education employed their first specialist supervisors in science. When the Act went into effect, there were only 11 state science supervisors in the nation. At the present time, there are 88 full-time state science supervisors and 13 combination science-mathematics state supervisors. In addition to employing specialist supervisors in science, many states have used supervisory and related services funds to conduct non-credit teacher inservice training programs in science. Heretofore, any assistance to science teachers by state departments of education was provided by generalist supervisors. The specialist supervisors in science assist local school systems in planning for the improvement of their science programs, in selecting appropriate equipment and materials and in the minor remodeling of science facilities. A major activity of state science supervisors is organizing, planning and in many cases conducting inservice training programs for science teachers. As consultants they participate in: presenting new curriculum materials such as those of BSCS, curriculum development, establishing certification standards, organizing youth activities and coordinating the resources of colleges, universities, professional science organizations and industries within the state. They frequently serve as liaison personnel between local school districts and the U.S. Office of Education.

Under the second Title III program, private, nonprofit elementary and secondary schools may apply for loans for purchases of laboratory equipment and for minor remodeling for science, mathematics and modern foreign languages. These loans are repayable within 10 years. In the first four years of the Act, nearly $3 million of federal funds were distributed for equipping and remodeling science facilities in nonpublic schools through the loan program.

TITLE IV. Under Title IV of the NDEA, the Commissioner of Education had authority to approve 1,500 graduate fellowships for the academic year 1962-63. To have its NDEA fellowship program approved, an institution of higher education must show how the proposed program will help increase the number of college and university teachers. Grants for the individual are $2,000 for the first year, increasing to $2,400 for the third year, with an additional amount for dependents. Three universities had Title IV fellowship programs in science education for the academic year 1962-63.

TITLE V. Provisions of Title V insure the development and improvement of testing programs in public and nonpublic elementary (not below grade 7) and secondary schools as well as guidance and counseling programs in public elementary (not below grade 7) and secondary schools through (1) grants to state educational agencies and (2) federal contracts with institutions of higher education. The purpose of Title V is to identify students with greater than average ability in science as well as other areas, to channel them into school programs most appropriate to their abilities and to encourage them to enter institutions of higher education. The funds—$17.5 million annually—are allotted on the basis of school-age population for this purpose.

Under Title V, $7.4 million are set aside annually for institutes for public school guidance personnel, to cover expenses, a $75 weekly stipend and allowances for dependents of grantees.

States are enabled to employ state guidance personnel to consult with local school systems in setting up guidance programs, to hold conferences for inservice preparation of local guidance personnel and to underwrite the cost of tests, record systems and for the rental of scoring equipment.

Since the summer of 1959 about 50 colleges and universities have held 416 guidance institutes of from four to 10 weeks in duration. In that period, almost 14,000 public school guidance counselors received training in principles and methods of counseling.

TITLE VII. A program promoting improved and wide use of new educational media was authorized under Title VII of the NDEA. Colleges and universities, professional societies, school systems, state departments of education and private agencies have received grants from the U.S. Office of Education. Media most commonly studied, in decreasing order of frequency, have been television, motion pictures, teaching machines, recordings and combinations of two or more of these media. Of the 200 projects receiving grants, 29 have been in the biological sciences, 33 in the physical sciences and 26 in mathematics; 55 have been at the elementary level of instruction, 25 at the junior high school level and 28 at the senior high school level. Results of these studies are disseminated by the Office of Education in the form of reports, reviews, abstracts and bibliographies. The Office of Education also provides consultant services to state and local school systems requesting assistance in the use of newer media.

The expenditure of $3 million was authorized for the fiscal year 1959 and $5 million for each succeeding year for these purposes.

TITLE VIII. Title VIII of the NDEA provides for annual grants of $15 million directed toward improved training and retraining of individuals in skills of importance for the national defense. Funds paid to the state agencies administering vocational education programs may be used for supervisory and teacher-training programs, expenses of consultant personnel, purchase or rental of instructional equipment, development of vocational training programs and expenses of youth included in the program.

TITLE IX. Title IX provides the Office of Scientific Information Service (OSIS) of the National Science Foundation with funds for collecting and disseminating scientific information under an advisory body, the Scientific Information Council. Activities of the OSIS include documentation and scientific information retrieval research, financial support of scientific publications, collection and translation of foreign scientific information and the training of science information specialists.

TITLE X. The purpose of NDEA Title X is the improvement of services of state educational agencies in processing and disseminating educational statistics. In the past, there have been almost as many methods of treating data as there are states. Lack of uniformity has made such data about science programs as science enrollments, per pupil cost, faculties, teaching load, certification standards and the like less meaningful than is desirable. By December 1961, 48 states, Guam and Puerto Rico had plans approved for improving and standardizing their statistical services.

Under Title X, states are required to meet a minimum set of standards to receive funds for improvement of statistical services. These standards have increased accuracy and recency of data, and, at the same time, have eliminated considerable duplication of effort and cost.

NDEA Effect on Science Education

The NDEA has resulted in improvement of at least five aspects of science education—state level consultant services in science by subject matter specialists, facilities, use of media, training and retraining of teachers, and guidance services.

STATE SCIENCE SUPERVISORS. A major contribution of NDEA Title III to science is the state science supervisor. Only seven state departments of education had science specialists on their staff prior to enactment of NDEA. Now 49 of the 56 states and territories included under the Act have at least one person on their staff who devotes one half or more of his time to science supervision. Twenty-two states employ more than one science specialist. A majority of the states, for the first time, have a science supervisor who is responsible for a statewide science program and who is in a position to identify many of the deficiencies in the program. He plans long range statewide programs for correcting these deficiencies. He may organize or conduct state-NDEA supported inservice programs and he may also provide feedback information to other institutions and agencies involved in preservice or inservice training of science teachers.

The ability of many states to sponsor inservice programs for science teachers has been limited by the state's failure to match all federal supervisory and related service funds. Schools or school systems interested in organizing non-credit inservice programs for science teachers should get in touch with the state science supervisor to find what services are available.

FACILITIES. Testimony of state science supervisors, school superintendents and others indicates that the science equipment and facilities secured under Title III have been of value in implementing improvements in science programs which would otherwise have been impossible. Secondary school science departments are now generally equipped with some of the essentials for teaching the modern science courses of the BSCS, the Chemical Bond Approach, the Chemical Education Materials Study, the Physical Science Study Committee and others. In fact, many schools would have found it extremely difficult to introduce such new courses as BSCS Biology without Title III financial assistance. The NDEA funds are particularly helpful as far as BSCS Biology is concerned since this is a highly laboratory-oriented type of course and the lab requirements are different from those of a lecture-demonstration course. Thus, many schools need a major retooling in their biology laboratories.

Audio-visual materials, such as the BSCS Techniques and Single Topic films, projection equipment and science reference materials for students and teachers may be secured under the NDEA. Textbooks are excluded, although a small number may be obtained for reference purposes. Thus, under Title III, it would not be possible to order copies for each student of such standard reference work as are cited in the bibliography in the BSCS books. However, three copies of a given reference might be the number allowable in that state.

Likewise, under NDEA it would be possible to secure a limited number of sets of the Blue, Yellow and/or Green Versions of BSCS Biology, but not classroom quantities. The same is true of the BSCS Laboratory Block materials, the BSCS *Research Problems in Biology* volumes, BSCS Pamphlets and other BSCS publications.

In the early days of NDEA, state and local districts frequently gave priority to equipping secondary schools. By 1962, however, school districts were beginning to give greater attention to purchasing equipment and remodeling facilities in grades 1-9. Recent visits to elementary and junior high schools reveal that requests for equipment under the NDEA are larger than those during the early years of the Act, and that more proposals are being submitted for construction of storage space and for individual laboratory work at these levels.

Responsible school administrators, science supervisors, teachers and taxpayers want to know how Title III funds are being spent. A study by Smith[1] indicates that 24 per cent of the total funds approved through fiscal year 1959 for improvement of science, mathematics and foreign language instruction in the State of Kansas was spent for language and audio-visual equipment and materials; 15 per cent was spent for furniture; 14 per cent for minor remodeling and installations; 12 per cent for equipment and materials related to the study of light, sound and wave motion (including optical equipment); 11 per cent for printed materials; 6 per cent for measuring and indicating devices (e.g., meters and gauges); 4 per cent for equipment and materials related to the study of electricity, magnetism or electronics; 3 per cent for equipment and materials related to the study of biology;[2] and the remainder in smaller percentages for other aspects of science, mathematics and modern language instruction.[3]

STATISTICAL SERVICES. If fully implemented, Title X (statistical services) would bring about improvement of teaching facilities as well as the other aspects of science education considered in the following pages—use of new media, qualifications of teachers and guidance services. For example, information concerning science teaching facilities in all the biology laboratories of a state could be put on IBM cards and processed. This would indicate schools which needed the greatest assistance in securing equipment, materials and facilities for teaching biology. Such a method would also indicate schools failing to make appropriate use of newer media.

Data concerning the training of teachers could likewise be processed. For example, data concerning the recency and nature of subject-matter training of biology teachers could be punched on cards and processed. Processing would indicate teachers who had not up-dated their biology backgrounds within the last 5, 10 or 15 years and those who had insufficient courses in modern chemistry, physics or mathematics to do a good job of teaching biology. It would also indicate geographical areas where biology institutes and workshops would be of greatest value. Processing of similar data about guidance personnel and programs could lead to improved guidance services.

USE OF NEWER MEDIA. Research in more effective use of films, television, radio and other media under Title VII would be of value in biology education. As in any other science course, there are times when a film is the best way to show a speeded-up process in time-lapse photography. Use of the BSCS Single Topic Films might be the best way to convey an idea or process that could not otherwise be demonstrated in the classroom.

TRAINING AND RE-TRAINING OF TEACHERS. The provisions of the NDEA, the programs of the National Science Foundation and the materials of the BSCS complement each other in the training of high school biology teachers. The training and re-training of biology teachers are crucial problems. In no other field of science have recent developments been more rapid than in the biological sciences. Many biology teachers whose training in the biological sciences is more than a few years old may find themselves inadequately prepared to teach a new type of biology course.

As a result of the NDEA, students with ability in science and interest in teaching are given financial support to prepare for careers in science and science teaching—Title II through loans to college and university students and Title IV through graduate fellowships.

To date the National Science Foundation has been responsible for financing the re-training of several thousand teachers of the Green, Yellow and Blue

[1]Herbert A. Smith, "Purchases under Title III of the National Defense Education Act," *University of Kansas Bulletin of Education*, May 1962.

[2]This is exclusive of microscopes; if all microscopes purchased were used for biology, the total percentage of funds expended for biology equipment would be 13 per cent.

[3]For further information on the Titles of the NDEA, see: *The National Defense Education Act of 1958: An Annotated Bibliography on the Administration of the National Defense Education Act of 1958 and its Impact on American Education*, Bibliographic Series: 64-1, compiled by Alice H. Songe, Education Specialist, Department Library, U.S. Department of Health, Education and Welfare, 1964.

Versions of BSCS Biology through stipends and allowances, which have enabled teachers to take advantage of preparation opportunities. Some of these teachers have attended the many Summer Institutes emphasizing BSCS Biology. Others have attended in-service institutes and still others the Academic Year Institutes using BSCS materials. Information on names of some institutions offering BSCS training financed through NSF grants may be obtained from the Institute Division, National Science Foundation, Washington 25, D. C. Each institution, in turn, will supply application forms and statements of requirements for its BSCS training program.[4]

GUIDANCE SERVICES. Identification of able science students is feasible under the guidance, counseling and testing provisions of Title V. Research studies indicate that career decisions are most frequently made during the junior high school years, with a majority of the remainder being made in the senior high school. To insure an adequate level of science manpower and the scientific literacy of the entire population, secondary school students need a minimum number of science courses. Left to their own devices, they may fail to elect those most appropriate to their own needs and to the national needs.

Guidance personnel without adequate professional training may likewise fail to recognize scientific aptitude, the course prerequisites for post-high school education in science or the wide spectrum of career opportunities in science (including science teaching). Equally as important for the guidance person is a good understanding of the general education value of science courses for students not preparing for specific science-oriented careers.

