Selected Procedures in Teaching Biology

BY

E. Irene Hollenbeck

and

Elmo Nall Stevenson

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EDITOR'S PREFACE

This monograph had its beginnings during the year 1943-44 when Miss E. Irene Hollenbeck initiated the study for a master's thesis under Dr. Elmo N. Stevenson, professor of science education at Oregon State College. In its present form the study includes revisions and additions by both authors. Miss Hollenbeck is a teacher of biology in the Senior High School at Salem, Oregon, and Dr. Stevenson is president of the Southern Oregon College of Education, Ashland, Oregon.
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INTRODUCTION

Good teaching employs a wide variety of the avenues of learning. It makes use of many elements of the drama; it capitalizes on the particular interests of individual pupils; it provides unlimited opportunities for self-expression. Good teachers like to utilize teaching procedures which embody these principles. Many teachers, however, find themselves handicapped by lack of time to find appropriate aids or by lack of sufficient sources of material.

Modern professional textbooks on methods and materials for teaching high school science give little attention to the presentation of interesting classroom activities. Descriptions of useful fascinating devices may be found scattered through numerous periodicals, pamphlets, and biology textbooks, but nowhere have such descriptions been collected in readily accessible form. If the textbook in use in a biology class happens to be one that contains few suggested activities, some teachers—especially beginning teachers—find it difficult to enrich the biology course with a variety of experiences. The purpose of this monograph is to present in a conveniently organized form a selected group of tested procedures in teaching biology in secondary schools.

Changes in American life have come about rapidly. Changes in commerce and industry, in family life and amount of leisure time, and in international relations have all brought about a change in the number, capacities, and interests of the young people in our secondary schools. The new pupil “is more inclined to find fun and humor in all situations, with more compelling desires to be physically active and to live in the present, usually impatient with books and abstractions, and less likely to favor an intellectual, disciplinary, and decorative education . . .” (10:101)* Such a change in high school population implies a change in teaching procedures. According to Douglass “ . . . it is a subject worthy of experimentation to determine

*Numbers in parentheses refer to references in the Bibliography. The number following the colon indicates the page in the reference where the quotation or data may be found.
whether a more informal curriculum and teaching method may be more effective than the highly authoritative system so commonly employed in the schools today.” (10:76) Among the changes he suggests are the following:

Methods should involve more visual and concrete material, especially for those with less ability to deal with abstractions... Methods should allow liberally for opportunities to do, as well as to learn—construction, application, exemplification, illustration, expression of reactions. (10:102)

Curtis also mentions the need for “analyses for the purposes of determining a wide variety of profitable classroom, laboratory, and extra-classroom activities, devices, and practices distinct from teaching methods, with objective determination of the relative values of these.” (8)

Because biology is rich in material contributing toward an understanding of the principles that underlie good health and intelligent, happy living, there is a growing tendency to add it to the list of required subjects in high school. Biology teachers confronted with large classes of less academic students face new problems, among them: the need to overcome the antagonistic set that accompanies anything required of an individual and the need to adapt teaching procedures to a more heterogeneous group.

Teachers have expressed these needs significantly in replies to two recent questionnaires, one sent out by a magazine editor and the other by the authors at the time they were making this study. In November 1943 the editor of the *American Biology Teacher* invited readers to state their preference in regard to material they would like to have published in the journal. Out of nearly four hundred replies, 162 expressed preference for teaching techniques. In the Oregon questionnaire all teachers replying expressed a need for such information.

The plan of the present study was as follows:

1. A survey was made of professional textbooks dealing with methods of teaching science and biology. Only books published since 1920 were used.
2. Recently published high school textbooks, workbooks and laboratory manuals, and teachers' guides were reviewed for teaching aids.
3. Pamphlets and publications of supply houses were checked for suggestions to teachers.
4. Current periodicals were searched for contributions sent in by teachers describing successful teaching procedures.
5. A short questionnaire on the use of instructional procedures was sent to biology teachers in Oregon high schools employing twelve or more teachers.
Each teaching procedure given in this monograph was selected on the basis of the following criteria:

1. Does it challenge the interest of a majority of high-school sophomore boys and girls? Does it include a wide variety of sensory experiences, provide many opportunities for activity on the part of the learner, or possess an element of suspense, exploration, discovery, competition, or wonder? Is it an activity that teachers have found highly acceptable to high school students?

2. Does it provide for educational growth? Is the device used to develop skill, to provide opportunity for social contacts or for development of civic responsibilities, or to develop civic understanding, appreciations, attitudes, or good thinking? Unless the procedure results in growth of the pupil, its use cannot be justified.

3. Is it economical of both the teacher's and the pupil's time in attaining the goals of education? Is it economical in regard to expenditures and equipment? Since motion picture equipment is still unavailable in many schools, procedures involving use of motion pictures are not included in the present study.

4. Is it not to be found in professional manuals, textbooks, or other publications readily available to the average teacher?

Since a variety of procedures is essential for good teaching, the devices selected represent a cross section of those available for field trips, for visual aids other than motion pictures, and for such recreational activities as games, contests, listening activities, construction activities, and dramatizations. These procedures are not intended to be used as a substitute for an established pattern of teaching but rather as techniques that may be used for the purpose of stimulating further activity on the part of the student or for enriching, introducing, or reviewing a unit. A resourceful teacher will find no difficulty in adapting them to many situations and in developing others of a like nature.

FIELD TRIPS

If biology teachers agree with Kinsey (23) and others (34, 39, 47) that one of the most important objectives of biology is to interest the student in the world about him, acquainting him with the plant and animal forms and their behavior, then the most worth while and satisfying experience in which teacher and class can engage is the field trip. Field trips enable students to observe and to enjoy organisms in their natural surroundings. How much more fun to study living grasshoppers caught in the vacant lot across the street than to dissect preserved ones in the laboratory! Why rely on reading
about trees and flowers, conservation, or protective adaptations when living examples are but a short distance from the classroom?

In reviewing the findings of thirty writers on the use of the field trip in biology classes, Dexter (9) reports that at least half of the students enrolled in biology had had no class work in the field, that students would have found biology more interesting if outdoor classes had been held, and that modern museums are ahead of schools and colleges in directing the attention of visitors toward exhibitions of living materials. In Oregon, Stevenson (39) conducted a study of high-school biology field trips through members of classes in the Oregon Colleges of Education. Of the students who had taken high school biology about forty per cent had been on field trips.

Factors contributing to the inadequate use of field trips include: (1) too large classes, (2) the teacher's lack of experience with field trips, and (3) the feeling on the part of some teachers that successful field trips involve travel with its ensuing problems of transportation, expense, and encroachment upon the time of other classes. Yet a field trip to be successful need not go beyond the school grounds. Large classes may be divided into squads under the leadership of capable students, and all members may be given mimeographed instructions outlining interesting things to do. This section includes ideas for only a few field trips; they should suggest many others to the teacher.

Treasure Hunt

In the most popular treasure hunt, clues are placed at interesting points in the area to be covered. Well written directions give the student an opportunity to apply what he has learned, and the review is fun. For example, in studying flowers, each pair of students receives easy directions for finding a certain shrub. Pinned to the shrub they find a message something like this: "If the flowers on this plant are pistillate flowers, look for the shrubs at the north entrance to the gymnasium; if they are staminate, your next clue is on a branch of the tree at the north entrance to the auditorium." Arriving at the gymnasium entrance they find this clue: "If this plant is the male form of the one you have just seen, go to the yellow-blooming shrub across the court; if it is of a different species, go examine the pine tree in the parking lot." At the Scotch Broom is this statement: "If this flower is cross-pollinated, your next clue is in the laurels on the north lawn; if it is self-pollinated, cross the field to the willows by the tennis courts." At the end of the hunt the first pair to finish brings back a "winner's certificate." When a student makes a wrong decision and arrives at an alternate plant, he finds a note to that effect. The note also tells him how to recognize the flower he missed and directs him to start again.
Nature Trail

Student leaders, or the teacher, lay a trail to a common meeting place, which may be in the home room or in the vicinity of a natural oddity. The purpose is to acquaint the pupils with the plants enroute to the meeting. The leader uses 3" x 5" cards, upon which he gives the common name, scientific name, and uses of selected plants. The labels are affixed to the bole of the tree or shrub or placed in a split peg. At the bottom of each data card is placed an arrow and a distance note. The students sight along the arrow, go the prescribed distance, and there find another data card.

This is a yellow pine
Pinus ponderosa
It grows in the transitional
life zone and is one of the
principal lumber trees in Oregon.

35 paces

Where duplicate plants are used, the name, use, or some other fact may be deleted. The student, in a group or alone, is expected to fill in the blanks. A check is made at the meeting place to see which team has the greatest number of correct responses.

This type of field trip challenges the pupil, lends interest, and provides information. A final review may well be made of the nature trail by leaving many blanks. The specimen—leaf, twig, bark, etc.—may be brought into the room for the review check. By using Dennison tags or other all-weather materials (wood and plant, aluminum foil, etc.) a permanent nature trail may be set up in the city park or in some other public land for the use of visitors and those who wish to know common natural objects.

Scavenger Hunt

In another type of hunt groups of students receive a list of things to find such as two composite flowers, two trees that bear catkins, three flowers that are cross pollinated, etc. Such a hunt provides a valuable review. It also makes an interesting teaching lesson, if, for instance, each member of the class first picks a dandelion, discovers why it is a composite, and then goes to look for two more to be found in the same area. When most of the class has returned, they are then instructed regarding imperfect flowers. After studying some examples, they go out to find a given number of similar examples. A record of material brought in by each group makes it possible to determine the winner at the end of the period.
A Scavenger Chase for Review

As a review activity over a unit on "The Trees and Shrubs about Our School," one class devised the field activity for review and check on learning described herewith.

Four table groups, each consisting of five or six students, made a scavenger hunt list of 20 requests for different types of leaves, fruit, bark, and other objects, and facts about the campus plants. After each request there was a blank space into which the name most appropriate to the description was to be written. The lists were interchanged between table groups. Each was to collect the objects on its list and report back to a central meeting place within a time limit of twenty-five minutes. Since each list was different, each table group went a different way.

One of the lists follows and is illustrative of the other three:

Scavenger Hunt List
(Find, collect, and name the plant)

1. A parallel veined, bi-lobed leaf
2. Largest leaf that you may pull
3. A flower of Escalonia Montevidenis
4. Toughest leaf found on campus
5. Berry that grows in an umbel
6. A compound leaf
7. Small piece of fibrous red bark
8. Piece of bark used for medicinal purposes
9. Pine needles in bunches of three
10. A cone over six inches long
11. Leaf from the first tree named on the Pacific coast
12. Leaf used as a condiment
13. Leaf from tree that has at least three common names
14. What every girl wants to be (leaf)
15. Cone that hangs downward
16. An ubiquitous flower
17. Barb from a tree with a thorn one inch or more in length
18. Leaf of a tree important to the hosiery industry
19. Leaves from two trees having animals in their titles
20. Leaves from three plants named for countries outside of Europe

After the groups had found the specimens requested, they reconvened. Each checked its list and objects in the presence of the rest of the class. The group arriving first with the greatest number of right objects and responses was declared the winner.
Snatch the Bacon Adaptation for Review

After the "Scavenger Chase" the objects of the hunt were placed on the ground in a pile. The students were divided into two teams. Each team was numbered off consecutively, and was lined up parallel to and facing each other with the pile of objects between them and at least 25 feet away. A student leader called the name of one of the objects or indicated by a statement the nature of the object. Then he shouted a number. The players with that number rushed to the pile to find the object indicated. The player getting the object first and returning back to his line, without being tagged by the opposing player, made a point for his side. If the opponent tagged the player with the object before he got back to his safety line, the opposing side received the credit. This is an adaptation of the game called "Snatch the Bacon."