Summary

P. L. 88-210 amended and extended the NDEA through June 30, 1965. Whatever its fate may be after that date, it seems fairly certain that the provisions of at least most of its titles will be continued under some form of federal legislation.

By providing for better facilities, for fellowships and loans to undergraduate and graduate students and improved guidance and statistical services, in the first years of existence the NDEA has already brought about marked improvement in the teaching of science, mathematics and modern foreign languages. Other resources exist for continued improvement in science education. These resources include modern science curriculum materials such as those of the BSCS, Summer and Academic Year Institutes of the NSF for up-grading the subject-matter backgrounds of science teachers, and the scientific know-how of persons in the community. If all of these resources are wisely melded, continued improvement certainly will result.

[4]Information on some of the other teacher preparation opportunities for BSCS Biology may be obtained from the BSCS.

APPENDICES

BSCS Biology—Second Course

The Interaction of Experiments and Ideas (1963-64 revised experimental edition)

BSCS Biology Special Materials, 1964-65 edition (for the lower ability student)

Supplies and equipment for BSCS Biology: For supplies and equipment needed and sources for these, see BSCS NEWSLETTER 21, April 1964. There are no "official" or "recommended" BSCS suppliers.

Publications now out of print

BSCS NEWSLETTER

Nos. 1-16, 18

BSCS High School Biology, 1960-61 edition*

Blue Version: Text, Laboratory Manual, Teacher's Guide
Green Version: Text, Laboratory Manual, Teacher's Guide
Yellow Version: Text, Laboratory Manual, Teacher's Guide
Teacher's Commentary
Laboratory blocks (teacher and student editions)
- *Plant Growth and Development*
- *Animal Growth and Development*
- *Complementarity of Structure and Function*
- *Microbes: Their Growth, Nutrition and Interaction*

Biological Investigations for secondary School Students, Vol. 1

BSCS High School Biology, 1961-62 edition*

Blue Version: Text, Laboratory Manual, Teacher's Guide
Green Version: Text, Laboratory Manual, Teacher's Guide
Yellow Version: Text, Laboratory Manual, Teacher's Guide
Teacher's Handbook
Biological Investigations for Secondary School Students, Vol. 2
Laboratory blocks
- *Animal Behavior*, by Harper Follansbee
- *Regulation in Plants by Hormones*, by William P. Jacobs and Clifford LaMotte
- *Plant Growth and Development*, by Addison E. Lee
- *Ecology of Land Plants and Animals*, by Edwin A. Phillips
- *Interdependence of Structure and Function*, by A. Glenn Richards
- *Microbes: Their Growth, Nutrition and Interaction*

Equipment and Techniques for the Biology Teaching Laboratory, by Richard E. Barthelemy, James R. Dawson, Jr., and Addison E. Lee
BSCS Biology Second Course: Laboratory Block Sequence No. 1: Student Supplement, Teacher's Manual
BSCS Biology–Special Materials (for the lower ability student) 1963-64 experimental edition

Special Publications Series

No. 1, Guidelines for the Preparation of Inservice Teachers, by Evelyn Klinckmann

*All listed volumes have been replaced by later editions or will be replaced by new editions shortly.

Publications in press and under preparation

BSCS High School Biology

BSCS Single Topic Films: Series in preparation; distributors have not yet been designated.
Laboratory blocks
- *Regulation in Plants by Hormones*
- *Animal Behavior*

Research Problems in Biology: Investigations for Students, Series Three and *Series Four*

BSCS Biology, Second Course

Biological Science: The Interaction of Experiments and Ideas, 1965 edition

APPENDIX B

1964 BSCS REVISED LABORATORY CHECKLIST

As a result of their visits to BSCS classrooms during the first experimental year of BSCS Biology testing—1960-61—Mr. Norman Abraham and Dr. Alfred Novak, then BSCS Staff Consultants, prepared a Laboratory Facilities Checklist, which indicated facilities appropriate for teaching BSCS Biology. This Checklist first appeared in BSCS NEWSLETTER 9, in September 1961. The following is a 1964 revision of the Checklist, in terms of the commercial editions of BSCS Biology, Blue, Yellow and Green Versions; this revision was prepared by Mr. John R. Schaefer, BSCS Staff Consultant, in consultation with BSCS teachers and staff.

The Checklist is not intended to be prescriptive, but rather to set up guidelines to assist educators in planning for implementation of BSCS Biology. As is the case with the equipment and supply lists prepared for BSCS Materials, *it is not necessary to have all of the equipment listed before BSCS Biology may be introduced in the classroom. However, a well-equipped laboratory, properly used, will certainly enhance the teaching of BSCS Biology or any laboratory-oriented biology course.*

To facilitate comparative evaluation of present biology laboratory facilities in a school, a Checklist is proposed for a laboratory used daily by four classes of 28 students each. This Checklist is *not* to be construed as the definitive standard; it is simply a means of permitting a general comparison of a school's facilities with optimal facilities.

In the Checklist, facilities have been grouped in categories to permit a separate evaluation of each category, since the pedagogic and monetary values of the various categories cannot be equated. For example, the Fixed Laboratory Installations category is the most costly and is of paramount importance. A high rating in this category would be more significant than a high rating in the Demonstration Aids category.

The Checklist may be used in the following manner:

—For each facility listed, *circle* the category that best describes your laboratory. In the last column on that line, write in the point value for the circled item; i.e., the point value at the head of the column in which the circled item appears. E.g., under Fixed laboratory installations, if you have 200 square feet of shelf storage space, circle 200, and in the column at the extreme right put down 8 points, the value assigned to that item.

—Where the laboratory has none of the facility mentioned, do not circle any item and enter a zero in the *Your School* column, since the response value is zero.

—Find the category sub-totals for your school in each of the seven areas, and compare these with the maximum possible scores for each area.

—Obtain a grand total for all areas and compare it with the rating scale below:

RATING SCALE

Rating	Points	Per Cent of Optimal
A	460-541	85-100%
B	379-459	70-84
C	298-378	55-69
D	216-297	40-54
E	135-215	25-39
F	8-134	0-24

1964 Revised Laboratory Facilities Checklist
(Based on 28 students)

Facility	Point Value				
Category A	16 pts.	12 pts.	8 pts.	4 pts.	Your School
Fixed laboratory installations—*maximum possible score 216 pts.*					
Demonstration table	1	—	—	—	______
Work counter (peripheral)—linear feet	120	60	30	15	______
Sinks—regular	4	3	2	1	______
—laundry	—	—	2	1	______
Water—cold	4 taps	3 taps	2 taps	1 tap	______
—hot	—	—	2 taps	1 tap	______
Outlets—gas	7	5	3	2	______
—electrical	7	5	3	2	______
Compressed air	—	—	—	Yes	______
Garbage disposal	—	—	—	Yes	______
Shelf storage sq. ft.	450	300	200	100	______
Preparation room	large	medium	small	—	______
Life alcove	large	medium	small	—	______
Project work area	large	medium	small	—	______
Science library/min. 50 vols.	large	medium	small	—	______
Display cases (in halls)	—	—	2	1	______
Light and ventilation	good	fair	poor	—	______
Sub-total points					______
Budget considerations—*maximum possible score 48 pts.*					
Funds for perishables, glassware, chemicals, specimens, etc.	$500/yr.	$250/yr.	$125/yr.	$50/yr.	______
Funds available *during* year as needed	yes	—	—	—	______
Capital outlay funds	$500/yr.	$250/yr.	$125/yr.	$50/yr.	______
Sub-total points					______
Microscopes—*maximum possible score 32 pts.*					
Compound microscopes	28	14	7	4	______
Binocular stereo microscopes	28	14	7	4	______
Sub-total points					______
Lab assistants—*maximum possible score 16 pts.*					
Paid lab assistants—5 hrs. per week per section	1	—	—	—	______
Sub-total points					______
Category B	12 pts.	9 pts.	6 pts.	3 pts.	Your School
Major equipment—*maximum possible 111 pts.*					
Refrigerator	1	—	—	—	______
Gas range/oven	1	—	—	—	______
Incubator	2	1	—	—	______
Balances (.01 g)	4	3	2	1	______
Autoclave	1	—	—	—	______
Pressure cooker	2	1	—	—	______
Centrifuge	—	—	2	1	______
Temp., humidity & light controlled chamber	—	—	1	—	______
Fume hood	—	1	—	—	______
Laboratory cart	2	1	—	—	______
Power supply units (AC/DC portable)	—	—	2	1	______
Sub-total points					______
Category C	8 pts.	6 pts.	4 pts.	2 pts.	Your School
Small equipment—*maximum possible 70 pts.*					
Basic laboratory equipment*	many	adeq.	few	sparse	______
Aquaria	4	3	2	1	______
Terraria	4	3	2	1	______
Glassware	many	adeq.	few	sparse	______
Collecting equipment	many	adeq.	few	sparse	______
Animal cages	8	6	4	2	______
Covered disposal containers	2	1	—	—	______
Electric hot plates	—	2	1	—	______
Chemicals	many	adeq.	few	sparse	______
Sub-total points					______
Demonstration aids—*maximum possible 48 pts.*					
Specimen sets	many	adeq.	few	sparse	______
Models and charts	many	adeq.	few	sparse	______
Prepared microscope slides	many	adeq.	few	sparse	______
Overhead projector	—	1	—	—	______
Cartridge projector	1	—	—	—	______
Slide projector	—	1	—	—	______
Microprojector	—	—	1	—	______
Sub-total points					______
[illegible]					
Your school—total score					______

*Includes items such as centigrade thermometers, pipettes, Bunsen burners, dissecting sets, tripod stands, ring stands, etc.

APPENDIX C

LIST OF SUPPLIES AND EQUIPMENT FOR BSCS BIOLOGY*

To assist teachers in ordering laboratory supplies and equipment for BSCS Biology, BSCS Staff Consultant John Schaefer has prepared lists of materials and equipment needed for the 1963 edition of each of the versions of BSCS Biology; lists were prepared for six lab blocks in the 1963 and 1964 commercial edition by the staff of the Committee on Laboratory Innovations. A supply list for the experimental edition of the BSCS Second Course was prepared by the Supervisor Norman Abraham. As new editions of BSCS materials are issued, the appropriate supply and equipment lists will be available through the BSCS.[1]

In using the BSCS supply and equipment lists, it is imperative that the following considerations be kept in mind:

—These lists include the *minimum* amounts and only actual supplies and equipment needed to carry out laboratory exercises. These lists do *not* replace the 1964 revised BSCS Laboratory Checklist (see Appendix B, page 76.); they provide greater detail than does the 1964 Checklist, and they include only minimal amounts, where the Checklist includes minimal, as well as optimal, quantities. The lists should be used in conjunction with the Checklist.

—They are based on needs for 1 class of 28 students, working individually, in pairs or in squads, depending on the type of lab exercise. Some materials and supplies are reusable. Thus, the teacher will have to decide which materials must be ordered for each class section, and which are reusable.

—They do not include items students can supply or items to be purchased locally from petty cash (e.g., toothpicks, newspapers, aluminum foil, plastic bags, oatmeal, fresh vegetables, etc.).

—Where exercises are classified as Basic, Highly Recommended, Supplementary and Optional, it is strongly recommended that all classes complete all Basic exercises, and it is hoped that many other exercises will be used also. Items listed for Highly Recommended, Supplementary and Optional exercises are *in addition to*—and do not duplicate—materials needed for Basic exercises.

—*It would be highly misleading to assume that any class needs all the supplies and equipment listed for any of the versions, since it is unlikely that any one class will do all the exercises in a version.* Thus, before ordering supplies, it is important that each teacher decide which labs his class will do, and whether students will be working individually or in squads for these labs.

—Where living materials are involved, the exercise number is included, to give some indication of the date materials will be needed.

The BSCS has lists of those biological supply houses interested in providing materials to BSCS teachers. Each such company has indicated those items the company can supply in good quality and adequate quantity. However, *the BSCS assumes no responsibility for the quality of service rendered by the listed suppliers, and the BSCS does not recommend any supplier, whether listed or not, over any other supplier.* The BSCS would appreciate hearing directly from teachers of any difficulties that may arise with the listed suppliers or in obtaining needed materials.