Two simple games were modified and used to provide a review and evaluation exercise. The list of requests in the "Scavenger Hunt" was intriguing; it involved recall and led to considerable thinking. Organization of knowledge and of group members was required. Competition within and between groups was a motivating factor. Review under such circumstances proved interesting; it was conducive to both direct and concomitant learning, and it enabled the teacher to evaluate the progress of his students and the effectiveness of his instruction.

Pictorial Field Trip

To use the pictorial field trip, prepare a mimeographed pictorial map of the region to be covered. Sketch interesting items in the margin of the paper and list "things to do" in the center or on the back. After the pupils have used such a direction sheet, they will enjoy making one of their own. Listed below are the directions which appeared on the back of one such map.

1. (Open field.) Mark off a square yard here. Count all the different plants and animals that you can find. Which plant seems to have crowded out most of the others? Why?

2. (At the tennis court.) Find out how the vines that you find here climb.

3. (At a mill creek.) Look for the "garbage collectors" of the streams. Are they facing up or down stream? Can you explain why?

4. (Oak grove.) Open several of the balls on the oak leaves. What do you find inside? Are they all alike?

5. (Oak grove.) Find three kinds of lichens growing on branches of the oak trees.

6. (Wood pile.) Examine the wood pile for cocoons, caterpillars, pill bugs, scorpions, and other animals.
7. (Rose bushes near outdoor fireplace.) Find three enemies on the rose bush. Look for the damage done by each.
8. (At various places along the route.) Collect protective adaptations.
9. (Under ash trees.) Gather here to report what you have found.

Map Making Field Trips

To locate unfavorable conditions that may endanger the health of the community, students are divided into groups, assigned to a block, and told to look for weed patches, open garbage containers, refuse piles, stagnant water, and outhouses. On returning to the classroom they locate unsanitary conditions with signal dots on a map of the community. (1)

A tree map of the community may be made by letting each group of students study the trees in a block. Once familiar with the trees on the school grounds, the student should know most of them, but may take along a tree key for consultation. As a last resort, if the guide fails them, they may sketch the leaf, note the leaf arrangement and other characteristics of the tree, and look it up the following day.

Making a map of a pond or lake calls for a study of ecological conditions and accurate observations. Students like to work in groups, some studying shore-line organisms, others shallow-water plants and animals, and some deep-water life. It may be necessary to make several trips to obtain all data on the condition of the water, the temperature of the water in different areas, and the condition of the bottom of the pond, as well as to collect and identify organisms.

Tree Trail

To help students become familiar with the trees on the school grounds, prepare a mimeographed direction sheet for a trip around the school grounds. Give the students the correct location of each tree, call attention to specific things to be observed, and if time permits tell them something interesting about the tree. Following are some of the directions for a trip that was taken in the fall of a recent year:

1. Leave the building by the stairway nearest the classroom. The tree just outside the entrance is a mountain ash. Examine the fruit, the leaves, and the trunk, and write here two ways you may recognize the tree in other places on the grounds.

2. Go out the walk toward the shop. The tree on the south side of the walk is a sugar maple. Does it bear fruit? What is the tree on the north side of the walk? When you go back to the classroom, find out why all maples are called Acer.
3. As you walk south along the drive the trees on your left are Lombardy poplars. What is their characteristic branch arrangement? Find two other places on the grounds where poplar trees grow.

4. There are two kinds of birch trees growing in the south court. Which one is cut-leaf birch? Describe interesting features of the bark of birch trees.

Tree Detectives

To gain practice in using a key, to review leaf forms, and to become familiar with the trees on the school grounds, the class is divided into squads of three or four each. The leader of each squad receives a card describing the location of a tree on the school grounds. The students then use a previously prepared key to trees and pursue each “clue.” When the identity of the tree is discovered the name is written on the card and returned to headquarters where another detective job is assigned. The squad identifying the most trees within the class period is the winner.

This activity is more fun when experienced outside but can be adapted for use inside. Twigs and flowers may be substituted for trees.

Exploring the School Grounds

A good field trip for the first week of school is one in which the class becomes an “exploring party.” The party is divided into groups, and each group is given the equipment necessary for collecting representative specimens of a specific habitat: the stream, the woods, or the open field. Those organisms which cannot be collected are noted in a record book. The groups return to the laboratory in time to place their living catch in a suitable habitat: aquaria, terraria, etc. The party having the largest number of organisms is considered the most “expert.” The following day the chairman of each group makes a report using the organisms as illustrative material. Mention is usually made in each report of the difficulty in catching or finding the animal life, and a discussion of adaptations of organisms follows.

Head the Line

This activity arouses interest in taxonomy. The students are arranged in single or double file. The leader halts frequently and asks the person in front to identify the object pointed out, which may be near or far. If this person fails, he goes to the end of the line and the second person has a turn. If the second person fails, he goes to the end and so on down until the correct answer is given. The one who remains at the front longest wins. Instruc-
tion is best given at the halts and is usually called for by the questions of the players. Correct answers may be drawn from the student by skillful questioning.

For example, the leader upon stopping and pointing at a bush, may ask its name. If the first student does not know he goes to the end of the line. The next player names the bush correctly as a barberry. The leader then says: "Did you know that the original blonde dye originated from the bark of this shrub? Vernon Quinn in his book on *Shrubs in the Garden and Their Legends* relates how the bark of the barberry was used in the Elizabethan days by the ladies of the court and elsewhere as a dye for blonde hair. Blondes were favored by the gentlemen at that time. The berries make excellent jelly. Furthermore, the drug, lycium, is made from the shrub and used as a medicine. Are there any questions?" A member might want to know why the shrub was called a barberry. The leader would call on someone who knew, or he might have to answer. In either case, the comment would be like this: "You can see the berries, and if you'll look at the stems you will see three pronged thorns or barbs. Put the two together and you have it."

Note that information of interest to all types of students is presented. Some one or more of the facts about the barberry will persist. No doubt the blonde dye, or jelly, will "stick" in the minds of most students. Knowing the common things about the plants on the school grounds or elsewhere makes them the students' friends.

Interesting instructional material for this trip may be obtained from Vernon Quinn's book *Shrubs in the Garden and Their Legends*. Should the teacher not be familiar with the names and data on common plants in the garden, it is suggested that the cooperation of the local nurseryman or other plant enthusiast be enlisted. Community resource use is commendable and is excellent for public relations.

**Matching Leaves**

The class is divided into two sides and is instructed as follows: "You will be given just one moment to gather as many different kinds of leaves as you can. Only one leaf may be taken from each plant. At the end of the minute each team will gather under the leadership of the captain of that side and there select one leaf of each different kind assembled by that side. All duplicates are discarded. Then each member will be handed one of the selected leaves in turn until that side's supply is exhausted. The side should name as many of the leaves as is possible. The teacher will help the side when it has exhausted its own resources. When this has been done the two sides will line up facing
each other. Each member of each side will then in turn, alternating between the sides, hold up a leaf and give its name if possible. If some member on the opposing team has a leaf that matches the declarer's, he must indicate it. A point is given to the side whose leaf is not matched by one from the opposite side. The side having the greatest number of points when all species of leaves have been shown wins.

I Saw

To summarize and review objects seen on field trips the students are arranged in a circle. The one who is to start is determined by lot. The starter names an object which he has observed and describes it briefly. The second player mentions that object and adds one observed by him with a brief description. Succeeding players mention these in order, adding a new one each time. Should any player omit a name or be unable to add a new object, he must pay a forfeit. This continues until all objects have been mentioned.

Prove It

As a variation of "I Saw" the students merely name the object, describing it only when challenged by another to prove it. If challenged one cannot, he pays a forfeit; if he can, the challenger pays a forfeit. (40)

Winter and Life

To find out how and where organisms survive the winter, students work in teams and investigate the following habitats:
1. Inside rotting logs.
2. Under shaggy bark of trees.
3. Inside galls on various kinds of plants.
4. Among decaying leaves on the ground.
5. In the top layer of soil.
6. In soil more than a foot down.
7. On water plants in a pond.
8. In the mud at the bottom of a pond or stream.
9. Walls of a cellar or cave.
10. In garages, barns, unheated buildings.

They compare the temperature of the various habitats, in the air, in the snow, in the soil, at various levels of pond water, on north and south sides of trees, and on north and south slopes. They compare readings for cold and warm days. Students will discover why earthworms migrate downwards, why surface insects seek refuge in soil, and why more organisms are found in some locations than in others. (50)
Other suggestions for winter field trips include the examination of a pail of frozen earth. Put this in warm water in the laboratory and watch for insects rising to the surface. (33)

Biology of the Stream

Trips to collect organisms may be used for an introduction to a study of adaptations or habitats. In quiet pools or backwaters look for algae, water cress, duckweed, Euglena, protozoa, hydra, rotifers, and water fleas. In a moderate current will be found planaria, hairworms, annelids, and crayfish. Spiders will be found on shore near the water's edge. Many stages of the life cycles of insects are present in the mud or shallow waters of quiet streams. Minnows, suckers, and sunfish are often seen in the stream while frogs, turtles, and snakes are found on the shore. Look for birds that build nests near streams and for such mammals as the muskrat and beaver.

Such physical factors of temperature, hardness, turbidity, concentration of minerals, oxygen content, acidity or alkalinity, depth, velocity, type of bottom, type of shore, and presence of obstructions in the stream should be measured and the effects noted in terms of their influences on plant and animal life.

Change in population should be noted during flood, drought, and winter. Observations regarding adaptations to aquatic conditions should be made.

In small streams an ecological succession may be started by constructing a small dam or submerging a log. (4)

Spring Field Trips

To observe the response of plants in springtime and to stimulate further observation of twig and leaf development, a spring field trip is worth while.

A walk around the school grounds will disclose on some of the bushes buds that are larger than on others, examples of the opposite and alternate mode of growth of buds, and of the old leaves protecting the new. Examples of thorns, fur, gum, and other means of protecting the buds, of the color of young twigs, and of catkins blooming on some of the trees may also be found. The following exhibits may be arranged as a result of the trip: (1) where buds grow; (2) how buds are protected; (3) what buds make such structures as blossoms, leaves, and stem; and (4) the color of young twigs. Ensuing activities might include a diary of the growth and development of twigs kept indoors compared with those outdoors, an exhibit of twig and leaf growth, and an exhibit of catkins. (21)

A somewhat different activity was suggested and carried out by a class at the end of a unit on behavior. The leader posted the blueprint of the
school grounds, told each student to select a tree and to observe its response to the spring conditions of light, warmth, and soil conditions. Wherever possible the students compared trees growing on the sunny side with those growing on the shady side of the building. Upon returning, some students expressed dissatisfaction with the chosen tree because the buds were still dormant. The class decided to observe five trees the following week and to continue this activity each week, keeping a diary of each tree.