Additional information concerning use and/or construction of items for the various versions and blocks and acceptable substitutes for some listed items is included in the teacher and student manuals to the versions and blocks. For a number of items, see also *BSCS Biology, Innovations in Equipment and Techniques for the Biology Teaching Laboratory.*

*See BSCS *NEWSLETTER* 21, April 1964 for Lists of Suppliers.

[1]These lists do not include materials for supplementary laboratory exercises included in the BSCS NEWSLETTERs. Also they apply to the printings available as of September 1964. It is anticipated that new exercises may become available, and these may require some modification in these lists.

BLUE VERSION—*BIOLOGICAL SCIENCE: MOLECULES TO MAN*

Equipment and Supplies

(quantities for 1 class of 28 students)

The following list does not include items students can supply or items to be purchased locally from petty cash (e.g., toothpicks, newspapers, aluminum foil, plastic bags, oatmeal, fresh vegetables, etc.).

	Amt	Equipment
		LARGE
BASIC	2	Aerators
	1	Autoclave or pressure cooker—22 qt.
	2	Balances—double pan
	4	—triple beam (.01 g)
	1	Centrifuge
	1	Geiger counter
	1	Hoffman electrolysis apparatus
	2	Hotplates—electric
	1	Incubator—bacteriological
	1	—egg—100 egg size
	7	Lamps—goose neck
	1	—ultraviolet (germicidal)
	1	Metronome
	14	Microscopes—compound monocular
	7	—stereo binocular
	1	Projector—2 x 2
	1	—screen
	1	Refrigerator
OPTIONAL	1	pH meter
	1	Spectrophotometer
		SMALL
BASIC	28	Blood lancets—sterile, disposable
	1	Borer—cork, 6 mm
	14	Brushes—camel's hair
	14	Burners—Bunsen
	5 yd	Cheesecloth
	14	Clamps—pinch
	14	—screw
	5 lb	Corks—assorted sizes
	3 lb	Cotton—absorbent
	3 lb	—nonabsorbent
	7	File—triangular
	28	Forceps
	14	Frog web boards
	14	Lens—hand
	7	Metersticks
	28	Needles—dissecting
	14	—inoculating
	18	Needles—hypodermic—1"—18 ga.
	2	—24 ga.
	7	Pans—large dishpan
	3 pkg	Paper—filter—9 cm
	1 pkg	—12.5 cm
	50 ft	—strip
	2 rl	—glucose test
	350 shts	—graph
	4 bk	—lens
	2 rl	—pH, 1-11 range
	2 lb	Paraffin
	14	Pencils—marking
	7	Plant marker grids
	1	Prism—45° or 60°
	14	Ring stands—36"
	14	—Burette clamps
	14	—ring clamps
	7 pr	Rubber gloves
	5 lb	Rubber stoppers—asst., solid, 1 and 2 hole
	10 ft ea	Rubber tubing—assorted sizes
	28	Rulers—mm, plastic—30 cm
	28	Scalpels
	28	Scissors—fine point
	1 pkg	Splints—wood
	7	Syringe—hypodermic—2 ml
	2	—10 ml
	14	Test tube holders
	14	Test tube racks—10 hole
	7	Thermometers—(—10° to 110°C)
	14	Trays—dissecting
	2	Vacuum bottles—1 pt
	14	Wire gauze—asbestos center

	Amt	Equipment
		GLASSWARE
BASIC		Beakers—Pyrex or Kimax-Griffin—low form, spout
	21	—100 ml
	14	—250 ml
	12	—1000 ml
	7	—2000 ml
	24	Bottles—Barnes dropping 30 ml
	4	—Narrow mouth—4—5 liters
	16	—Wide mouth—500 ml
	4	Burettes—50 ml
	14	Centrifuge tubes
	½ oz	Cover glass—#1 sq.
	2 oz	—#2 sq.
	112	Dishes—Petri—100 mm x 15 mm
	21	—Specimen—4½" diam.
		Flasks—Pyrex or Kimax—
	14	Erlenmeyer— 250 ml
	7	—1000 ml
	1	Volumetric—1000 ml
	2	Funnels—Pyrex or Kimax—large
	14	Glass—rods—6"
	7	—squares 13 cm.
	14	Graduated cylinders— 10 ml
	14	— 100 ml
	2	—1000 ml
	28	Medicine droppers
	14	—with drawn out tip
	7	Mortars and pestles
	14	Pipettes, measuring— 1 ml
	14	—10 ml
	14	Porcelain spot plates
	56	Slides—glass—regular
	28	—depression
		Test tubes—Pyrex or Kimax
	100	—8-12 mm x 70-100 mm
	200	—15-17 mm x 155 mm
	28	—20-25 mm x 200-250 mm
	12 ft ea	Tubing—glass—asst. sizes
	144	Vials—glass—80 mm x 23 mm
	14	Watch glass—Syracuse
		CHEMICALS
BASIC	1 pt	Acetic Acid
	1 oz	Acetocarmine
	1 gal	Acetone
	20 ml	Acetylcholine 1:10,000 aqueous sol.
	20 ml	Adrenaline 1:10,000 aqueous sol.
	½ lb	Agar—nutrient
	4 oz	—plain
	1 pt	Ammonium hydroxide
	14	Antibiotic disks—penicillin and aureomycin
	1 pt	Benedict's solution
	100 gm	Bile salts
	50 gm	Biuret reagent
	1 lb	Calcium carbonate
	1 lb	Calcium chloride
	2 lb	Calcium hydroxide
	10 gm	Carmine
	1 lb	Chloroform
	75 mg	Chloropromazine
	10 gm	Congo red
	1 gm	d-amphetamine sulfate
	100 gm	Dinitrophenol
	2 gal	Ethyl alcohol
	1 gm	Giberellic acid
	1 lb	Glucose
	1 lb	Gum arabic
	10 ml	Histamine acid phosphate 1:10,000 aqueous soln.
	1 lb	Hydrochloric acid-concentrated
	1 pt	Hydrogen peroxide—3% soln.
	1 gm	Indoleacetic acid
	1 qt	Iodine—potassium iodide solution

Equipment and Supplies (Continued)

	Amt	Equipment
		CHEMICALS (Cont.)
BASIC (Cont.)	5 gm	Lactic acid
	1 lb	Magnesium chloride
	1 lb	Manganese dioxide
	10 gm	Neutral red
	100 gm	Nicotine alkaloid
	100 gm	Pancreatin
	15 gm	Peptone
	1 pt	Petroleum ether
	1 gm	Phenol red
	1 lb	Potassium chloride
	1 lb	Potassium hydroxide
	4 oz	Potassium phosphate—dibasic
	4 oz	—monobasic
	100 gm	Propionic acid
	1 oz	Quinine sulfate
	1 lb	Soda lime
	2 lb	Sodium bicarbonate
	2 lb	Sodium chloride
	2 lb	Sodium hydroxide
	1 lb	Sodium nitrite
	10 μc	Sodium phosphate sol. cont. 10 microcuries of P^{32}
	4 oz	Sodium phosphate—monobasic
	1 lb	Soluble starch
	1 gm	Testosterone
	4 oz	Wright's blood stain
		BIOLOGICAL MATERIALS
		Living
BASIC	18	Cockerels—day old male chicks (Ex 52(18))
	35	**Elodea**—small sprigs (Ex 17(7), 24(14), 40(7), 60(7))
	36	Frog (Ex 42(14), 47(4), 55(14), 62(4))
	18	Goldfish (Ex 50(4), 60(14))
	24	Hens' eggs—fertile (Ex 31)
	7	Moss (Ex 40)
	7	Mice (Ex 47)
	100	Seeds—Beans—Kentucky Wonder

	Amt	Equipment
		BIOLOGICAL MATERIALS (Cont.)
BASIC (Cont.)	1 pkg	Seeds—Radish
	100	—Peas—Alaska
	1000	—Tobacco—albino
	49	Water snails—small (Ex 60)
		Cultures—enough for 1 class of 28
BASIC	X	**Aerobacter aerogenes** (Ex 57)
	X	**Bacillus cereus** (Ex 20)
	X	**Chlamydomonas** (Ex 27)
	2X	**Chlorella** (Ex 25(1), 7(1))
	2X	**Daphnia** (Ex 27(1), 45(1))
	X	**Drosophila**—Vestigial wing (Ex 36)
	X	—Wild type (Ex 35)
	X	Hydra-green or brown (Ex 27)
	X	**Paramecium** (Ex 27)
	X	**Physarum polycephalum**—dry sclerotia (Ex 26)
	X	**Planaria** (Ex 28)
	X	Protists (Protozoa) (Ex 6)
	X	**Pseudomonas fluorescens** (Ex 57)
	X	**Serratia marcescens** (Ex 57)
	X	**Volvox** (Ex 27)
		Preserved
BASIC	1 set	Anti-A and Anti-B serum
	14	Eyes—cow or sheep
	28	Grasshoppers
	14	Hearts—mammal—large
		Prepared Slides
BASIC	14	**Ascaris** eggs
	14	Leaf—dicot cs
	14	—monocot cs
	14	Onion root tip
		Cultures—enough for 1 class of 28
OPTIONAL	X	**Amoeba** culture (Ex 14)

YELLOW VERSION—*BIOLOGICAL SCIENCES AN INQUIRY INTO LIFE*

Equipment and Supplies

(quantities for 1 class of 28 students)

The following list does not include items students can supply or items to be purchased locally from petty cash (e.g., toothpicks, newspapers, aluminum foil, plastic bags, oatmeal, fresh vegetables, etc.).

	Amt	Equipment
		LARGE
BASIC	2	Aquaria—6 gal
	1	Autoclave or pressure cooker—22 qt.
	2	Balances—double pan
	4	—triple beam (.01g)
	1	Fan—electric
	2	Hotplates—electric
	1	Incubator
	4	Lamps—goose neck
	7	Lenses—oil immersion
	14	Microscopes—compound monocular
	7	—stereo binonocular
	1	Refrigerator
		SMALL
BASIC	1	Battery—dry cell 6 V
	1	Borer—cork
	14	Brushes—camel's hair
	14	Burners—Bunsen
	5 yds	Cheesecloth
	5 lbs	Corks—assorted sizes
	5 lbs	Cotton—absorbent
	3 lbs	—nonabsorbent
	28	Forceps
	28	Lenses—hand
	14	Loops—inoculating (.05 ml cap.)
	14	Metersticks
	7	Mortars and pestles
	28	Needles—dissecting
	14	—inoculating
	7	Needles—hypodermic—1"—18 ga.
	7	—25 ga.
	3	—27 ga.
	1 btl	Oil—immersion—cedarwood
	2 pkg	Paper—blotting 19" x 24"
	12 shts	—cobalt chloride 8" x 10"
	3 pkg	—filter— 9 cm
	1 pkg	—12.5 cm
	1 pkg	—15 cm

	Amt	Equipment
		EQUIPMENT—SMALL (Cont.)
BASIC (Cont.)	100 shts	—graph—1 cm grid
	4 bks	—lens
	5 lbs	Paraffin
	12	Pencils—marking
	7	Ring stands—36" rod
	8	Ring stand clamps (burette & tube clamp)
	5 lbs	Rubber stoppers—asst. solid, 1 and 2 hole
	10 ft ea	Rubber tube—asst. sizes
	28	Rulers, mm. plastic 15 cm.
	14	Scissors—straight—student quality
	7	—straight—fine point
	14	Scalpels
	3	Spatulas—6"
	1	Switch—elect., reversing
	3	Syringes—hypodermic—1 ml
	7	—2 ml
	6	Test tube baskets—wire
	14	Test tube holders
	7	Test tube racks—10 tube
	14	Thermometers—0°-100° C
	3	—0°-300° C
	2	Tongs—large
	1 rl	Toweling (insecticide—free)
	7	Tripod stands—single ring
	420 cm	Tubing—cellophane dialysis (5/8")
	7	Wire gauze—asbestos center
SUPPL.	1	Bottle—polyethylene squeeze type with attached pipette tip
	½ lb	Carborundum grinding powder #400
	1	Chart—malaria life cycle
	4	Compasses
	1 rl	Film—cellulose acetate
	7	Forceps—fine point
	1	Hoffman electrolysis apparatus
	4	Jars—insect killing
	14	Micrometers—eyepiece
	1	—stage