Dandelion Adaptions Field Excursion

Instructional potentialities inherent in objects in the immediate environs may be illustrated by the following brief description of a campus trip to introduce a unit on adaptation. The teacher initiates the activity by stating, “Tomorrow we are going outside to study the adaptations of the dandelion. We shall play a game which will require information on this plant. You have the rest of the period and any other time you may have to discover all available facts on the dandelion. Each fact will give you a point and the one with the most points will win.”

At the next class meeting (which is out-of-doors) the teacher starts the activity by having the students run around the block. The first one back pointing out a dandelion will be first and get one point. Others line up in the order of arrival. The first player may start by stating how the dandelion gets its name. The edges of the leaves are deeply notched and sharp pointed so they resemble the teeth of a lion. The French called the plant dent-de-lion and we shortened this word to dandelion. The next player observes that no two leaves are alike; another that the leaf arrangement is a rosette. This makes possible maximal leaf surface exposure to the sunlight, which makes for good food manufacture and warmth. Both favor growth. The next player in turn declares the plant as one which blooms first in the spring and last in the fall, since it hugs the ground, getting the last heat and the first. Moving air only cools the top surface and is slowest near the ground.

And so the class continues until a few minutes before the end of the period. Some of the additional facts include the root and its adaptations, the stem architecture, the composite flower features, sleeping habits, how to produce dandelion curls, trombones, and how to determine years yet to live, other folklore, poems, articles, etc.

The treatment of each fact is illustrated. The dandelion seeds are covered with little barbs which enable them to cling fast wherever they chance to settle on the ground. The feathery parachute enables the seed to be carried by air currents. This umbrella-like structure is affected by the humidity so
that the seed falls in favorable situations for growth. A dandelion plant produces two mature seed heads a week, each head bearing more than 125 seeds. Since the plant is a perennial, it has possibilities of producing 12,000 seeds a year. Enormous numbers of seeds make it possible for this plant to "people the earth." It is found in all lands from sea level to mountain tops. The dandelion growers collect the heads of the plant and turn them into wine. They pluck the leaves and sell them for salads on the market. Several horticultural varieties have been developed that form large leafy plants. The roots are gathered and used for compounded medicines, such as laxatives, liver stimulants, etc. Besides the collecting of roots, leaves, and flower heads, the Oregon growers gather several thousand pounds of seeds annually to be shipped to the eastern markets for the manufacture of dyes.

CONTINUOUS STORY

A continuous story serves as an interesting review and summary of the contributions made during the period. Each person takes his turn in adding one pertinent fact to the subject under discussion until no other information is known. Students not able to give additional data pay a forfeit. To illustrate: the starting student may say, "The following are the tactics by which the dandelion has become so widespread and abundant: it blossoms and produces seeds from early spring to late fall." The next student adds, "It flourishes on all sorts of soils and thrusts its long taproots down into the soil and thus gets moisture and food not reached by other plants." Another student says, "Its leaves spread out from the base, crowding and shading out all neighboring plants." The story is continued until everything which had been learned during the period has been told.

Such is the way an introduction to a unit on adaptation may be started. Other common plants may be used. The teaching techniques are interesting and effective. The field-trip lesson is psychologically sound especially when ended with an overview-drill that knits the learnings into a whole.

FIELD STUDY IN ECOLOGICAL SUCCESSIONS

To determine what plants year after year invade, gain supremacy, or fail in a given area, select a plot of ground in a place which is likely to be untouched for a number of years. Mark it off and remove the top soil for a depth of one foot. This should be done in the spring for a fall study. Keep a geographical description of the area, observe the total species, and record accurately. Tabulate results carefully and predict what is likely to happen in the way of success or failure. (54)
SELECTED PROCEDURES IN TEACHING BIOLOGY

BIRD STUDY OUT-OF-DOORS

The classroom study of birds should be supplemented by some outdoor activities which help the student to build up an acquaintance with the resident and migratory birds of that area.

Besides being able to answer the question, "What bird is that?" the students should have their attention directed toward the following observations: What food is available for birds? What evidence can you find that birds are controlling insects? Which birds are found in the open woods? How are different birds adapted for their mode of feeding or flight?

In collecting bird nests in the fall it is well to select one of each type for exhibit, to compare the nesting in one area with another, and to compare the nests as to the type of trees used and the height of the nest above the ground. The identity of the nests may be determined by reference to the Stevenson Key. (41)

A survey of the food and shelter plants for birds about the school may be made. Weekly observations by class or by individuals during the migratory period make interesting data. (53)

BIRD GOLF

Bird field trips with the usual class are difficult because the noise and number of people frighten the birds. A procedure which eliminates the difficulty is to divide the class into foursomes or possibly sextets. Each set includes a student with intimate knowledge of the birds. Each set keeps a score card similar to the illustration below:

Time ........................................

Bird Scout ........................................
Players ........................................ Date ........................................
 ........................................ Place ........................................

Birds Identified (seen or heard and positively recognized)

Link One ........................................
1. ........................................ Score ........................................
2. ........................................ Time ........................................
3. ........................................

Link Two ........................................
1. ........................................
2. ........................................

Link Three, etc. ........................................ Total ........................................
Each set decides for itself when and where to start. Play begins with the first bird seen if counted. Each set goes a different way. Each link is ten or fifteen minutes in duration depending upon the length of class or field trip time. Overtime on any link must be deducted from the next link. Only birds recognized by two or more in any set count. Birds of a species or either bird of a pair recognized but sex not determined counts as a male bird. Birds identified count but once in the period. Male birds count one, female birds count three. Birds seen long enough for identification but not made out are indicated by numbers. This total may be counted as a handicap. Other rules or modifications may be worked out by the participants and mutually agreed upon.

Bird golf makes bird study intensely interesting. The small groups operate much more effectively, covering a greater territory and affording a maximum participation for all class members.

**Stump Scouting**

Stumps provide interesting material for an appreciation of the past history of trees. A questionnaire was given several groups of students. Each group was given an opportunity to observe the stump and make out its own report. The questions called for keen observation and interpretation of the data. Evidence and conclusions were discussed by the entire group later.

**A Museum Trip**

A trip to a museum was used to study the many adaptations of birds. Each member of the party was asked to look for what he considered the most interesting bird, to observe interesting adaptations of birds, and to count the number of species in the collection. When this was finished the group discussed each student's nomination for the "most interesting bird." (38)

**Community Health Survey**

An interest in community health problems may be aroused by making a study of the ways a community protects the health of its residents.

Each class committee chooses one of the following places to visit: a dairy, creamery, meat market, grocery, restaurant, bakery, slaughter house or meat packing company, beauty shop, the city health department, the Pure Food and Drug laboratory, or some other place that performs a service to the public. The day before the trip the committees meet to formulate questions for the interview and to make an appointment with the manager of the place to be visited. The students will want to find out something about the city, state, and federal laws regarding sanitation and the handling of food and how
these laws are enforced, how instruments are sterilized, what diseases might be transmitted if people are careless, and whether or not employees must have a health examination.

The day following the trip the chairman of each committee acts as a member of a panel which discusses the city water supply, food supply, sewage and garbage disposal, and facilities for caring for the sick. The class then decides what improvements might be made and what part each student as a citizen can play in bringing about the desired improvements.

**Legs and Whiskers**

The time enroute to the center of interest on a field excursion may be used profitably and in an interesting way. Also, many trip problems are avoided. The teacher may divide the class into two groups. Each side is to count the number of legs observed on its side of the street while going to the objective. Duplications may, or may not, be allowed. Each different species of organism with legs counts. The number of legs on a fly is six, on a man is two, on a spider eight and on a goat four. Added interest is gained if five points are given for organisms with whiskers. The goat would then be worth nine points. The side with the greatest number of points wins. Not only is such a walk entertaining but the students learn the salient characteristics of various forms of life. Such a trip may be used to introduce the study of the arthropoda.

**Plants and Animals**

Plants and Animals may be used as a variation of the legs and whisker procedure. The teacher who wishes to introduce, develop, or conclude a nutrition unit involving food origins might have the class visit a grocery. While there for a limited time, the class groups would list the groceries seen on the shelves and indicate whether their origin was plant or animal. Other points may be earned by adding the number of legs on any live animal witnessed in the store.

Experience has indicated that permission must be secured from the grocer to make such an inventory at a time when the customer load is lightest. He should be warned about possible embarrassment from the discovery of vermin. The students must be cautioned to avoid moving commodities. The leaders of the groups must be directed and responsible.

**Roadside Cribbage**

The class or teacher makes up a list of six to eight objects to be looked for enroute. A point value is attached to each, such as: each bird nest two points, each wild animal track three points, each male bird one point or two,
if recognized, each member of the composite plant family one point, etc. Only the person who observes the object first can score for his group or side. Sometimes one point is given to the observer and another to the namer. An umpire, usually the instructor, should be selected.

**Nature Pebbles**

Each student selects as counters ten, fifteen, or twenty-five pebbles. Better yet are leaves—they can't be thrown. The number must be uniform. The students then take turns asking questions about objects enroute, or the teacher assumes this task. Some of the questions might be: What is the name of that tall pyramidal evergreen ahead? What is the principal lumber use of this yellow pine? Where does that bird build its nest? What kind of clouds are those above us?

Each time a question is asked, all who know or think they know the answer, hold up their hands. The person asking the questions then gives the answer. All who have the right answer may toss a counter away. The one who gets rid of his counters first, or has the least number upon arrival at the objective, wins.

This activity stimulates keen observation and recognition of distant objects. Also, much science information is gained from the questions, answers, and discussion.

**Field Trip Suggestions by Kinsey**

Kinsey (22) in his *Field and Laboratory Manual in Biology* gives adequate directions for carrying out the following trips:

1. Introduction: one field period to discover and observe some interesting plants and animals.
2. Plant groups: a contest to identify groups of plants.
3. Genera: a field trip to gain a better understanding of genera by arranging leaves according to characteristics.
4. Animal groups: to discover and recognize groups.
5. Insect-collecting trip: to learn how to make an insect collection.
6. Woody plant organs: to observe how the organs of plants function under normal conditions.
7. Some physiological processes: to observe conditions that concern photosynthesis, nitrogen fixation, destructive metabolism, release of energy, and secretions.
8. Market foods: to observe the number, quantity, and methods of handling foods in our markets.
9. Commercial sources of foods: to observe ways in which food is prepared, preserved, or distributed. Profitable trips may be made to creamery, cannery, chicken farm, and other commercial sources of foods.

10. Good breeds and bad breeds: to observe the extent to which the principles of heredity are applied on our farms.

11. New breeds: a visit to a greenhouse, farm, or fair to observe recently introduced breeds of domesticated plants and animals.

12. Some plant adaptations: to observe adaptations by means of which the plant is protected, its growth furthered, and its seeds distributed.

13. Ecological relations: a visit to a park or weed patch to discover as many types of parasitic, symbiotic, social, economic, and scavenger relationships as possible.

14. Forest products: a trip to an industrial establishment that depends upon forest products for its raw materials.

15. Fly breeding places: to discover the possible breeding places of house flies in a given area.

16. Plant galls: a trip to the fields and scrub growth to observe the way in which normal plant tissues are modified by gall fungi and gall insects.

17. Midwinter plants and animals: a hike taken after a light snowfall to observe evidences of animal activities.

18. Mosquito breeding places: to make a survey of a small area for stray tin cans, buckets, mud puddles, or other possible breeding places.

19. Habitats: to observe some of the habitats of local plants and animals, and to note some of ecologic conditions of each habitat.

20. Plant sleep movements: a special trip to observe the positions of leaves at night.

21. Leaf mosaics: a study of the plants in the school yard to observe the positions of leaves and to note the cause of leaf mosaics.

22. Instincts of domesticated animals: a trip to a farm to observe and analyze some instinctive behaviors of domestic animals.

23. Ant nests: to observe some of the instinctive behavior of ants in their nest building, care of the young, slave making, etc.

24. Experiments with ants: to observe the behavior of ants under difficulties and their behavior toward stranger ants.

25. Bird behavior: to observe some habitats, and to study feeding, fight, song, and other behaviors.

26. Bird nests: a trip to the open country or to a city park to observe the number of birds that nest in a limited area.

27. Observation race: a trip to a familiar path or street to observe as many different kinds of plants and animals as possible.
28. A field survey contest: to determine the number of species in a limited area, and to test the student’s ability to make observations.

29. A discovery game: to test the student’s knowledge of, and ability to observe some one kind of plant.

30. Spring flowers: to observe the beauty and interesting biology of spring flowers.

Conservation Excursions

The booklet Conservation Excursions by Bathurst (2) devotes thirty-six pages to a table of field trips. The seventy-five excursions are distributed among the following topics: soil 8, water 8, flowers 7, trees 14, birds 10, fish 2, minerals 7, and history 19.

The table gives good directions for each trip telling where to go and what to see, what to do, and how to organize follow-up activities.

GAMES

Learning proceeds rapidly and easily in an atmosphere of informality and relaxation. Among the many ways of attaining this condition, games rank high with some teachers for they provide an opportunity for fun and laughter and a happier student-teacher relationship. Ormond (25) found that with laughter as an activating force pupils learned material thirty to forty per cent faster, retained it better, and were free from emotional blocking. Games provide an element of sport and competition so much enjoyed by boys and girls that drill ceases to be dull. Contests mean active participation, require quick thinking, develop good sportmanship, and contribute greatly toward the socialization of the students.

In urging teachers to use a variety of methods not only to keep the class interested but also to keep the teacher alive and interesting, Kinsey suggests: “It is well to acquire a repertory of competitive games for laboratory and field use.” (23:17) The games described below might serve as a nucleus for such a repertory. A resourceful teacher will be able to adapt them to many situations and to add new ones to the collection. Several activities described in the preceding chapter may be included in this section.

What Am I?

This game, an extremely popular one with high school pupils, may be used to review the characteristics of organisms, or it may be used to introduce a unit on animals or plants.

The teacher tells the class that he is going out of the room for a few minutes. While he is absent, the class under a leader is to decide upon an
organism which he is to represent. They are to review as many characteristics of the animal or plant as necessary for all to have a common understanding of the organism. Before he leaves the room, he may suggest some of the questions he will ask.

 Upon returning to the classroom the teacher will attempt to find out what he has been named by asking questions which can be answered by either "yes" or "no." If ascertaining his identity requires more than fifteen questions, the class wins; if less then fifteen questions, the teacher wins. If a pupil must answer "I don't know," the question does not count. In some cases the teacher may need to leave the room while the students look up the right answer. As an example: The teacher upon his return may ask if he belongs to the animal kingdom. If the answer is no, he may assume he is a plant. Other questions and possible answers follow:

 Am I a thallophyte? No.
 Am I a bryophyte? No.
 Am I a pteridophyte? No.
 Am I a monocotyledonous spermatophyte? No.
 Do I belong to the rosales (order)? Yes.
 Do I belong to the rosacea (family)? Yes.
 Do I belong to the rosa (genus)? No.
 Do I belong to the common fruit genus of the family? Yes.
 Have I a drupe seed? No.
 Do I have a pome fruit? Yes.
 Is my pit ribbed? Yes.
 Am I preserved? Yes.
 Am I a peach? Yes.

 As the teacher proceeds he may instruct the students upon vocabulary and other facts.

 Two students may be sent from the room at once, while the class decides upon them as the object. Upon their return they work together to determine what they are. Pairing students at first makes for less embarrassment and keeps the activity moving along.

 Instead of sending the students out of the room, have one student decide he is something and the rest of the class may ask the questions which may be answered by yes or no, or "I don't know." It is well for the student to let the umpire know his identity, so that he may help. This game may serve as an introduction, developmental or review activity. It is an excellent way of developing logical thinking.
Guess My Name

To introduce a unit on the classification of animals or plants, ask each pupil to write the numbers from eight to one in a column on a sheet of paper. The teacher then reads eight statements in descending order of difficulty about an animal. As he reads the first statement the pupil writes opposite the number eight the name of an animal to which he thinks the statement refers. He does the same for each of the following statements. Each student receives a score equal to the sum of the numbers opposite which the correct answer has been written. Should he be fortunate enough to answer correctly the first time and each succeeding time his score would be thirty-six.

Eight items which may be used to introduce a study on the human being follow:

8. There is an object in the room for which the raw materials cost about 98 cents.
7. Its length varies from five feet to six and one-half feet.
6. It weighs between 100 and 160 pounds.
5. It contains a pump.
4. It has an internal skeleton.
3. It contains approximately 300,000,000 tiny balloons.
2. It burns quantities of fuel every day.
1. There are 32 such objects in the room today.

Lingo

This vocabulary drill helps the pupil realize that a memorized definition of a word is not the equivalent of an adequate understanding of the term. The day before the game is to be played for the first time, give the pupils the following directions. (A little mystery about the whole procedure adds to the fun.)

1. Fold a piece of notebook paper lengthwise.
2. Now fold again in thirds; unfold.
3. Fold the paper crosswise, fold again in thirds; unfold.
4. Copy the thirty-six words from the board in the marked-off spaces. Copy them in any order.
5. Be sure you understand the meaning of each term tomorrow if you want to win this game.

The following day distribute colored squares of paper, or counters, to a circle of pupils. One of them starts the game by giving a "clue" or explanation of one of the words and covering it up on his paper. All students who think they know the word he has in mind cover it up on their paper. Con-
tinue around the circle, each student giving a clue to a word until one member has a complete row either horizontally or vertically and calls "Lingo." Before the winner is acknowledged all terms must be explained, subject to challenge by other class members. If all are acceptable, the game begins again. In succeeding games all clues to previously used words must be different. For variation the teacher gives all the clues, or a good student may volunteer to do so.

**Of What Are You Thinking?**

Review of a unit is looked forward to if it takes the form of a game. For this game the teacher chooses the name of a subject studied in the unit. In studying health it might be the name of a health hero, a method of preventing disease, or some other subject covered. When he announces he is ready the pupils try to determine the subject by asking direct questions which he can answer by "yes" or "no." After the teacher has answered about twenty of these questions, the game really begins. The first member of each team writes at the top of a sheet of paper the subject he thinks the teacher has in mind. He folds it down and passes it on to the next. In this manner the writing, folding, and passing continue until all have had a chance to guess. When the last member of the class has finished writing, the teacher announces his subject. The team that finishes first receives one point. Each correct answer counts one point. The team having the highest number of points wins.

(36:326)

**Testingo**

This game is also used as a review activity either to a lesson or to a unit plan. Have the students mark off 16, 25, 36, or 49 squares on a page, or fold the paper as described in Lingo above. Each square is to be numbered in any order. Each student then writes out one or two review questions. Each student then reads one of his questions and calls on any student who may, or may not, want to answer it. The class determines whether the question has been answered properly. If the answer is adequate all class members may cross out the square containing the number of the question. If the answer is incorrect or not complete the question is passed and the number of the question is not crossed out. After all 16, 25, 36, or 49 questions have been used, unanswered questions may be called in series again. The first student lucky enough to cross out all numbers or any vertical, horizontal or diagonal line of squares calls "Testingo" and of course is the winner.

**Vocabulary League**

To maintain interest in a weekly vocabulary review, let the class become a vocabulary league of five teams, and once each week hold a vocabulary
match. The leader of each team "pitches" words in turn to the member of the team "at bat" against his group. To advance the standing of his team during the week, each pupil may bring in any book or magazine with a list of the "contest words" and slips marking pages where these words occur, or he may bring in newspaper clippings with these words underlined. Each word reported on scores one point. Each poster with a drawing or cut-out picture accompanied by an appropriate legend containing one of the words counts five points. At the close of the contest a party is held in class for the winning team. (50)

**Who, Me?**

To review the life functions and characteristics of animals, divide the class into two sections or teams. Pass out two identical sets of animal names, one set to each team. Each team member draws one. The teacher then gives a series of characteristics of an animal and when a pupil recognizes them as a characteristic of the name he drew he stands and calls, "Who? Me?" The player scores one point for his side when he properly identifies himself.

**Bees**

The different types of "bees" described below make interesting review games.

1. **Question Bee.** The class divides into two teams and eliminations take place until a winner remains. Student leaders or the teacher ask the questions.

2. **Professor Quiz.** A pupil called "the professor" prepares a number of questions on individual sheets of paper and puts them in a box or hat. He calls for volunteers and each contestant selects a question which he hands to the professor to read aloud. Each answer is rated and the ratings tabulated on the blackboard. After a definite number of rounds the winner is selected.

3. **Baseball Bee.** Questions written on separate sheets of paper are divided into four groups according to their difficulty. The easiest receive the value of first base; the others are tagged second base, third base, and home run in order. Two teams of nine members each are chosen by captains, a diamond marked off on the blackboard, and a scorekeeper appointed. Each team has a chance to strike out three times before the side is retired. A strike occurs when a person fails to answer a question correctly.

4. **Football Bee.** In place of the baseball values given above a contest using football teams, a football field, and football scoring value may be substituted.
5. **Spelling Bee.** Normally spelling bees will be confined entirely to the spelling of biological terms. (15)

6. **Champ or Champ-nit Bee.** Pupils make questions or use natural objects for recognition. In the Champ-nit Bee, the class is divided into groups of six or eight. The leader of each group holds up an object for recognition. The first player to name the object steps out and displays the next object. This process is repeated until only one pupil remains in each group—the Champ-nit. Champ is a better variety of bee since all players are actively playing. The pupil recognizing the object or answering the questions first moves up one place nearer the head of the line. The one who remains at the head longest or is there when the period ends wins.

**Puzzles**

Pupils in a New York City high school originated the following types of review for their final week of work:

1. The class chairman called up the students during the period and instructed them to assume certain poses or positions or to perform various actions. The rest of the class attempted to guess the biological process or structure shown.

2. Simple sketches were outlined rapidly on the board and members of the class attempted to arrive at the correct name or term represented in each sketch.