Equipment and Supplies (Continued)

	Amt	Equipment
		EQUIPMENT—SMALL (Cont.)
SUPPL. (Cont.)	1	Net—dip—small aquarium
	4	—insect
	2 vials	Paper—litmus
	1 rl	—Whatman No. 1 chromatography
	28	Rulers—cm, 30 cm
	1 set	Slides—color—malarial stages
	1 pkg	Splints—wood
	14	Trays—dissecting
		GLASSWARE
BASIC		Beakers—Pyrex or Kimax—Griffin—low form, spout
	14	—100 ml
	14	—250 ml
	14	—500 ml
	2	—600 ml
	14	Bottles—Barnes dropping 30 ml
	24	—gas collecting—wide mouth—250 ml
	2	—125 ml
	½ oz	Cover glass—square, #1
	2 oz	—square, #2
	75	Dishes—Petri—100 mm x 15 mm
	7	—150 mm x 20 mm
	30	—specimen—4½" diam
	14	Flask—Pyrex or Kimax—Erlenmeyer—250 ml
	3	—1 l
	14	Funnels—Pyrex or Kimax
	3	Glass squares—clear 4" x 4"
	14	Graduated cylinders— 10 ml
	14	—100 ml
	14	—250 ml
	3	—500 ml
	48	Medicine droppers—4½"
	7	Pipettes— 1 ml
	15	—10 ml
	56	Slides—glass—regular
	14	—depression
	14	Stirring rods
	36	Test tubes—Pyrex or Kimax—15 x 125
	112	—20 x 150
	2	—25 x 200
	8 ft	Tubing—Capillary (.25 mm bore)
	12 ft ea	—Glass—assorted sizes
	56	Vials, glass—25 mm x 95 mm
	7	Watchglasses, Pyrex or Kimax—100 mm
SUPPL.	1	Beaker—750 ml
	7	Dishes—specimen 8" diam.
	14	Flasks—Pyrex or Kimax—125 ml
	4	Glass squares—plate—45 cm x 45 cm
	7	Medicine droppers—wide mouthed
	7	Spoons—porcelain
	32	Tubes, Durham fermentation
		CHEMICALS
BASIC	4 oz	Acetocarmine stain
	1 lb	Agar-granulated
	28	Antiobiotic disks
	1 pkg	Antuitrin "S" (Chorionic Gonadotrophin)
	¼ lb	Beef extract
	1 qt	Benedict's solution
	150 ml	Carbon tetrachloride
	2 gm	Carmine—powdered
	1 lb	Chloroform
	2 gm	Congo red—powdered
	10 gm	Crystal-violet stain
	1 lb	Ether
	1 gal	Ethyl alcohol 95%
	1 gm	Giemsa stain
	1 lb	Glucose
	1 qt	Hydrochloric acid
	1 pt	Hydrogen peroxide (30%)
	2 qt	Iodine solution
	1 lb	Mercury
	100 gm	Methyl cellulose
	10 gm	Methylene blue
	28	Methylene blue thiocyanate tablets
	X	Pituitary suspension (50 frog pit.)
	3 lb	Ringers solution—frog
	1 qt	Sodium hydroxide
	1 lb	Soluble starch
	1 gm	Testosterone
	1 rl	Tes-Tape

	Amt	Equipment
		CHEMICALS (Cont.)
SUPPL.	1 l	Acetone
	10 ml	Acetylcholine 1:10,000 aqueous soln.
	10 ml	Adrenalin 1:10,000 aqueous soln.
	25 ml	Bial's reagent
	50 gm	Biuret reagent
	5 gm	Bromthymol blue, soluble
	100 ml	Butanol
	1 gm	Chloretone
	75 mg	Chloropromazine
	1 tab	Dexedrine sulfate
	1 lb	Dextrose
	2 gal	Ethyl alcohol
	4 oz	Ferric chloride
	1 gal	Formalin
	1 qt	Glacial acetic acid
	80 gm	Lactose
	1 qt	Methyl alcohol
	1 can	Ninhydrin reagent (aerosol can)
	20 gm	Nutrient beef broth
	10 gm	Pentose sugar
	100 ml	Phenophthalein
	1 oz	Silver nitrate
	14	Sodium hydroxide—pellets
	1 pt	Sulfuric acid—conc.
	4 oz	Thymol crystals
	1 pt	Toluene
	150 ml	Trypticase agar base w. dextrose
	150 ml	Trypticase agar base w. lactose
	150 ml	Trypticase agar base
	1 lb	Urea
	1 pkg	Urine glucose test paper
	25 gm	Xanthydrol
		BIOLOGICAL MATERIALS
		Living
BASIC	14	Caterpillar (Ex 25.1)
	12	Cockerel—1 day old (Ex 27.1)
	14	**Elodea**—14 sprigs (Ex 3.5)
	17	Frog—mature female—8 cm (Ex 28.1)
	21	Frog—mature male (Ex 3.6(4), 28.1(17))
	4	Moss plants (Ex 14.1)
	840	Seeds—albino—corn or tobacco
		—Pinon pine—fresh
	14	**Ulva**—alive or pres. (Ex 13.1)
		Cultures—for 1 class of 28
	X	**Chlamydomonas,** pure culture (Ex 13.1)
		Drosophila cultures—
	X	—Wild type (Ex 25.1, 30.1, 31.1, 31.2)
	X	—Dumpy wings (Ex 30.3)
	X	—Sepia eye color (Ex 30.3)
	X	**Escherichia coli** (Ex 11.1, 11.5)
	X	**Oedogonium,** pure culture (Ex 13.1)
	X	**Paramecium** (for 5 ex./1 class)(Ex 19.1-19.5)
	X	**Paramecium**—mating types (Ex 19.6)
	X	**Sarcina lutea** (Ex 10.3)
	X	**Serratia marcescens** (Ex 10.3)
	X	**Staphylococcus albus** (Ex 11.1, 11.5)
		Preserved—for 1 class of 28
		Genetic Corn
	14	—Color segregated
	14	—F_2 of purple X nonpurple
	14	—Backcross—F_1 X nonpurple parental strain
	X	Moss plants w. antheridia & archegonia
	X	Moss plants with sporophytes
	X	Pine branch w. cones
	14	Pine pollen cones
	7	Pine seed cones—young
	7	—old
	X	Specimens—pres. or mtd. of 4 arthropod cl.
	1 set	Specimens—pres. or mtd. of 7 chordate cl.
	1 set	Specimens—pres. or mtd. of 10 mjr. animal phyla
	X	**Tradescantia**—flower buds
		Prepared Slides
	14	**Ascaris** or whitefish eggs
	2	Moss antheridia LS
	2	Moss archegonia LS
	2	Moss protonema WM
	14	**Oedogonium**—sexual stage
	14	Onion root tip
	14	**Paramecium**—conjugation
	14	**Paramecium**—fission

YELLOW VERSION

Equipment and Supplies (Continued)

	Amt	Equipment
		BIOLOGICAL MATERIALS (Cont.)
		Living
SUPPL.	14	Crayfish (Ex 20.2)
	14	**Elodea**—14 sprigs (Ex 6.2)
	14	Earthworms (Ex 20.2)
	16	Frogs—mature male (Ex 3.7(2), 20.3(7), 26.1(7))
	14	Goldfish (Ex 22.2)
	14 ea	Grasshoppers—adult and immature (Ex 20.2)
	36	Hens' eggs—fertilized (Ex 28.2)
	X	Mushroom growth kit, for 1 class (Ex 12.3)
	21	**Planaria** (Ex 29.1)
	14	Tadpoles (Ex 29.1)
		Cultures—for 1 class of 28
	X	**Daphnia** (Ex 22.1)
	X	**Drosophila**—Brown vestigial (Ex 31.1)
	X	—Brown (Ex 31.1)
	X	—Vestigial (Ex 31.1)
	X	—White eyed (Ex 31.2)
	X	**Paramecium** (Ex 3.7)
	X	**Physarum polycephalum** (Ex 12.2)
	X	**Rhizobium** inoculum w. spec. legume seeds (Ex 8.1)
	X	Vinegar eels (Ex 20.1)

	Amt	Equipment
		BIOLOGICAL MATERIALS (Cont.)
		Preserved
SUPPL	14	**Ascaris**
	14	Crayfish
	14	Earthworms
	7	Fossil leaves
	7	Fossil mollusks in limestone matrix
	14	Genetic corn—from test cross of a heterozygous F_1 (derived from a colored, nonshrunken, non-waxy seed) by a homozygous plant derived from a colorless, shrunken, waxy seed.
	700	Genetic peas—dried round
	700	Genetic peas—dried wrinkled
	14	Grasshoppers—adult and immature
	7	Precut, calcified petrifactions of plants (coal balls)
		Prepared Slides
	14	**Ascaris** cs
	14	Earthworm cs
	2	Fern gametophyte
	2	Fern stem cs
	14	Leaves—dicot cs
	14	Root—buttercup cs
	2 sets	Stages of malaria life cycle
	14	Stems—herbaceous dicot cs

GREEN VERSION—*HIGH SCHOOL BIOLOGY, BSCS GREEN VERSION*

Equipment and Supplies
(quantities for 1 class of 28 students)

The following list does not include items students can supply or items to be purchased locally from petty cash (e.g., toothpicks, newspapers, aluminum foil, plastic bags, oatmeal, fresh vegetables, etc.).

	Amt	Equipment
		LARGE
BASIC	1	Autoclave or pressure cooker—22 qt.
	2	Aquaria
	2	Balances—triple beam (.01 gm)
	2	Hotplates—electric, or stove
	1	Incubator
	7	Lamps—gooseneck
	14	Microscopes—compound monocular
	7	—stereo binocular
	1	Refrigerator
ALT. BASIC	1	Temperature gradient box
HIGH. REC.	1	Aquarium—5 gal
	2	Balances—triple beam (.01 gm)
	7	Lenses—oil immersion
OPTIONAL	1	Drying oven
	3	Temperature gradient boxes
		SMALL
BASIC	28	Blood lancets—sterile, disposable
	1	Borer—cork
	14	Brushes—camel's hair
	7	Burners—Bunsen
	5 yd	Cheesecloth
	28	Clamps—pinch
	5 lb	Corks—assorted sizes
	3 lb	Cotton—absorbent
	3 lb	—nonabsorbent
	4	Files—triangle
	28	Forceps—student grade
	7	—fine point
	7	Jars—battery
	28	Lenses—hand
	7	Loops—inoculating
	14	Metersticks
	4	Mortars and pestles
	56	Needles—dissecting
	2	Nets—insect

	Amt	Equipment
		SMALL (Cont.)
BASIC (Cont.)	4 pkg	Paper—filter, 9 cm
	600 shts	—graph, 1 cm grids
	28 shts	—graph, semilog
	4 bks	—lens
	1 roll	—pH test
	4	Pan-shallow laboratory, enamel
	5 lb	Paraffin
	12	Pencils—glass marking
	7	Ring stand—supports
	7	—burette and tube clamp
	7	—rings
	5 lb	Rubber stoppers—asst. solid, 1 & 2 hole
	10 ft ea	Rubber tubing—assorted sizes
	28	Ruler—mm, plastic—15 cm
	14	—cm, 30 cm
	28	Scalpels
	28	Scissors—straight—student quality
	7	—fine point
	7	Spatulas
	1	Test tube—wire basket
	7	—holders
	7	—racks—10 hole
	7	Thermometers (10°C to 110°C)
	14	Trays—dissecting
	560 cm	Tubing—cellophane dialysis ⅝"
	7	Wing tops for Bunsen burner
	7	Wire gauze—asbestos center
ALT. BASIC	7	Needles—hypodermic #25
	2	Syringes—hypodermic—2 ml
HIGH. REC.	1	Bar—plant grappling
	1 btl	Cedarwood oil—immersion
	7	Cotton sleeves for thermometer
	7	Loops—inoculating
	3	Mortars and pestles
	3	Pans—shallow laboratory, enamel

Equipment and Supplies (Continued)