3. Students brought into class elaborate drawings on large sheets of paper and held these up to the view of the class.

4. Crossword puzzles were used in the following ways: A stencil of the puzzle was cut and mimeographed and individual sheets distributed to the members of the class. The first one to hand in a correct solution won. The class was then shown the correct answers, and the various terms were reviewed. At other times the puzzle was ruled on the blackboard or drawn on a large sheet of cardboard which was held up for the class to view. When the definition was read the first student to guess the correct word was awarded a certain number of points. The student with the greatest number of points at the end of the game won. (15)

**Spotting**

To introduce a study of environmental relationships, place objects representative of a particular habitat on a table. Students are given a few minutes to observe them. Then they write down all that they can recall. In another column the characteristic or adaptation for that habitat may be recorded. (5)
Find the Spot

To review the study of adaptations of organisms to their environment, place a large outline map of the region on the bulletin board. Pictures of animals or plants being studied are drawn from a pile on the desk by students who pin them to appropriate places on the bulletin board. (5)

I Am

An unusual and interesting card game may be used to review the characteristics of organisms or to review important facts concerning scientists. Construct playing cards by mounting pictures of scientists or organisms or whatever is being studied on small pieces of cardboard. From four to six students sit at a table and place the shuffled cards in the center. A student draws a card, gives three distinguishing characteristics of the subject found on the card, and then keeps the card. He continues until he fails to give three characteristics. The student with the most cards at the end of the game wins. (5)

Twig Game

To learn to identify types of leaves, divide the group into sides. One side might be called opposites, the other alternates. Each member of the alternates is given a card with the name of a tree having leaves arranged in an alternate manner. Each player on the opposite side receives a card bearing the name of a tree having opposite leaves. Ten minutes are allowed in which to find the trees and to pin the card on them. The side which finishes first with the most trees correctly named wins. Each side may collect the tags of the other team as a check. Variations include leaf venation, simple and compound leaves, or annuals and perennials.

Characteristics

A card game, rather closely paralleling the old game of “Authors,” was prepared to teach the characteristics of gilled mushrooms. It may be adapted to teaching characteristics of other organisms.

The name of each of forty-nine selected genera of gilled mushrooms was written separately on a card with three to six descriptive characteristics, enough to distinguish the genus, listed beneath the genus name. A second set of cards, each one the size of ordinary playing cards, was prepared, and on each of the smaller cards one descriptive characteristic of a mushroom genus was printed. The genus cards are distributed equally among two to ten players. The “characteristic” cards are then shuffled and five are distributed to each player. The remaining “characteristic” cards are placed in a pile in the center of the table to be drawn from later.
The player looks at his genus cards and notes the number and kind of "characteristic" that he needs. Each player in turn may demand a characteristic card from any other player, and if his request cannot be honored the player draws a card from the top of the deck in the center of the table. A player may continue to call for the "characteristic" cards as long as he is lucky enough to obtain the card he wants by calling or drawing. When a player has all of the characteristics that are needed to identify a genus he has a "book." The value of any book depends upon the number of characteristics listed on the genus card. At the conclusion of the game the player with the most points wins. (26)

Nature Cards

Students may make their own cards or secure commercial ones. Goldfinch (birds), Larkspur (flowers), Chipmunk (mammals) and Monarch (butterflies and moths) may be secured from Angwin, California for $1.00 per deck. The cards are modeled after the game of "Authors." Four to six members of each family, or genera, constitute a set. Players take turns drawing. The one getting the greatest number of sets wins.

What Is It?

Place a different organism upon each desk. Students move from seat to seat at a signal given by the teacher, and each tries to identify the exhibit before him. He writes the name opposite the corresponding number on his paper. At the end of a given time the teacher reads a key list. The student having the largest number of items correct wins. Drawings, flowers, fungi, bird pictures, and leaves may be used.

Curio Collection

When it is necessary to take a long hike on a field trip, play a game like this: Divide the group into four units. While traveling along the trail, the leader names a curio and the players scatter to find it. The one who finds it first shouts; the others gather about and the discoverer scores for the group. The game continues with each new curio being named. Curios to be sought might include a conifer that sheds its needles, a broadleafed tree that has woody cones, a twig that grew a foot last year, a tree with lichens on the south side, a woodpecker's nest, or the nest of tent caterpillars. (42:167)

Blind Feeling

To introduce or review a lesson in natural objects ask the students to place their hands behind their backs. Put a natural object in the hands of each one. Each student may be allowed thirty seconds to feel the object in
his hands. At the end of this time he guesses the name of it. Some objects which may be used for this game are: seeds, leaves, fruits, evergreens, flowers, bark of trees, feathers, shells, or soils.

Variations of this game are Blind Testing and Blind Smelling. Materials useful for the sense of taste are rhubarb, sorrel, sugar, salt, peach, radish, cabbage, licorice, orange, and cucumber. For the sense of smell use mint, balsam, skunk cabbage, onion, tomato, rose, cedar, apple, mold, and cucumber. (41:102)

Reaction Time

To introduce a discussion of neurons, students and teacher join hands in a circle. The teacher starts a message around the circle by pressing the hand of the student on his right, at the same time starting the stop watch held in his left hand. As each student feels the pressure he passes it on to the student on his right. When the message arrives at the teacher he stops the watch and checks the number of seconds it took the message to complete the circuit. Try it several times to the right, then to the left. Try it using foot pressure instead of hand pressure and compare the time. It may also be varied by having circles of boys and girls competing against each other.

Pilot Tests

To develop a better understanding of the sense of balance try some of the following tests:

1. Blindfold a student, spin him around three times, and ask him to walk the chalk line drawn down the center of the room. Boys may compete against girls to see which can walk the farthest without straying off.

2. Have a student hold a cane in his right hand with the tip on the floor in front of him. Ask him to bend over, lay his forehead on his hand, and sidestep around the cane three times with his eyes closed. He should observe that his dizziness is quite different from that which results after whirling. (11:429)

3. Ask all members of the class to stand, close their eyes, and see if they can stand with one foot off the floor for fifteen seconds.

Spoon Tunes

The following devices help the student develop a better understanding of the sense of sound.

1. Ask each student to do the following: Tie a piece of string around a spoon so that the spoon is near the middle of the string. Wrap the free ends of the string around a finger of each hand. Swing the spoon until it hits a chair or the end of a table and listen for a slight ringing sound. Then, while
the spoon is still ringing, put the fingers around which the string is wrapped in your ears. Note the rich sound. (32:53)

2. Play part of a record and then remove the needle. Next have a student hold a common toothpick between his teeth and using it as a needle touch it lightly to the turning record. Report on how clearly the sound is heard. (32:53)