	Amt	Equipment
		SMALL (Cont.)
HIGH. REC. (Cont.)	1	Net—dip, large (1/4"-3/8" mesh)
	1	—plankton—medium mesh
	4	Tables—relative humidity
	6	Test tube—wire basket
	7	—holder
OPTIONAL	1 roll	Paper—pH test—wide range
	14	Ring stand—rings
	1	Seine—1.2 m x 6 m
	7	Syringe bulbs
		GLASSWARE
BASIC		Beakers—Pyrex or Kimax—Griffin low form, spout
	28	— 50 ml
	7	— 100 ml
	7	— 250 ml
	28	— 600 ml
	1	—1000 ml
	14	Bottles—Barnes dropping—30 ml
	28	—gas collecting—wide mouth—250 ml
	1/2 oz	Cover glass—#1 square
	2 oz	—#2 square
	36	Dishes—Petri, 100 mm x 15 mm
	30	—specimen—4 1/2" diameter
	7	—8" diameter
		Flasks—Pyrex or Kimax—Erlenmeyer
	14	— 250 ml
	7	— 500 ml
	2	—2000 ml
	7	Funnels—Pyrex or Kimax— 75 mm top
	2	—100 mm top
	2	—120 mm top
	12	Glass squares—clear—5" x 5"
	1	Graduated cylinder— 50 ml
	7	— 100 ml
	2	—1000 ml
	48	Medicine droppers—4 1/2"
	28	Pipettes— 1 ml
	7	—10 ml
	1	Pot—Pyrex or Kimax—2 l
	28	Screw cap culture tubes—20 x 150 mm
	14	Slides—glass—depression
	56	—regular
	14	Stirring rods
	76	Test tubes—Pyrex or Kimax—20 mm x 150 mm
	14	—25 mm x 200 mm
	12 ft ea	Tubing—glass—asst. sizes
	14	Watch glasses—Syracuse
	28	Vials, glass—25 mm x 95 mm
HIGH. REC.		Beaker—Pyrex or Kimax—Griffin—low form, spout
	14	—250 ml
	7	Dish—Petri, 150 mm x 20 mm
	7	Graduated cylinders— 10 ml
	7	—100 ml
	8	Screw cap culture tubes—20 x 150 mm
	7	Test tubes—Pyrex or Kimax—25 mm x 200 mm
OPTIONAL		Beaker—Pyrex or Kimax—low form spout
	7	— 50 ml
	21	—400 ml
	40	Dishes—specimen—4 1/2" diameter
	21	Funnels—Pyrex or Kimax—100 mm
	28	Stirring rods
		CHEMICALS
BASIC	2 pts	Acetic acid
	2 qts	Acetone
	500 gm	Agar
	1 gal	Alcohol—ethyl
	1 qt	—isopropyl
	10 gm	Beef extract
	1 pt	Benedict's solution
	10 gm	Bile salts
	50 gm	Biuret reagent
	4 oz	Bromothymol blue
	1 lb	Carnoy's solution
	1 pt	Chloroform
	10 gm	Crystal violet
	50 gm	Dextrose agar
	1 pt	Ether
	2 gal	Formalin
	100 gm	Glucose

	Amt	Equipment
		CHEMICALS (Cont.)
BASIC (Cont.)	1 pt	Hydrochloric acid
	1 gm	Indoleacetic acid
	2 qt	Iodine—potassium-iodide solution
	4 oz	Iron acetocarmin solution
	4 oz	Lanolin
	1 pt	Litmus solution
	10 gm	Methylene blue
	5 gm	Monobasic potassium phosphate
	1 gm	Pancreatin
	50 gm	Peptone
	1 pt	Petroleum ether
	100 gm	Propionic acid
	1 oz	Quinine sulfate
	1 pt	Sodium hydroxide
	1 pt	Sodium hypochlorite
	10 gm	Sudan IV
	1 rl	Test tape
	5 gm	Yeast extract
ALT. BASIC	X	Pituitary suspension
HIGH. REC.	10 ml	Acetylcholine bromide
	10 ml	Adrenalin chloride 1:10,000
	100 ml	Agar medium—Crone's nitrogen free
	10 gm	Ascorbic acid
	3 gm	Calcium phosphate, tribasic
	3 gm	Calcium sulfate
	3 gm	Dibasic potassium phosphate
	1 gm	Ferric phosphate
	10 ml	Histamine acid phosphate 1:10,000 aq. soln.
	1 gm	Indophenol
	1 pt	Lactic acid
	3 gm	Magnesium sulfate
	10 gm	Nicotine alkaloid
	10 gm	Potassium chloride
	10 gm	Sodium nitrite
	10 uc	Sodium phosphate solution of P^{32}
OPTIONAL	25 gm	Calcium carbonate
	1 lb	Cobalt chloride
	1 gm	Methyl red
		BIOLOGICAL MATERIALS
		Living
		Class samples (one each) living and/or preserved or mounted (Ex **1.1**, **4.1**)
BASIC	X	Amphibians
	X	Bacteria
	X	Cactus
	X	Centipede
	X	Crayfish
	X	Earthworm
	X	***Euglena***
	X	Fern
	X	Flatworm
	X	Green algae
	X	Large jellyfish
	X	Lichens
	X	Liverworts or mosses
	X	Luna moth
	X	Mammal
	X	Mollusk
	X	Mushroom
	X	***Paramecium***
	X	Pitcher plant or sundew
	X	***Planaria***
	X	Red algae
	X	Reptile
	X	Rotifer
	X	Sensitive plant
	X	Slime mold (fruiting body)
	X	Spider
	X	Sponge
	X	Starfish
	X	***Daphnia*** (Ex 14.3)
	28	***Elodea***—sprigs (Ex 1.3) (14), Ex 12 (14))
	16	Fish—***Corydoras***—males (Ex 18.1)
	8	—***Betta***—males (Ex 18.1)
	10	Frogs (Ex 12.1(3), Ex 14.1(7))
	36	Hens' eggs—fertilized (Ex 15.3)
	42	***Planaria*** (Ex 15.1)
	14	***Tradescantia***—stamens (Ex 12.1)
	420	Tobacco seeds—albino—(Ex 16.1)

Equipment and Supplies (Continued)

	Amt	Equipment
		BIOLOGICAL MATERIALS (Cont.)
BASIC (Cont.)	14	Water snails, small (Ex 1.3)
		Cultures—enough for 1 class of 28
	X	**Agrobacterium tumefaciens** (Ex 7.3)
	X	**Drosophila**—Wild type (Ex 16.3)
	X	—Dumpy (Ex 16.3)
	X	Mixed microorganisms (Ex 1.5)
	X	**Sarcina lutea** (Ex 7.2)
	X	**Serratia marcescens** (Ex 7.2)
	X	Small aquatic organisms (Ex 9.3)
		Preserved or Mounted
	1 set	Blood typing serum—Anti-A and B
	1	Skeleton—cat
	1	—human
ALT. BASIC	7	Frogs—female 8 cm (Ex 15.5)
	7	—male (Ex 15.5)
		Living
HIGH. REC.	2 btl	Brine shrimp eggs (Ex 4.4)
	4	Crayfish (Ex 4.4)
	12	Earthworms (Ex 4.4)
	11	Frogs (Ex 4.4(4), Ex 14.5(7)
	14	Genetic corn—F_2 dihybrid (Ex 16.6)
	500	Genetic peas—round (Ex 16.5)
	500	—wrinkled (Ex 16.5)
	12	Hydra (Ex 4.4)
	90	**Planaria** (Ex 4.4 (15), Ex 11.1 (75))

	Amt	Equipment
		BIOLOGICAL MATERIALS (Cont.)
HIGH. REC. (Cont.)	75	Water snails—small (Ex 11.1)
	28	**Zebrina**—shoots—20 cm (Ex 18.3)
		Cultures—enough for 1 class of 28
	X	**Euglena** (Ex 11.1)
	X	**Physarum polycephalum** (Ex 12.5)
	X	**Rhizobium** inoculum (Ex 7.4)
		Preserved or Mounted
	4	Crayfish
	1	Frog Skeleton
	7 sets	Insects—10 kinds
		Prepared Slides
	4	Earthworm cs
	4	**Hydra** ls
	4	**Planaria** cs
		Living
OPTIONAL	2 btl	Brine shrimp eggs (Ex 2.4)
	105	Hydra—**Pelmatohydra oligactis**—budding (Ex 2.4)
	36	Mealworms—**Tenebrio molitor** (Ex 14.7)
	36	Wireworms—**Agriotes** (Ex 14.7)
	36	Wood lice—**Armadillaria** (Ex 14.7)
	X	**Cultures**—enough for 1 class of 28
	X	**Drosophila**—with phenotypically dominant trait (Ex 16.7)
		—with recessive to above trait (Ex 16.7)

LABORATORY BLOCKS

Additional information concerning use and/or construction of the items for the various blocks, is included in the student and teacher manuals to the particular block. For a number of the items, see also *BSCS Biology, Innovations in Equipment and Techniques for the Biology Teaching Laboratory.*

Animal Growth and Development (1963 commercial edition)

Equipment and Supplies

(quantities for 1 class of 28 students)

The following list does not include items students can supply or items to be purchased locally from petty cash (e.g., toothpicks, newspapers, aluminum foil, plastic bags, oatmeal, fresh vegetables, etc.).

	Amt	Equipment
		LABORATORY APPARATUS AND/OR SPECIAL SUPPLIES
BASIC	1	Balances—Analytical or torsion**
	4-8	—Triple beam (0.1 g)
	1	Brooder, w. cone-type heating element**
	1	Chicken-egg incubator
	14	Compound microscope
	1 lb	Cotton—absorbent
	7	Dissecting instruments, one kit per squad, incl: dissecting needles; forceps, fine sharp-pointed; forceps, medium size (medium points); pipette; ruler, transparent cm; scalpel, scissors, med. size sharp-blunt; scissors, small, fine-pointed; spatula
	7	Dissecting microscopes**
	2 box	Filter paper
	4	Hypodermic needles—¾ inch, #18
	24	—¾ inch, #22
	18	Hypodermic syringes (1 ml tuberculin)
	1	Ion exch. col. or still for H_2O
	1	Refrigerator—pref. not to be shared non-block classes
	12	Single-depression slides w. cover slips
	7	Source for very bright light*
	1	Stove or hot plate
	1	Temp. gradient box w. 32 polyethylene refrig. dishes and covers, round 8 oz.
	12	Thermometers

	Amt	Equipment
		LABORATORY APPARATUS (Cont.)
OPTIONAL	X	Aquarium nets (125 mesh/inch)
	X	Filter Paper
	X	Needles (fine glass or steel)
		GLASSWARE
BASIC	14	Beakers—50-100 ml
	21	Fingerbowls—4" glass or 8 oz. polyethylene refrig. dishes w. lid
	21	—10" glass or 64 oz. polyethylene refrig. dishes w. lid
	10	Gallon jugs
	35	Jars—small screw cap
	2	—wide-mouth gallon
	14	Petri dishes
	30	Serum vials or bottles w. serum stoppers which fold down over bottle lips
	7	Syracuse dishes
	28	Test tubes
	4-8	Graduated cylinders—1 liter
	4-8	—100 ml
OPTIONAL	X	Erlenmeyer Flasks
	X	Jars, wide-mouth, gal
	X	Large flat dishes or enamel pans
	X	Serum vials w. fold over rubber serum stoppers

ANIMAL GROWTH

Equipment and Supplies (Continued)

	Amt	Equipment
		CHEMICALS
BASIC	25 g	Calcium chloride
	1 gal	Ethyl alcohol (70%) or Formalin
	100 mg	L-Thyroxine
	100 mg	L-Triiodothyronine
	10 g	Potassium chloride
	50 ml	Sesame oil
	1 lb	Sodium bicarbonate (baking soda)
	1 lb	Sodium chloride (noniodized table salt)
	500 mg	Testosterone propionate
	2 g	Thiourea
OPTIONAL	X	Agar
	X	Alpha-napthol
	X	Calcium chloride
	X	Chloretone-(1,1,1-Trichloro-methyl-2-propanol)
	X	Chorionic gonadotrophin
	X	Ethylenediamine tetracetic acid-disodium salt
	X	Iodine
	X	Neutral red stain (soln.)
	X	1 N hydrochloric acid
	X	Para-phenylene diamine (p-Diaminobenzene)
	X	Potassium chloride
	X	Potassium iodide
	X	Potassium phosphate—(dibasic)
	X	—monobasic)
	X	Sodium azide
	X	Sodium phosphate—(dibasic)
	X	—(monobasic)
	X	Thiourea
	X	Tri (hydroxymethyl) aminomethane

	Amt	Equipment
		BIOLOGICAL MATERIALS
BASIC	Abund	Algae, **Elodea** or leafy green vegetables
	14-21	Day-old cockerels of same breed
	66	Eggs, fertile hens'
	3	Frogs—live mature females
	7	—live mature males
	150	—tadpoles in or near hindlimb bud stage
	2 oz	Glass cover slips
	½ gr	Microscope slides—glass
	14	—single depression
	X	Prepared frog pituitary suspension or mature female frogs
OPTIONAL	X	**Artemia** eggs
	X	Chicks—embryos—living 36 hrs
	X	—living 60-72 hours
	X	—Day-old cockrel
	X	—Day-old pullet
	X	Frog—embryos, pre- and post-gastrula
	X	—larvae—Shumway's stage 16-17
	X	—tadpoles—Shumway's stage 25 to
		—metamorphosis onset
	X	—mature female
	X	**Hydra**
	X	Microscope slides, glass
	X	Pituitary extract (comm. or freshly prep.)
	X	**Planaria**

*If possible

Plant Growth and Development (1963 commercial edition)

Equipment and Supplies

(quantities for 1 class of 28 students)

The following list does not include items students can supply or items to be purchased locally from petty cash (e.g., toothpicks, newspapers, aluminum foil, plastic bags, oatmeal, fresh vegetables, etc.).