Peg It

To demonstrate an advantage of binocular vision arrange two pegs on a table about a yard apart and mark the midpoint of an imaginary line between them. Draw a second line at right angles to the first and place a third peg on it. Let the students work in pairs. One sits with his eyes at the level of the table and asks the second to move the third peg backward or forward in the direction shown in the diagram below until he thinks it is exactly on the line between A and B. Measure the mistake each time. Try it using only one eye. (32:124)

```
A * --- --- --- --- + --- --- --- --- * B

* C

Student
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Tree Tag

For a game to help the students become acquainted with the trees in a given area divide the class into two teams. Give each team twenty tags with the names of twenty trees common to that area. Let them have twenty minutes to pin the tags five feet from the ground on the south side of the tree named. No tree is to have more than one tag on it. All trees correctly named count one point. As a check each team collects the tags posted by the opposite side.

One Hundred Dollars

To review a unit get the individual attention of each pupil by giving each of them ten squares of paper, each representing ten dollars. Thus each pupil would have one hundred dollars. Ten sentences about whatever you happen to be studying are written on the board by an equal number of pupils. As the board material is discussed one unit at a time the students are required to agree or disagree with the statement on the board. If the sentence is correct those who disagree give up ten dollars; if incorrect all who agree give up ten dollars. (19)

Electrical Chart

The uses to which an electric chart can be put are unlimited. It may be used by individuals to learn the names of flowers, birds, trees, or mammals, or to review the names of scientists, biological principles, or organs and their functions. It may be used as a contest device with one team pointing out the questions, the other finding the answers. It is often used as a project by individual students who make and replace sets of pictures and answers weekly. With the subject always changing it never ceases to be an interest center in the room.

The materials needed for a chart are: one piece of wallboard three by four feet, one pound of copper wire, two contact points for each picture on the chart (one-inch paper fasteners or brass-headed tacks may be used for this), two pointers similar to blackboard pointers, a flashlight, and a set of pictures and labels or questions and answers.

Space the contact points far enough apart so that a picture may be tacked above each point on one side of the board, a label tacked above each point on the other side of the board. The flashlight should be between the two sides and near the top of the board. A picture contact must be connected with a name contact by a piece of bell wire on the back of the board. Electrical connections are made with the flashlight in such a way that when one pointer
is put on a picture contact and the other placed on the correct name contact the lamp lights.

Complete directions for making this chart will be found in Science Guide for Elementary Schools. (35)

DRAMATIZATIONS

Among the recreational techniques that might be used to greater advantage are dramatizations. The elements of the drama—suspense, conflict, action, and dialogue—are interest holding. Plays are an excellent device for giving a measure of reality to other times, persons, or places. In biology the lives of scientists and scientific discoveries lend themselves well to drama, impersonations, or dialogue. Plays also provide a means of organizing material. Ideally, students write and produce the classroom dramas. If properties and costumes are kept at a minimum, the new understandings and appreciations gained by the students warrant the time spent on the production. This section lists some available dramatic material which may be adapted to high school biology classes.

PLAYS

Most of the following plays have been written and produced by students as a result of some interest or need. They provide good suggestions for other classes wanting to write and produce their own plays, or they may serve as ready-made plays for those who do not have the time to write their own.

1. A Scientific Tableau. A play concerning the Herschell family, the Curies, and the Wright Brothers. (18)
2. Convincing Harold. A play written about the sewage disposal problems of Detroit. An example of the way oral reports may be worked into a play. (6)
3. The Advancement of Medical Science Through the Ages. Consists of four parts, each a separate tableau or play. (20:222)
4. A Lesson in Forest Conservation. A puppet play having four scenes, and requiring four puppets. (20:223)
5. Food for Thought. A one-act play about how plants get their food and what it means to us.

The following plays are reprints that may be obtained from School Science and Mathematics.*

1. The King of Plants. 25¢
2. Youth Looks at Cancer. 25¢
3. An English Christmas Tree. A conservation play. 25¢

* See Appendix.
The following original plays were presented during review week by a New York high school class.

1. **The Digestive System Goes on a Strike.** A sketch which portrays the dream of a little boy who has gone to sleep with a bad stomach ache. In his dream he sees and hears the various organs of his digestive system arguing among themselves. They are discussing the advisability of calling a strike against their employer. The organs cite their grievances such as irregular hours, mushy sweets, and the lack of good substantial nutrients they need. The boy awakens just as they are about to call the strike.

2. **March of Science.** This may be given as a radio broadcast by having each student read his part of the script showing developments in biological science. If given as a play, a comparison of the crude surgery of the past with the modern methods of today is effective. Blood-letting in the barber shop may be contrasted with our modern use of instruments and anesthesia.

3. **Jury Trial: The State versus Dr. Jones.** Dr. Jones is a prominent physician who tries out a new serum on a dying patient. The patient dies and the wife sues. Attorney for the defense cites many instances wherein great scientific discoveries had been made possible through experimentation on lower animals and subsequent application to human beings. (15)

**Dramatic Biology During Review**

The following dramatizations were devised by students for a review.

1. **The Reincarnation of Aristotle.** The members of the class were changed into ancient Greeks and had the honor of listening to the new theory proposed by an esteemed contemporary, Aristotle. A volunteer gave a forceful proof of spontaneous generation.

2. **Trial of Insects.** The classroom was the courtroom, the class the jury, and the teacher was the judge. The jury was told that the entire insect world was to be brought up on charges and that the decision would be "Guilty" with a verdict for all insects, or, "Acquittal," in which case all would go free. An Attorney for the Defense and Prosecuting Attorney were chosen and witnesses were called to the stand—Farmer Brown, a grasshopper, a clothes moth, and others. Attorneys, of course, attempted to confuse the witnesses in the approved manner. The case was summed up and the jury was asked to retire to consider its verdict. (28)

**Halloween Party**

The ghosts of famous biologists meet for a banquet. Each student impersonates a famous scientist and must be prepared to relate some inter-
testing anecdote regarding his life or discoveries. Each guest at the banquet is responsible for introducing the scientist on his right. Students bring cookies and punch or some other refreshment to eat while enjoying the recollections of other scientists.

**Radio Script**

The following radio scripts suitable for use in biology classes may be borrowed from the Educational Radio Script and Transcription Exchange.*

851 *Trees* (15 min. Narr., 2m, 1 boy, 1 girl). Stresses the importance of conservation.

852 *Apples in the Orchard* (15 min. Narr., 8m, 1f, 4 children). A charming script of the legend of Johnny Appleseed.

124 *Contributions in Science* (Ann., 2 Narr., Reader, 26m, 5f). A thirty minute program which is a panorama of American achievements in agriculture, medicine, exploration, and physics.

732 *Women in Medicine* (30 min., Ann., 3 Narr., 11m, 16f, 1 boy).

734 *Women in Nursing* (30 min., Ann., 3 Narr., 8m, 11f, 5 girls, 2 boys, voices).

736 *Women in Science* (30 min., Ann., 3 Narr., 11 m, 3 f, 1 girl, 1 boy, voices).

130 *George Washington, the Farmer* (15 min., Ann., 10m, 5f). George Washington discusses with his neighbors such problems as soil erosion, rotation of crops, soil fertility, and disinfection of seeds.

856 *The Conquest of Fate* (30 min., Narr., 3m, 3f). This script portrays the absorbing story of the personal and family life of Edward Livingston Trudeau so inextricably involved with tuberculosis.

778 *Story of Vitamins* (30 min., Ann., 29m). A dramatization about the men who discovered and developed the great medical weapon, vitamins. The use of vitamins in combating the four diseases, scurvy, beriberi, pellagra, and rickets is discussed.

779 *Mary Meets the Vitamins* (15 min., If, 7 boys, 1 girl). A radio script dramatizing the role of vitamins in promoting vigorous health and growth; suitable for young audiences.

867 *Moth Control in Wartime* (15 min., 7m, 4f). The secrets of the deadly mischief performed by moths on woolens, furs, and feathers are revealed in a dramatization between two moths. This script is “dated” in such a way as to make it unsuitable for broadcasting but furnishes excellent script material for adaptation.

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*See Appendix.*
Epoch Discoveries of the Past. A volume of six scripts for radio plays of a scientific nature.

1. The Scientist Spallanzani.
2. Eli Whitney and the Cotton Gin.
4. The Romance of Radium.
5. The Glass Heart.

Each year the National Tuberculosis Association sends out short radio plays which are used for publicity during National Tuberculosis week. These may be obtained from the local health office.

Dramatization Starts It

One teacher used the following procedure to introduce a unit on the ductless glands. He selected four students to act as applicants for a position. He was the interviewer. The applicants were interviewed one at a time. The tall oversized boy was too large and slow. The tall, slender nervous boy could not stand the pressure. The short, chubby girl was given the position. She had never been "fired." The others had for the reasons indicated above. The instructor amplified these deficiencies in the interview. After the selection had been made, the teacher asked the class for the best explanation for the selection and rejection of applicants. Gland deficiency or over activity was suggested. This led to a supervised reading period and the class was well on the way into an intense study of endocrine glands.

VISUAL AIDS

Probably the oldest of all supplementary devices and the most widely used today are the visual aids. Next to the actual specimen itself they are the most effective. Most teachers recognize the fact that one picture is worth pages of print, and that the opportunity to see and handle an object gives reality to words. The term visual aid is comprehensive. It often includes pictures, objects, specimens, models, graphs, charts, the blackboard, the bulletin board, field trips, motion pictures, slides, and strip films. In this monograph, field trips have been considered in a separate section because they are so extremely important in biology. Motion pictures have not been included in this study because many high schools are not equipped to show them. This section contains a few of the ways in which teachers have made use of visual aids such as the blackboard, the bulletin board, and exhibits.
**What’s Wrong with This Picture?**

To introduce a study of habitats draw on the blackboard a nature relationship scene such as a typical marsh, field, or forest in which there are a number of errors in relationships. Students are divided into groups and all are given one minute to observe the scene. At the end of the time each group lists the errors. The group detecting the greatest number of errors wins. (41:186)

**What Happened Here?**

In the dust, on the mud flats, on sandy beaches, or in the snow may be found tracks and other telltale evidence of life activities. The shape, pattern and arrangement of tracks reveal the kind of animal and what it was doing. Often stories both tragic and humorous may be told by the tracks. A unit or lesson plan on adaptations can easily be introduced through observation of such animal writing. The story of tracks can be reproduced on the blackboard.

**The Do-You-Know Quiz Book**

This is an excellent way to arouse curiosity about nature subjects. A book made of two pieces of wood is hinged together and captioned “Do you Know?” It is hung in a conspicuous place. On the front is a place to insert the question card between two strips of wood; inside is a place for the answer card. Use interesting questions such as “Do you know what insect *buries the dead*, covering the dead body with earth and using it as a storehouse for future meals?” Change the questions daily or let students contribute questions and answers. A more complete description of this device will be found in a leaflet obtained from the National Recreation Association.*

**The What-Is-It Shelf**

Set aside a shelf labeled “What is it?” On it place unidentified finds until someone discovers their names. Here, too, put objects which you wish to call to the attention of the class. Give credit for proper identification. (27:37)

**Root Hairs Via the Test Tube**

To provide root hairs that can be studied without being destroyed by air currents, grow seeds in test tubes. Corn kernels may be soaked and placed on watersoaked paper towel for germinating. Place them in a large flower-pot saucer and invert a second saucer over it to prevent moisture from escaping. Test tube mounts are prepared by cutting strips of cardboard so that

*See Appendix.
they will easily slide into the tubes. Provide for one-eighth inch on either side for expansion when the strip becomes saturated. The strip should be one inch shorter than the test tube to provide room for a cotton plug. As soon as the process of germination has started, pin the kernels singly to the strips by placing the pin to the side of the embryo. Slide the strip into the test tube. Pour about one inch column of water into the tube. Cotton plug may be used if root hairs do not develop satisfactorily. Observe the daily rate of seedling growth, root-hair development, location of root hairs, appearance of different sections of root, and the areas of lateral root origin. (31)