Amt	Equipment
	LABORATORY APPARATUS AND/OR SPECIAL SUPPLIES
15 sq ft	Cellophane*—Dark blue
5 sq ft	—Dark green
15 sq ft	—Dark red
1	Cork borer
1 lb	Cotton, nonabsorbant
7	Cutter (tissue)
1	Distilled water or deionizing unit
X	Eye piece micrometer, 1/scope or 14/lab
1	Fingerprint ink, tube
2	Fluorescent lights (40 w., cool white or slim line)
160	Germination—blotters
15	—tray w. light openings
12	Hacksaw blades
7	Hand microtomes
1	Incandescent light (150 W)
14	Microscopes
24	Millimeter rulers
7	Pan or breakers
7	Plant marker
8	Scissors
1-3	Stage micrometer
1	Styrofoam 1" x 1' x 3' (green)
7	Volumeter
	GLASSWARE
24	Beakers
100	Cover slides
8	Dropper bottles
1 lb	Glass beads, 6-8 mm diam.
8	Graduate cylinders
48	Petri dishes
16	Pipettes (medicine dropper)
100	Slides

Amt	Equipment
	GLASSWARE (Cont.)
48	Test tubes—Pyrex or Kimax—20 mm x 150 mm
16	—13 mm x 100 mm
24	—25 mm x 200 mm
8-16	Watch glass or shallow dish
	CHEMICALS
6 g	Agar
750 ml	Alcohol, Ethyl 95%—reagent grade
50 g	Ascarite
3 g	Boric acid
10 g	Calcium chloride
25 g	Calcium nitrate $Ca(NO_3)_2 \cdot 4H_2O$
5 g	Corn starch
1 g	Cupric sulfate $CuSO_4 \cdot 5H_2O$
25 ml	Formaldehyde
100 mg	Gibberellic acid
25 ml	Glacial acetic acid
200 mg	Indoleacetic acid
5 g	Iodine
10 g	Lanolin
5 g	Magnesium sulfate $MgSO_4 \cdot 7H_2O$**
2 g	Manganese chloride $MnCl_2 \cdot 4H_2O$**
2 ml	Nitric acid (concentrated)
1 g	Potassium chloride**
25 g	Potassium dichromate
10 g	Potassium iodide
10 g	Potassium nitrate**
5 g	Potassium phosphate—monobasic**
2 g	Safranin stain
115 g	Sodium hydroxide (pellets or crystals)
1 g	Sodium ferric ethylenediamine tetraacetate
3 g	Sodium molybdate Na_2MoO_4

*While DuPont cellophane in MSC 300 and K210 series is desirable, supplies may no longer be available. Similar results may be obtained by using such other types of filters as plastics, plexiglass, theatrical gelatins and cellophanes from general department stores. Where these are used, the teacher should expect slightly different results from those in the *Teacher's Supplement* to the Plant Block.

**Must be reagent grade

Equipment and Supplies (Continued)

Amt	Equipment
	CHEMICALS (Cont.)
2 liters	Solution of commercial plant food
40 g	Sucrose
200 ml	Sulfuric acid (concentrated)
2 rolls	Testape (glucose urinalysis)
1.5 g	2,3,5-triphenyltetrazolium chloride
3 g	Zinc sulfate $ZnSO_4 \cdot 7H_2O$*
	BIOLOGICAL MATERIALS
	Seeds
450 g	Alaska peas
55 g	Castor beans
550 g	Corn
15 g	Grand Rapids lettuce (light sensitive and shipped under light-tight conditions)
3 g	Great Lakes lettuce
125 g	Kentucky Wonder beans (Bush or Pole variety)
55 g	Little Marvel peas
40 g	Oats (**Avena sativa**, variety Victory preferred, but some other varieties available locally are satisfactory)

Amt	Equipment
	BIOLOGICAL MATERIALS (Cont.)
55 g	Okra (Louisiana Green Velvet) (Not pre-tested for germination)
5 g	Sorghum (RS 610)
	Others
	Prepared Slides
16	1. Corn root sections (median or near-median longitudinal sections, 5 mm long, cut at a distance 15 mm from root tip of a 3-day old root)
16	2. Corn root sections (median or near-median longitudinal sections 5 mm long, cut from 6-day old roots at a position marked 15 mm from the root tips when they were 3-days old)
16	3. Corn root tips (median or near-median longitudinal sections 12 mm long cut from 3-day old root tips)
4	Variegated **Coleus** plants

Microbes: Their Growth, Nutrition and Interaction (1964 commercial edition)

Equipment and Supplies

(quantities for 1 class of 28 students)

The following list does not include items students can supply or items to be purchased locally from petty cash (e.g., toothpicks, newspapers, aluminum foil, plastic bags, oatmeal, fresh vegetables, etc.).

Amt	Equipment
	LABORATORY APPARATUS AND/OR SPECIAL SUPPLIES
3	Aspirators (opt.)
1	Autoclave or pressure cooker, 22-26 qt
4-6	Balances (0.01 g)
3	Buchner funnel & suction flask (opt.)
7	Bunsen burners
1	Cotton (plugging) package
1	Dry sterilization oven—or range with oven
1	Heat source for autoclave—or range with oven
1 box	Filter paper
14	Forceps
14	Hemacytometer
14	Inoculation loop or needles*
14	Medicine droppers
14	Micron discs (B&L or equiv.)
14	Microscopes
1	Refrigerator
14	Swinny filters, Millipore or B&D (opt.)
6-8	Thermometers
1	Thermostat*
8	Transfer chambers (opt.)
1	Water still or deionizing column
	GLASSWARE
X	Beakers (asst.)
100	Cover glasses
84	Culture tubes
2-3	Dispensing column (opt.)
35	Erlenmeyer flasks (125 ml)
8-10	Graduated cylinders (asst.)
14	Growth tubes*
28	Petri dishes, glass or 77 plastic
21	Pipettes, 1 ml
100	Slides
14	Spreading rods
	CHEMICALS
	Stains
100 ml	Decolorizing agent—95% EtOH or subst.
100 ml	Gram's iodine
100 ml	Gram's stain (Hucher's ammonium oxalate crys. violet)
2 oz	Methyl cellulose (10%)
100 ml	Methylene blue stain
100 ml	Safranin stain
100 ml	Spore stain—6% aqueous Malachite green

Amt	Equipment
	CHEMICALS (Cont.)
	General
30 g	Agar
0.2 g	Biotin
5 g	$CaCl_2 \cdot 2H_2O$
5 g	Casein hydrolysate—vit. free
3 g	Cellulose
3 g	Fructose
30 g	Glucose (dextrose)
0.2 g	Inositol
15 g	KH_2PO_4
3 g	Lactose
3 g	Maltose
3 g	Mannose
5 g	$MgSO_4 \cdot 7H_2O$
50 g	NaCl
2500 ml	**Neurospora** medium-deficient
20 g	$(NH_4)_2SO_4$
20 g	Nutrient agar (dehyd media)
5 g	Peptone
20 g	Potato dextrose agar (dehyd media)
0.2 g	Riboflavin
10 g	Sodium lactate (60%)
3 g	Starch
25 g	Sucrose
0.2 g	Thiamine
10 g	Tryptone
15 g	Yeast extract
5 g	Yeast nucleic acid
	BIOLOGICAL MATERIALS
X	**Aspergillus niger**
X	**Bacillus mycoides**
X	**Bacillus subtilis**
X	**Neurospora crassa** (Inositol defic. st.)
X	**Rhizopus nigricans**
X	**Sarcina lutea**
X	**Serratia marcescens**
X	**Staphylococcus albus**
X	Yeast (package dry)

The Complementarity of Structure and Function (1963 commercial edition)

Equipment and Supplies

(quantities for 1 class of 28 students)

The following list does not include items students can supply or items to be purchased locally from petty cash (e.g., toothpicks, newspapers, aluminum foil, plastic bags, oatmeal, fresh vegetables, etc.).

Amt	Equipment
	LABORATORY APPARATUS AND/OR SPECIAL SUPPLIES
100	Applicator sticks, wooden
7	Balances
7	Balancing tables
28	Blood lancet, sterile, dispos.
14	Clamp-holder
7	Cockroach racetrack
14	Compound microscopes
7	Dissection kits, w. blunt probe
7	Frog pinning board
14	Hand lenses or dissecting scopes
7	Insect etherizing chamber
7	Kymograph, muscle clamps & lever arm*
7	Lung model*
70	Marbles (16 mm)
7	Meter sticks
1 pkg	Pins, rustproof, straight
7	Spring scales, 25 kg or 2 kg
14	Stand, support
7	Stimulator, 1-6 volt
20	Styrofam balls, ½"-¾"
4 kg	Washers or wts for lever arm 70-100 gm
7	Watches
1	Whetstone, 120-180 grit
	GLASSWARE
7	Beakers, 400 ml
72	Cover glasses
7	Graduated cylinders, 10 ml

Amt	Equipment
	GLASSWARE (Cont.)
72	Microscope slides
7	Petri dishes
1 doz	Pipettes, medicine droppers
	CHEMICALS
1 pt	Alcohol (70%)
5 ml	Anti A-B bloodtyping serum
20 g	Benzene or zylene
10 g	Carbon tetrachloride
20 g	Ether
1 g	Janus green B stain
10 g	Methyl cellulose, dry
1 g	Methylene blue stain
500 ml	Ringers solution
20 g	Sucrose
	BIOLOGICAL MATERIALS
1 unit	**Amoeba** culture
7	Birds (may be preserved)
1 unit	Ciliated protozoan culture
7	Cockroaches or large beetles, living
14	Earthworm, large, living
70	Fly (**Musca domestica**), living
28	Frogs, living
7	Preserved large flying insects
14	Slides of striated muscle
14	Slides of cross section of earthworm
14	Slides of cross section of intestine showing villi

FIELD ECOLOGY (1964 commercial edition)

Equipment and Supplies

(quantities for 1 class of 28 students)

The following list does not include items students can supply or items to be purchased locally from petty cash (e.g., toothpicks, newspapers, aluminum foil, plastic bags, oatmeal, fresh vegetables, etc.).