**Pollen Tube Growth**

In order to illustrate pollen tube growth and the chemotropic movements of pollen tubes to the students use a number of pollen grains from an available plant. Place a drop of specially prepared solution on a glass slide. This solution is made up of one gram of gelatine, four to five grams of cane sugar, and fifty cubic centimeters of distilled water warmed until the solution is homogeneous. Add pollen to the drop of the solution. Cover with a cover glass. Keep it in a moist chamber at about eighteen degrees Centigrade and examine eight or ten hours later. The pollen tubes will point toward the center of the preparation or away from contact with the air. Make a second preparation and treat as above, but seal the edges of the cover glass with vaseline to make it air tight. The germinating pollen tubes will grow in all directions.

**Soil Conservation**

To guide the students toward a better understanding of the problems of conservation arrange the following exhibit.

Provide seven funnels equal in size. Put a different type of soil in each one: leaf mold, subsoil, rich top soil, barren top soil, dry leaves, sand, gravel. Be sure the soil is dry. Arrange a glass below each funnel. Pour equal quantities of water into each funnel and after a given time measure the amount of water that has run through. (1:217)

**Invertebrate Animals**

As the follow-up study of invertebrate classification scatter about forty or fifty specimens about the laboratory tables. Number them but cover all labels. Give the students a laboratory sheet giving the invertebrate phyla, a few of the most important classes, and the characteristics of all phyla and classes. Provide a space for recording the number, the common name, and the most important characteristics of each specimen. This procedure "results in a scene of scholastic activity that is pleasant to behold." (14)
SELECTED PROCEDURES IN TEACHING BIOLOGY

Science on Display

Arrange interesting displays at regular intervals on bulletin board, shelves, tables, cabinets, or in regular glass display cases. Some displays which might be used are:

1. Believe It or Not. As an example place a sign by a tomato: This is a berry.

2. Biology’s Tool—for exploring into the world of things too small to see—the microscope. Display all types of microscopes, what may be seen, and pictures of the first scientists to use them.

3. Bugs and How to Kill ’Em. Large colored pictures of insect pests obtained from advertisements of a spray company are mounted on cardboard. Samples of stomach poisons and contact poisons are shown along with pictures or exhibits of methods of applying them. A toy airplane, a spray gun, or a bellows are among those that might be shown.

4. Seasonal Exhibits. The Easter lily, facts about the lily, its growth habits, propagation, and its close relatives may be displayed. At Christmas time a showing of “Native Shrubs for Christmas Cheer” is effective. When the state flower is in bloom it may be used for an educational display.

5. Series of Exhibits on Some One Subject. A series on “Health”, “How to Make,” or “The Parade of the Animal Kingdom” provides effective teaching material.

6. The Truth About Patent Medicines. A display of empty bottles, cartons, and advertisements on these medicasters is educational. (24)

Calendars

Many interesting kinds of calendars may be posted throughout the year.

1. Clock Calendar. Construct a poster resembling the face of a clock with months instead of hours. Place in the proper place pictures of birds seen during the month. (43)

2. Migration of Birds Calendar. Keep a daily watch of migratory birds in order to get the peak of migration. Record the number of birds seen each date, where they were, and what they were eating. (44)

3. Wild Flowers. Make a chart showing the date, common name of the flower, flower family, habitat, and name of finder. Whenever a student brings in the first wild flower of a certain kind it is his privilege to record it on the calendar. A contest between classes is an added stimulus. The calendar may also be compared with one made in a previous year.

4. Spring Buds. There is such a variation in the time the leaves come out that some students are interested in keeping a calendar of tree buds recording the date when the first green shows.
A Calendar of the Birthdays of Scientists

To commemorate the birthdays of scientists the bulletin board may be used in the following ways.

1. An attractive reproduction of the calendar or a part of the calendar may be placed in the center of the bulletin board and ribbons run from the names of the men studied in a particular unit to pictures depicting some events associated with the scientists.

2. "Ask Me Another" is a calendar surrounded with cards bearing questions related to the key scientists of the unit.

3. The calendar may be used to assist the teacher in the selection of men whose work is to be emphasized in a particular display. The teacher of biology may wish to show something of the history of the microscope during October and could select the name of Anton van Leeuwenhoek around which to center the bulletin-board display during the week of October twenty-fourth.

4. Surround the calendar with pictures of the scientists whose work will be discussed during the month.

Following is a list of birthdays of scientists that are of interest to biology students. Many other birthdays of scientists are listed by Teller (46, 47) in a series of articles in School Science and Mathematics.

<table>
<thead>
<tr>
<th>Month</th>
<th>Day</th>
<th>Year</th>
<th>Name</th>
<th>Birthplace</th>
</tr>
</thead>
<tbody>
<tr>
<td>September</td>
<td>13</td>
<td>1851</td>
<td>Walter Reed</td>
<td>Glouster County, Virginia</td>
</tr>
<tr>
<td>September</td>
<td>14</td>
<td>1849</td>
<td>Ivan Pavlov</td>
<td>Ryazan, Russia</td>
</tr>
<tr>
<td>October</td>
<td>24</td>
<td>1833</td>
<td>Alfred Nobel</td>
<td>Stockholm, Sweden</td>
</tr>
<tr>
<td>October</td>
<td>24</td>
<td>1632</td>
<td>Anton van Leeuwenhoek</td>
<td>Delft, Holland</td>
</tr>
<tr>
<td>November</td>
<td>7</td>
<td>1867</td>
<td>Marie Curie</td>
<td>Warsaw, Poland</td>
</tr>
<tr>
<td>November</td>
<td>14</td>
<td>1891</td>
<td>Frederick Banting</td>
<td>Alliston, Ontario</td>
</tr>
<tr>
<td>December</td>
<td>11</td>
<td>1843</td>
<td>Robert Koch</td>
<td>Klausthal, Germany</td>
</tr>
<tr>
<td>December</td>
<td>21</td>
<td>1823</td>
<td>Jean Henri Fabre</td>
<td>Aveyron, France</td>
</tr>
<tr>
<td>December</td>
<td>25</td>
<td>1842</td>
<td>Sir Isaac Newton</td>
<td>Woolsthorpe, England</td>
</tr>
<tr>
<td>January</td>
<td>10</td>
<td>1729</td>
<td>Lazaro Spallanzani</td>
<td>Scandiano, Modena, Italy</td>
</tr>
<tr>
<td>January</td>
<td>17</td>
<td>1706</td>
<td>Benjamin Franklin</td>
<td>Boston, Massachusetts</td>
</tr>
<tr>
<td>February</td>
<td>11</td>
<td>1847</td>
<td>Thomas A. Edison</td>
<td>Milan, Ohio</td>
</tr>
<tr>
<td>February</td>
<td>12</td>
<td>1809</td>
<td>Charles R. Darwin</td>
<td>Shrewsbury, England</td>
</tr>
<tr>
<td>February</td>
<td>15</td>
<td>1564</td>
<td>Galileo Galilei</td>
<td>Pisa, Italy</td>
</tr>
<tr>
<td>February</td>
<td>16</td>
<td>1848</td>
<td>Hugo De Vries</td>
<td>Haarlem, Holland</td>
</tr>
<tr>
<td>March</td>
<td>7</td>
<td>1849</td>
<td>Luther Burbank</td>
<td>Lancaster, Massachusetts</td>
</tr>
<tr>
<td>March</td>
<td>10</td>
<td>1628</td>
<td>Marcello Malpighi</td>
<td>Crevalcoro, Italy</td>
</tr>
<tr>
<td>March</td>
<td>14</td>
<td>1854</td>
<td>Paul Ehrlich</td>
<td>Strehlen, Silesia</td>
</tr>
<tr>
<td>April</td>
<td>5</td>
<td>1827</td>
<td>Joseph Lister</td>
<td>Upton Essex, England</td>
</tr>
<tr>
<td>April</td>
<td>26</td>
<td>1780</td>
<td>John James Audubon</td>
<td>Santo Domingo</td>
</tr>
<tr>
<td>May</td>
<td>4</td>
<td>1825</td>
<td>Thomas Henry Huxley</td>
<td>Ealing, England</td>
</tr>
<tr>
<td>May</td>
<td>17</td>
<td>1749</td>
<td>Edward Jenner</td>
<td>Berkeley, Gloucestershire, England</td>
</tr>
<tr>
<td>May</td>
<td>20</td>
<td>1807</td>
<td>Jean Louis Agassiz</td>
<td>Lake Morat, Switzerland</td>
</tr>
</tbody>
</table>
“Picture Shows”

Interesting picture shows may be presented by using a baloptican or a slide projector.

1. The Life and Love of Imogene Anopheles. In Nature Magazine for May 1944 is a picture story of the malaria-carrying mosquito. Obtain two copies, cut and paste the pictures in order on a roll of paper, and pull through the opaque projector a picture at a time. Similar stories may be drawn and presented by students.

2. Murder Mystery. On etched glass make a sketch of animal tracks in the snow showing signs of a struggle and bloodshed. Print “Whodunit” at the top of a second slide and under it print the following questions: Who was the villain? Who was the victim? Who were the witnesses? Draw as many slides as needed of the feet and mouth parts of animals that might have been present at the time of the crime. Show these pictures in the order given above and let the students try to unravel the mystery.

Bulletin Board Cut-outs

To vary the use of the bulletin board try some of the following ways:

1. Cut pieces of flower parts out of colored paper, arrange and fasten to the bulletin board to represent a generalized flower. These may later be rearranged by students to represent imperfect flowers, incomplete flowers, adaptations for pollinations, or other phases of the study.

2. Cut out strips of colored paper to represent chromosomes. Pin these to a poster on which a large cell has been drawn. Demonstrate reduction division by rearranging the chromosomes.

3. To demonstrate mitosis the paper chromosome may be replaced by two-strand yarn which may then be split to represent the splitting of the chromosomes.

Preview of Biology

To provide the student with an interesting and active introduction to biology while the teacher is occupied with the registration of the class on the first day of school arrange the room like a “Science Fair.” Invite the students to explore the biology room, to examine carefully anything of interest to them, and to be ready to report to the class the next day on interesting discoveries.

On the tables and bulletin boards about the room arrange some of the following exhibits. These will vary with the location of the school, the equipment available, and the time of the year. These exhibits may be set up during the year rather than on the preview day alone.
this subject will be found in “Previews of Biology” by E. Irene Hollenbeck, *The American Biology Teacher*, May 1945.

Do You Agree?

On this table display believe-it-or-nots such as the following:

<table>
<thead>
<tr>
<th>DISPLAY</th>
<th>ACCOMPANYING STATEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Tomato on a plate</td>
<td>a. The tomato is a fruit.</td>
</tr>
<tr>
<td>b. Banana</td>
<td>b. The banana is a berry.</td>
</tr>
<tr>
<td>c. Two similar bowls of flowers; aspirin</td>
<td>c. Aspirin helps make flowers stay fresh.</td>
</tr>
<tr>
<td>d. Eggs (insects, chicken, other available)</td>
<td>d. Eggs breathe. (Can you prove it?)</td>
</tr>
<tr>
<td>e. Various kinds of seedy fruits; an appendix</td>
<td>e. Appendicitis is often caused by seeds lodging in the appendix.</td>
</tr>
<tr>
<td>f. Horned toad</td>
<td>f. The horned toad is not a toad.</td>
</tr>
<tr>
<td>g. Corn worm</td>
<td>g. This is a young moth.</td>
</tr>
</tbody>
</table>

Biology and Your Future

On a bulletin board post large pictures of people in various occupations. Connect these by means of colored ribbon to materials associated with that occupation which are on display on a table below. It is also helpful to place near each exhibit cards bearing stimulating questions or suggesting things to do or observe in connection with the display.

1. Artist. Display commercial art work making use of biological designs (greeting cards, wall paper, Disney insignia for the air corps) ; Photographs hand-colored; decorative textiles having biological designs.

2. Aviator. Display the book *Biology of Flight* by F. L. Fitzpatrick (Macmillan, 1942) and any of the manuals regarding fauna and flora of various regions in which pilots might be forced down.


4. Doctor. Set up a microscope with some easily observed specimens. Have a former student on hand to answer questions or assist in its use. *Doctors at Work* by Alice Keliher (Harper, 1941) and *Test Tubes and Dragon Scales* by George C. Basil and Elizabeth Lewis (Winston, 1941) are two of many good books which may be displayed.
5. **Entomologist.** Exhibit insect cases with instructions to the students to count the number of flies in the mount, find the fly that mimics a bee, find the tachina fly which was imported to kill the earwigs, etc.

6. **Farmer.** Exhibit local products of inferior and superior quality with the accompanying question: What knowledge of biology helps the farmer produce the superior quality?

7. **Forest Ranger.** Seedling trees, tree posters, and the books *Green Kingdom, The Way of Life of a Forest Ranger* by W. A. Du Puy (Row, 1941) and *Forest Trees of the Pacific Slope* by W. A. Eliot (Putnam, 1938) attract the boys interested in forestry.

8. **Housewife.** Display government charts on nutrition, exhibits of mold, damage done by clothes moth, or other household pests.

9. **Gardener or Florist.** Display seeds, cuttings, and bulbs of interesting plants with an invitation to start the schoolroom garden. Girls are also attracted by unique flower arrangements.

**Biology and You**

1. **Your Health.** Post on the bulletin board student-made colored posters dealing with health. Exhibit a map showing a student-made sanitary survey of the community health problems.

2. **Your Leisure Time.** Display campcraft equipment (a tin can stove, for example); projects made by previous classes (collections, models, maps, posters); empty aquaria, terraria, ant nests, animal cages, and a few of the materials and animals that belong in them with suggestions as to how and what to collect to complete them.

3. **Reading.** Arrange a display of interesting travel and science books and magazines opened to dramatic stories or pictures. Book reports of former students who have recommended the books for a permanent reading list may be displayed also.

**Things to Do**

1. **Run the Projector.** In one corner of the room set up a projector and a selection of student-made slides which tell a story.