Amt	Equipment
	LABORATORY APPARATUS AND/OR SPECIAL SUPPLIES
1	Anemometer (wind meter)
7	Bitterlich sighting device
3 ea	Blotting paper, various colors
140 cm	Capillary tubing
7	Carpenters levels
7	Clamps, Mohr
1	Cork, borer set
7	Cover frames
1	Evaporator, Livingston
35	Filter papers
7	Insect collecting nets
7	Killing jars, wide mouth
1	Light meter
10	Maximum-Minimum thermometer
14	Mercury thermometers
21	Meter sticks
1	Meter stick balance
28	Microscope slides & cover glasses
	Modified Horne trap (amt. depends on quantity of animals)
7 vials	pH paper scale 3-11
15 shts	Photographic copying paper—Driazo Sepia Intermediate 1401T or Sepia Ozalide No. 33 NT 8½ x 14"
7	Plant markers

Amt	Equipment
	LABORATORY APPARATUS (Cont.)
7	Plastic triangles, 45°, 45°, 90°
7	Point frame apparatus
7	Ruled plastic overlay for bryoid cover 10 x 10 cm*
28	Ruler, plastic 15 cm
7	Stoppers to fit burette
7	Support stands
7	Tape, measuring—Preferably 30 meter steel
7	Two-hole stoppers
14	Volumeters
7	Soil test kits
28	Graph paper, preferably with squares in mm
7	Level or carpenter's "T" squares
28	Polar coordinate papers
	GLASSWARE
7	Burettes—straight pinchcock, 25 ml
1	Graduated cylinder, 100 ml
28	Plastic culture dishes 50 x 12 mm
	CHEMICALS
25 ml	Ammonium hydroxide for developer (conc.)
7	Collodion—small bottle
1	Humidity indicator (Cobalt chloride type)
7	Calcium chloride—small bottle

REGULATION IN PLANTS BY HORMONES (1964 commercial edition)

Equipment and Supplies

(quantities for 1 class of 28 students)

The following list does not include items students can supply or items to be purchased locally from petty cash (e.g., toothpicks, newspapers, aluminum foil, plastic bags, oatmeal, fresh vegetables, etc.).

Amt	Equipment
	LABORATORY APPARATUS AND/OR SPECIAL SUPPLIES
48	Applicator sticks (wooden)
1	Autoclave heat source (range with oven)
1	Autoclave or pressure cooker, 22-26 qt.
1	Balance—analytical or torsion
4-8	—triple beam (0.1 g)
1 box	Filter paper
96	Plant tags
14	Plastic mm rulers
1	Pyrex or Kimax still for H_2O or ion-exchange column
1	Refrigerator
7	Transfer chambers
	GLASSWARE
77	Beakers (1 liter) or substitute containers to mix solution
14	Flasks Erlenmeyer (125 ml)
8	Jars (1 qt.) for storing solutions
140	Petri dishes

Amt	Equipment
	CHEMICALS
1 qt	Alcohol
20 g	$Ca(NO_3)_2 \cdot 4H_2O$
10 g	Calcium hypochlorite or
200 ml	chlorox
2 g	Ferric tartrate
300 mg	IAA
10 g	KCl
5 g	KH_2PO_4
10 g	KNO_3
3 oz	Lanolin
5 g	$MgSO_4 \cdot 7H_2O$
0.5 g	Nicotinic acid
0.1 g	Pyridoxine
400 g	Sucrose
0.1 g	Thiamine (B_1)
	BIOLOGICAL MATERIALS
1 lb	Bean seeds
90	*Coleus* plants
2 oz	Tomato seeds

APPENDIX D

NUMBER OF MINUTES PER WEEK IN CLASS FOR BSCS BIOLOGY CLASSES 1961-62, BY VERSION AND GRADE LEVEL

No. minutes per week	No. of classes					
	Yellow		Blue		Green	
	9th grade	10th grade	9th grade	10th grade	9th grade	10th grade
200		2		39	4	4
205						
210						
215	22				6	14
220					1	4
225		29	3	7	9	29
230					3	1
235				7		
240		2	2	8		2
245						4
250	11	42	12	19	5	35
255			2	2		
260	1	12		5		9
265		2		7		13
270		12		16	3	35
275	15	210	10	203	2	96
280		18	9	25	13	6
285				4		37
290		2				10
295		4	1	4		8
300		10	2	15	4	37
305		2				
310				19		8
315		11	2	6		1
320						
325						
330						
335		4		6		
340						
345						4
350						
480						5

APPENDIX E

THE DIRECTOR ANSWERS QUESTIONS ABOUT THE BSCS

My reaction is . . . *

Arnold B. Grobman, Director

The availability of BSCS materials in commercial form has generated considerable interest in the program and its products. Informative discussion has proved highly rewarding and in some areas of the country there have been conferences for the exchange of viewpoints among teachers interested in (and often with some experience in) the BSCS courses. In some instances, however, misleading statements may have been made through lack of adequate information, and the enthusiasm of some salesmen has led to exaggerated claims for the BSCS and its materials.

Thus, it might be useful to record my personal reactions to some of the statements that have come to my attention. For some of these matters, the BSCS has no established policy and so I am simply offering my personal opinions. These reactions are arranged in the form of questions and answers. Reference may also be made to the Questions and Answers in BSCS NEWSLETTER No. 17. Users or potential users of BSCS materials who have any further questions they would like discussed should feel free to write to us about them.

Which of the three Versions is most difficult?

The goal of the BSCS writers was to produce three Versions at similar levels of difficulty. A very extensive evaluation program has been concerned with this matter as well as with other aspects of the BSCS courses. At the end of the 1961-62 school year (the last year for which full data have been analyzed) large numbers of students who had studied each of the three Versions were given the same comprehensive final examination. The differences among their scores amounted to less than one per cent. This result indicated to us that at that stage of development, the Versions were of equivalent difficulty and were of equivalent effectiveness in teaching high school biology. Further information may be found in NEWSLETTER No. 19, pages 5-29.

When I examine the Versions, I seem to detect considerable differences in levels of difficulty.

This is a fair observation and to many teachers, one of the Versions does seem easier than the other two Versions, though it is not always the same Version that seems easier. A reason for this may be that biology teachers may tend to equate, perhaps unconsciously, something that is *different* with something that is *difficult.* Hence the more novel (different) the material and approach, the more difficult the books seem. For this reason, one or another of the new BSCS materials may appear to be difficult to some teachers. On the other hand, almost all of the material is new to the entering biology student. He does not have the same standard of comparison a teacher has and so to him no one approach is more difficult than another. Thus while one or another of the BSCS Versions may *seem* more difficult to a teacher, this has not been the case with the average student. Actually the Versions may be less difficult for the students than are conventional books because the effort to reduce technical terms to be memorized and the close interrelation of ideas should aid the student in both comprehension and retention.

What do you think of using one Version for the tenth grade and a second Version for an advanced course in the eleventh or twelfth grade?

I would recommend against this procedure, because there is a substantial amount of material common to all three Versions. Hence, a student who had studied one of the Versions in tenth grade would be repeating much of this material if he studied a second BSCS Version in the eleventh or twelfth grade. The BSCS is developing a Second Course in biology which will be available commercially in September, 1965. I suggest that you consider the use of this Second Course at the twelfth grade, rather than a second BSCS Version. The same point should be made concerning using a Version as a second course to follow a conventional tenth-grade course. While each of the BSCS Versions includes much material not found in traditional books, naturally not all the information and ideas formerly taught have been discarded, even though the manner of presentation may be new.

In our school we are going to use one of the Versions in the ninth grade so that students can have an extra year of science in senior high school. Do you have any suggestions about which Version to use?

Each of the BSCS Versions was designed for average and above-average youngsters at the tenth grade. After careful evaluation, we have concluded that the BSCS Versions may be used successfully with *above-average* ninth graders. We do not recommend the use of any BSCS Version with unselected ninth graders. (For an expanded discussion see H. Grobman, "High School Biology: On What Grade Level Does it Belong?" *Clearing House,* April 1964, pp. 498-99.)

Is it true that one of the Versions is more suitable for use in rural areas and another more suitable for use in urban areas because of the problem of field trips?

No. Each one of the three Versions has been thoroughly tested in rural, suburban and urban areas and appropriate adjustments have been made in designing

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these Versions so that they might be used successfully in all of these situations. Many ecological observations can be made through use of a window box or an empty city lot as well as through a visit to an undisturbed semi-tropical beach.

Is it possible for a teacher to combine the best features of the three Versions and develop a superior course?

This is highly unlikely. In the first place, while the courses were being constructed, each team of writers had full access to the work of the other teams and so did incorporate "the best features" of the other teams for use in its own Version. Secondly, themes and concepts are woven as threads through the materials and picking out pieces would tend to destroy this continuity. Thirdly, if, in all of its developmental work, the BSCS had decided that a single composite Version would be superior, it would have taken this approach itself. Thus I would recommend against a patchwork course. On the other hand, after a teacher has had experience with one of the Versions—and I think he should go through one of them carefully with his classes for at least two years—he might then wish to supplement his course with materials from various sources, including the other Versions.

Half of the biology teachers in our school wish to use one Version and the other teachers prefer a different Version. Please comment.

In theory, I think this is an excellent procedure. It provides for flexible offerings in the school and permits teachers to use the program they personally prefer. Minor, but practical, problems would include reduced flexibility in transferring students from one section to another during the middle of the year; maintenance of a double book inventory; and a dual ordering of supplies.

In our state we have been told that the BSCS course is experimental and therefore only a small number of teachers will be permitted to use the books this year. How long is it intended that the BSCS courses will be experimental?

In the normal sense of the word "experimental," the BSCS courses could have been so considered during the period 1960-63, but at the present time the BSCS courses are probably less experimental than most biology courses currently available. I say this because the present form of the BSCS courses rests on an enormous amount of experimentation, evaluation, feedback and consultation with teachers and students. Thus, these courses have been more adequately tested than is the case with any other biology course generally available. (In a rather special interpretation of the word, all good courses are "experimental" in that their designers and teachers are always interested in changing them and improving them as new conditions indicate. Hence a teacher who teaches a course with static content and finds that a new or different technique he has developed is more effective than the methods used previously is experimenting with his course. Good teachers are always experimenting in this fashion.) The answer I would give is that the commercially published BSCS courses are *not* experimental in the sense of your question.

I have looked over one of the BSCS Versions and find that some of my favorite exercises—such as the dissection of the crayfish, the dissection of the frog and the dissection of the earthworm—are not included. What BSCS exercises would you recommend be omitted so that I could include these favorite dissection exercises of mine?

None. This matter was considered carefully when the laboratory exercises were written for the Versions and it was felt that the material presently included in the exercises is of greater educational value than the materials omitted. It is extremely difficult for a teacher to refrain from presenting to his class material with which he is thoroughly familiar and which he has used repeatedly with satisfaction. A teacher must carefully consider the educational value of the material he would add and its compatibility with the Version being used. My recommendation would be to try one of the BSCS Versions *as the writers intended* it for at least two years before trying to introduce substitute exercises.

The BSCS courses do not include as much identification of animals and plants and several other subjects, as we previously taught in our general biology. Do you think these aspects of biology are unimportant?

On the contrary. These are very important aspects of biology but they should be started at the junior high level or earlier. I have observed—as have many others—that when students are in elementary and junior high grades they are far more interested in identification than when they are at the senior high level and we should take advantage of student interest at every level. Just because certain material is not stressed in the BSCS books does not mean that the BSCS writers consider it unimportant. Rather, it is a reflection of the fact that the present BSCS books comprise the selections by the BSCS writers of the materials they felt most significant and appropriate for tenth graders at the present time.

Is a BSCS Version a rigid course or could one deviate rather widely from it?

Both procedures are possible. The text and laboratory manual are designed to be sufficient to provide an interesting and modern course in biology for tenth graders. However, there is a tremendous amount of built-in flexibility. For example, in each Version there are many more laboratory exercises than could be completed in a year by any one class, thus the teacher has considerable opportunity for variation and flexibility by his choices among the exercises. Additional optional laboratory exercises are published in the BSCS NEWSLETTER from time to time, and these, too, could be substituted for Version exercises or used to extend them. Discussion meetings could be varied in an interesting fashion through the use of the "Invitations to Inquiry" from the BSCS *Biology Teachers' Handbook*. Any one of the Versions could be supplemented through use of one of the Laboratory Blocks. (Five Blocks are now commercially available and others will be issued in the near future.) Furthermore, a teacher could select any one of the three Versions as his basic program and still achieve the same general BSCS goals. The *BSCS Pamphlets* could be used for supplementary readings. Other supplementary materials currently being prepared include Single Topic Films.

Do BSCS courses teach evolution?

Yes. All three Versions cover evolution as a major scientific theory.

Do BSCS courses teach the origin of man differently from the story of creation as presented in the Bible?

The BSCS courses deal solely with biology and not with theology. They do not attempt to bring scientific information in conformity or in conflict with biblical teachings.

Do BSCS courses cover sex education?

The biological basis for mammalian reproduction is thoroughly discussed. It is presented as a major biological process; sex education, in the restricted sense, is not treated in BSCS courses.

The President's Science Advisory Panel reported that the BSCS courses were designed for college-bound students. Is this true?

No. BSCS courses were designed for average and above-average tenth grade high school students regardless of their educational goals or career motivation. They are intended to be general liberal education courses for future citizens regardless of whether the students will become salesmen, statesmen or scientists.

Is it true that one of the Versions is both traditional and modern?

Each of them is to some degree. Each Version contains considerable basic biological information that has been known (and taught) for a long time and, to that extent, consists of traditional materials. But these materials are approached in fresh and new ways providing the distinctive flavor of the BSCS courses.

Who decided the final content of BSCS publications?

Responsibility for content of all BSCS publications has been under full control of the BSCS writers, who are research biologists and high school teachers. Content control has *not* been vested in the publishers.

How many books comprise a Version?

For each version there is a textbook, a laboratory manual and a teacher's guide. The publisher may issue the textbook and laboratory manual bound together in a single volume or bound separately in two volumes. The teacher's guide may be in one volume or two volumes according to the decision of the publisher. It is strongly recommended that a teacher using one of the versions also use the BSCS *Biology Teachers' Handbook* for study and reference. There are also tests to accompany each Version for use during the year, and final examinations suitable for use with all Versions.

Do teachers need special training before teaching a BSCS course?

This depends on the background of the teacher to a very large extent. Less preparation is needed if the teacher has had recent training in modern biology and understands inquiry and teaching methods useful in implementing an inquiry approach—including, among others, laboratory and field techniques. There are many teachers with good background who can teach a BSCS course without receiving special training. For some of these, the BSCS *Biology Teachers' Handbook* may provide sufficient additional background. In fact, there are many competent teachers in the United States who, given sufficient time and facilities, could design (and have designed) their own courses which would be equivalent in educational value to the BSCS courses. However, many teachers have not had opportunities for such experiences in biology. In the education of a number of teachers, biology was presented in a didactic fashion and the laboratory exercises were primarily of the "cookbook" type wherein what is already known to both the student and the teacher is unimaginatively reaffirmed. Also, some may not have studied the newer areas developed in the BSCS courses such as population genetics. These teachers—and I would guess they constitute a substantial number of biology teachers in America today—should receive some preparation in the new materials and should have an opportunity to develop an appreciation and understanding of inquiry and investigation in science. They should have an opportunity to complete many of the laboratory exercises, before they supervise students who will be trying these exercises themselves; and they should have an opportunity to overcome subject matter deficiencies. It is most important that prospective BSCS teachers understand the rationale of the BSCS courses and have some appreciation for its objectives and goals.

I understand that the BSCS will provide a copy of the BSCS Biology Teachers' Handbook *to each teacher using BSCS materials. How can I obtain a copy?*

As long as its supply of *Handbooks* lasts, the BSCS will provide a copy of the *Handbook* to each teacher using the 1963 edition of one of the Versions in his class as the major text. To receive a copy, a special request card must be obtained from the publisher of the Version you are using—or plan to use—and it should be filled out by the teacher and mailed to the BSCS. The publisher of the *Handbook* is not authorized by the BSCS to distribute free copies upon direct request.

How much special training should a prospective BSCS teacher have?

This depends, of course, upon the prior academic preparation and experience the teacher has had and so no hard and fast rules are applicable. We have seen teachers handle BSCS materials successfully after experience with an inservice workshop, a summer institute, or a short briefing session. As an arbitrary rule of thumb, the BSCS has recommended a minimum of 40 contact hours in a teacher preparation session with the BSCS materials before using them in the high school classroom.

Does the BSCS course require more laboratory equipment and supplies than a conventional biology course?

The BSCS is a laboratory-oriented biology course and so a reasonable amount of equipment and supplies is needed. This is true for any good modern biology course that is laboratory oriented and there should be no substantial difference between BSCS courses and other modern biology courses regarding funds required for laboratory materials. BSCS courses, if taught properly, will require more laboratory equipment and supplies than lecture-type courses. But savings on preserved specimens and models normally used can be directed to purchase of living materials and cultures.

Catalogues from scientific-supply houses seem to indicate that the BSCS courses require an excessive amount of laboratory equipment and supplies. What is your reaction to this?

The catalogues often give this impression. However, the point is that these catalogues list *all* of the equipment and materials needed for *every* BSCS laboratory exercise in a Version—both the recommended and supplemental exercises for the entire course. Since the complete course includes many more laboratory exercises than any one class will attempt during the year, the impressions from the catalogues are misleading. (The purpose of this provision of additional exercises is to insure that teachers will have the desired degree of flexibility in organizing their own courses.) Before ordering materials, a teacher should go through the Laboratory Manual *and decide which exercises his classes will use during the year.* He should then order only the materials necessary for those exercises. Also, he should check to see what is on hand so that he does not reorder materials already available. (After the first year, this will obviously be less of a chore.) Further, such items as aluminum foil, string, thumb tacks, etc., can be more inexpensively obtained locally than by ordering through scientific supply houses. The teacher needs a petty cash fund readily available to take care of such local purchases. BSCS teachers who previously taught laboratory-oriented courses report that BSCS is not more expensive than their earlier courses.

Is it recommended that one of the BSCS Versions be supplemented with one of the BSCS Laboratory Blocks?

This is exactly the purpose for which the Laboratory Blocks were designed. Some teachers might find it desirable to use one of the Blocks as a supplement after they have had a year's experience with one of the Versions. Each of the Blocks provides an opportunity to experimentally explore a limited area of biology. The choice of a Block should reflect the interests of the class and teacher.

In my district we will not have an opportunity to adopt a new text for some years. Would it be possible to use one of the Laboratory Blocks as a supplement to the non-BSCS textbook we are currently using?

We believe this should work successfully. The Blocks are independent units and should be just as valuable a supplement to a non-BSCS course as to a BSCS course, providing the students have an opportunity to develop laboratory skills and the Block is taught with an inquiry approach.

Were the Blocks designed to provide students with Science Fair Projects?

No.

What is the BSCS doing for students who cannot use the regular materials?

The BSCS is currently developing *BSCS Biology—Special Materials* for those students of low ability for whom the Versions are too difficult. This includes some low ability students now taking biology as well as some students who do not normally register for a biology course because they believe it would be too difficult or because they are counseled away from it. In general, we believe the Special Materials would be useful for most tenth graders who have DAT scores below the 40th percentile. The Special Materials are not designed for underachievers or for average and bright students who lack motivation.

Do the Special Materials *comprise a full course?*

The 1963-64 edition of the *Special Materials* consisted of a few experimental units for feasibility testing in representative schools. The reaction of teachers and results of student testing were quite favorable and the BSCS is improving the present units and preparing additional units to make up a full one-year course, which are being tested during 1964-65.

We have a three-track system in our district and I wonder what your recommendations for BSCS biology would be?

The BSCS *Special Materials* for the lower ability student are still under development. When they are completed, these would be possible options:

Slow lane: Special Materials
Medium lane: One of the Versions
Fast lane: One of the Versions plus one of the Laboratory Blocks.

Do the Research Problems in Biology *contain suggestions for Science Fair Projects?*

No. *Research Problems in Biology* were not designed for students seeking Science Fair Projects. They include relatively sophisticated prospectuses of long-term investigations for science-oriented students. The prospectuses are not designed for average youngsters faced with the necessity of preparing a short-term Science Fair project.

Could a biology course be organized around three or four of the Laboratory Blocks?

We think this would make a very interesting type of course. We would urge teachers who are so inclined to experiment with such a course, and to keep us informed of their successes and failures. Some teachers may wish to design their own second level courses in this fashion.

Could the Laboratory Blocks be used in college classes?

They should have a special value in teacher preparation classes in helping teachers appreciate methods of inquiry beyond those presented in the Versions and there may be other collegiate situations in which they will prove to be useful.

Is the BSCS Biology Second Course an accelerated course for bright students?

No. This is a second course in biology, to follow a first high school course, preferably one of the versions. It is intended for the student who is interested in biology and wants further work. Some of these students may be planning a career in biology, others may not.

What is the relationship between the BSCS and the Advanced Placement Program?

There is no formal association between the two organizations. Neither the three BSCS Versions nor the Second Course were designed to serve as a collegiate course to be taught in the high schools.

Are the College Entrance Examination Board tests in biology appropriate for BSCS students?

Through the courtesy of CEEB, two special committees of BSCS have had the opportunity of examining recent CEEB biology tests. These committees were aided by independent reviewers from the fields of biology and psychometrics. It was the unanimous opinion of those involved that the CEEB tests examined do not adequately reflect the kinds of learnings that the BSCS hopes will be achieved through the study of one of the BSCS Versions. It is our considered opinion that the CEEB Biology tests we have examined do not provide full opportunity for BSCS students to adequately demonstrate what they have learned. This leads me to the position that the CEEB Biology tests are not now as appropriate a measure of achievement for BSCS students as is the BSCS comprehensive Final Exam.

The BSCS has been in communication with CEEB over the past three years on this problem and it is hoped that a satisfactory solution will be found in the near future.

Many colleges and universities (Amherst, Johns Hopkins, Barnard, Kansas State) are modifying their own biology courses in order to reflect the more sophisticated preparation the students of the new high school biology programs are bringing with them as they enter college. It is clear that BSCS students are well prepared for collegiate biology courses.

Has the BSCS produced any films?

The BSCS has produced a series of *Techniques Films* designed primarily to acquaint teachers with common laboratory techniques with which they may not have become familiar because of recent advances in techniques or through gaps in their own academic preparation. The BSCS also has in preparation a series of *Single Topic Films.*

I have seen a BSCS list of recommended films from one of the film producing companies. Has the BSCS produced such lists for other companies as well?

The list you saw was not prepared by the BSCS. The BSCS has not produced a recommended list of films to accompany the BSCS courses. The only "official" recommendations made by the BSCS are those made by the BSCS writers and included in the Teacher's Guides and the BSCS *Biology Teachers' Handbook.* While lists published by some of the film-producing companies may superficially appear to be BSCS lists prepared by BSCS staff members, and may actually have been written by persons associated at one time with the BSCS, they are not official BSCS lists and do not necessarily reflect BSCS attitudes regarding use of films with BSCS materials.

What is the position of the BSCS regarding supplementary films for use with BSCS Versions and other BSCS materials?

The BSCS has taken no position as an organization but it would seem to me that films must be considered as quite secondary in a BSCS program, because the BSCS programs are primarily laboratory-oriented. The BSCS programs are essentially participant courses rather than spectator courses. On the other hand, there are occasions when a good film can bring home to a student a point that could not otherwise be as well understood.

What is the BSCS policy on the programming of its materials?

The BSCS has no policy on this matter. However, several of the BSCS writers feel that developing an appreciation and an understanding of investigation are beyond the present techniques of programming. Some of the staff of the BSCS feel that certain aspects of the BSCS course might be suitable for programming and then could be made available to the teacher to use as a supplementary teaching device, probably for those in the class who did not grasp the topic during its regular presentation. Certain skills and techniques might lend themselves to programming.

What happens to the royalty income derived from the sale of BSCS books?

These funds are held in an escrow account, the use of which is basically determined by our principal source of support, the National Science Foundation. Upon request of the BSCS, the Foundation may make these funds available to further the work of the project. There are no royalties paid to individual writers.

Does the BSCS plan to revise the Versions and continue developing other projects in biological education?

Yes. The BSCS has committed itself to revision of its books and does plan further contributions to the improvement of biological education. New information about BSCS programs will be recorded in the BSCS NEWSLETTER as it becomes available.