2. **Play a Game.** Locate a game device such as an electric chart in an uncrowded corner of the room so that a number of students may assemble around it.

3. **Look Through the Microscope.** Set up a microscope showing some of the larger animals to be found in pond water. If possible have a former student present to assist.
4. **What Is It?** Arrange a number of interesting specimens such as cocoons, a water tiger, a shark's egg, and a skull on a shelf or table and direct the students to answers posted elsewhere.

5. **What's Wrong With This Picture?** Draw on the blackboard or post on a bulletin board several pictures such as a hawk with the wrong kind of toes, a group of polar bears against a dark background, or a Darwinian insect with the head of a bee or a butterfly. Have slips of paper handy so that the students may write their answers out and place them in a ballot box below the pictures.

6. **What Can You Make?** Provide modeling clay, etched glass slides, and colored pencils for those who would like to try out this activity.

7. **Can You Figure This Out?** Place an interesting model out where students can examine it. Questions concerning the model may be written on one side of a card and the answers may be written on the back.

**CONSTRUCTION ACTIVITIES**

Rare is the person who does not feel the urge to make something when materials for its construction are suggestively within reach. Rare, too, is the teacher who makes use of this type of procedure to its fullest extent. Yet, more and more emphasis is being placed on the importance of the construction activities in the learning process for "... understandings are best developed when pupils have the opportunities to engage in a variety of experiences which may include much manipulation and construction." (55:84)

Such teaching requires cooperative planning, and unlimited and stimulating suggestions from an enthusiastic teacher.

Most construction activities are projects. A project is a large unit of work or undertaking of a lifelike nature planned and carried to completion by the students. Some problem, usually the doing or making of something, is attacked as a whole. The construction activities presented in this section, however, are of a different nature since they are devices used by a teacher to stimulate interest in the introduction, development, or conclusion of a unit.

**Matchbox Mitosis**

To help the students develop an understanding of mitosis provide a matchbox, scissors, cellophane, and a sheet of blank paper for each two students. Have the students cut eight strips of paper to represent chromosomes, roll them loosely in a ball, and wrap cellophane around them. Let this ball represent the nucleus at rest. Place it in the center of the inner part of the matchbox, which represents a cell with the top cell wall removed.
Now let the students do the following:

1. Remove the cellophane, unroll the eight strips of paper, cut each strip in half lengthwise, and place half of each strip in one pile and the other half in another pile.

2. Wrap in cellophane the eight halves of paper strips from one pile. Do the same for the other pile.

3. Place the two balls in opposite ends of the box and insert a piece of cardboard to represent the new cell wall. (37:255)

The Diorama as a Teaching Aid

The construction of a diorama is a useful device for reviewing or organizing material presented in a unit.

Miniature dioramas may be made of the life cycle of plants and animals, habitat relationships, or typical events in the lives of great scientists. After a scene has been decided upon a box is made to house the completed picture. The background is painted on a curved cardboard. Items such as actual specimens, drawings, paintings, or cut-outs may be used in the foreground. (7)

Diorama cases are about one foot square and eight inches wide and may be constructed from ordinary wooden boxes. Figures are modeled about a wire frame or armature. Plastic clay figures are posed on the wire nails to prevent them from falling forward. Trees are made from small twigs which are forced onto small wire nails for support. Leaves may be made from artificial flowers. Rock formations may be imitated by smearing screen wire with plastic clay. The screen can be bent any shape and tacked into place on small blocks of wood. The entire study should be protected by glass in front of the diorama case. (16)

Model Making for Biology

Though the making of models takes several periods of class time it is an excellent means of review. Complete directions for making four types of models—Plasticine, bas-relief models, plaster cast plaques, and three-dimensional latex models—are given in an article in the December 1943 issue of School Science and Mathematics. Suggestions for subjects, materials to be used, and procedures to be employed are included in the directions. (17)

Soap Modeling

Use a soft soap, orangewood sticks, and a sharp knife. A drawing of an appropriate size is made on paper and transferred by means of carbon paper to the soap. Use the orange stick to remove the area between the parts
to be shown in relief. The regions may be colored with water color. Shellac will prevent the cake from warping later. (43)

**Birds' Eggs**

Birds' eggs may be made from plaster of paris. A mold can be made by placing a rounded end of stick into soft clay. Plaster of paris is then poured and when hard the egg is shaped with a knife and the rough spots are sandpapered. Color the models to duplicate real eggs. (44)

**Human Manikin**

The Turtox human manikin obtained from the General Biological Supply House* is one-seventh natural size when completed. It consists of a cover showing the muscles and a page each of the skeleton, circulatory system, organs of the digestive and respiratory systems, and the nervous system. In coloring, cutting out, arranging, and making a key to the organs the student gains a good understanding of the important systems of his body. Each separate page may be used as an introduction to a new system.

**Map Making**

1. **Ecology.** The conservation stamps obtained from the National Wild Life Association may be placed in the proper place on a map of the United States.

2. **Conservation.** The location of state fish hatcheries and state parks can be shown on a map of Oregon by using colored signal dots. Bird sanctuaries, game refuges, and National Forests may be colored in.

3. **Sanitation Survey.** An interesting map of the community may be made. Show the location of the water supply, sewage disposal plant, garbage dump, incinerator, unsightly places, insect breeding places, or other areas which concern public health.

4. **Tree Maps.** Make maps showing the location of trees on the school grounds, in the park, or in the area adjacent to the school.

5. **Ecology.** Make a map of the area covered in a field trip to study the relation of organisms to their environment.

**Lantern Slides**

Etched glass slides provide an interesting and worth-while activity for students. Each student is provided with a slide on which he sketches something the class is studying at the time (adaptations, cells, organs). Colored

*See Appendix.*
pencils are used to bring out certain parts. When the slides are complete one student operates the projector and each student gives a short talk about his slide when it is shown. After the “show” the slides may be washed and made ready for the next unit.

**Prehistoric Forms of Life**

Illustrations, photographs, and Plasticine or plaster of paris models may show general structure, but contribute little to a true concept of size. Outline with chalk dust, plaster of paris, or lime powder the body contour of Triceratops, Brontosaurus, etc., in life size dimensions on the ground in a sports arena before a grandstand. Students constructing the outline as well as those who view the forms from the vantage point of the grandstand get a realistic impression of the size of the ancient life forms.

**OTHER TEACHING AIDS**

The greater the variety of learning aids used, the greater will be the interest and attention of the class and the more complete and permanent the learning. In this section are supplementary aids that make use of the sense of taste and smell, listening aids, and aids that appeal to a student’s urge for expression.

**Cheese Day**

In order to study bacteria and molds in relation to the flavoring of cheese, committees of students were organized to plan the work. Some brought in cheese of various types, others crackers, and still others looked up articles on the subject of cheese and volunteered to make oral reports to the class. The cheeses were labeled and placed on the demonstration desk. After each different type was reported on, the students lined up and sampled cheese. The report included the historical background of the cheese, the process of manufacture, and how the sample was flavored. (29)

**Apple Day**

One biology class celebrated apple week by arranging a program and apple exhibits. A committee planned the program which consisted of reports on apple pests, apple relatives, grafting, cultivation, apple storage and marketing, nutritive value of apples, apples in legend and history, apples in song and verse, apples around the world, the development of apples from flower to fruit, and the economic value of apples in our county, state, and nation.
Refreshments planned by another committee were served whenever the program called for it. They consisted of apple sauce, apple jelly on saltines, cider, applesauce cake, tiny apple pies with cheese. (12)

CHRISTMAS SUGGESTIONS

In order to integrate biology with other school subjects a program of topics relating both to biology and Christmas was planned for the day before the Christmas vacation. A student chairman introduced the speakers who reported on the following topics: mistletoe, origin of the Christmas tree, fruits for Christmas, decorative plants, nuts, topics related to animals such as the geese in Lithuania, reindeer, or turkeys, Christmas poems, paper, Yule log, candles, relation of yeast and bacteria to Christmas, frankincense, myrrh, and Santa Claus. (13)

RECORDS OF AMERICAN SONG BIRDS

The following records of American Bird Songs may be obtained from the American Nature Association.* The bird songs were recorded by the Albert R. Brand Bird Song Foundation, Laboratory of Ornithology, Cornell University. They are the product of many months of travel and many hours of patient prowling in the birds' natural haunts by a group of Cornell ornithologists using the finest of modern equipment for photographing and transcribing delicate sounds.

1. Birds of the Northwoods.

LUTHER BURBANK RECORDINGS

Seven 16" records, each containing two fifteen-minute programs at 33½ r.p.m., and entitled "Gardening the Luther Burbank Way," are available from Educational Radio Script and Transcription Exchange.*

SCIENCE QUESTIONS

Science questions or quizzes may be used in a number of ways to stimulate the interest of students. They may be placed on the electric game chart, on a game wheel, or in the "Do You Know?" quiz book. They may be used as a radio quiz program or as questions for a contest. Below are some of the quizzes which students have thoroughly enjoyed.

* See Appendix.
Who's Who in the Animal Kingdom

1. What animal gives birth to its young during the long twilight sleep of hibernation? (Polar bear.)
2. What is the only bird that can fly straight up, down, sideways, and backwards? (Hummingbird.)
3. What fish can climb trees? (Mudskipper in North Borneo.)
4. What is the largest creature ever known to be on this earth or in its waters? (Blue whale.)
5. What bird will plunge at full speed into a snowbank in order to escape the rigors of a winter's night? (Grouse.)
6. Can you name this animal? The female is a cow, the male is a bull, the offspring is called a pup? (Seal.)
7. What bird can swim but cannot fly? (Penguin.)
8. What wild animal refuses to eat food that he does not wash? (Raccoon.)
9. What animal made many of the trails over the hills and plains of North America—routes so perfect from an engineering standpoint that many of our highways and railways have been built upon them? (Bison.)
10. What creature has the habit of swallowing some hard, indigestible substance such as a stone before it hibernates? (Alligator, crocodile.)
11. What bird is always in continuous flight away from its nest? (Chimney swift.)
12. What land animal lives the longest? (Tortoise.)
13. What bird holds the world's long distance flight record? (Arctic tern.)
14. What animal is thought to have taste organs on its feet? (Butterfly.)

Animal Families

Name the male of the species:
1. cow  bull
2. duck  drake
3. sow   boar
4. hen   rooster
5. goose gander
6. doe   buck

Name the female of the species:
1. tiger  tigress
2. ram    ewe
3. stallion mare
4. fox    vixen
Name the young:
1. bear  cub
2. goat  kid
3. mink  kit
4. whale calf
5. sheep lamb
6. duck duckling
7. frog tadpole
8. swan cygnet
9. chicken chick
10. hen pullet
11. horse colt, foal
12. horse filly
13. deer fawn
14. elephant calf
15. cat kitten
16. goose gosling
17. bull bullock
18. cow heifer
19. guinea hen keat
20. pigeon squab

What do we call groups of animals:
1. of sheep flock
2. of cattle herd
3. of lions pride
4. of wolves pack
5. of snipe wisp
6. of fish school
7. of quail covey
8. of bears sloth
9. of bees swarm
10. of puppies litter

What do we call their natural homes:
1. of birds nest
2. of lions den
3. of beavers lodge
4. of rabbits burrow
5. of eagles aerie
Name the shelter we build for them:

1. for dogs kennel
2. for pigeons coop
3. for pigs sty
4. for cows shed
5. for rabbits hutch

Name the sounds they make:

1. lions roar
2. pigs squeal
3. wild geese honk
4. cows moo
5. ducks quack
6. wolves howl
7. crows caw
8. snakes hiss
9. donkeys bray
10. hens cackle
11. frogs croak
12. cocks crow
13. elephants trumpet
14. owls hoot, screech
15. doves coo

Best Answer Questions

Intriguing questions which require inquiry into the natural history of organisms may be used in several ways: to introduce a study of some form of life, to bring about an understanding of adjustment, to encourage the finding and formation of questions by students, and to provide motivation. Contests may be started to see which youngster first finds the answer to a daily question. Some examples and most reasonable explanations follow.

1. Have you noticed that a horse gets up on his front feet first, and in lying down gets down on his front legs last, whereas the cow does the reverse? What is the most reasonable explanation? (A study of the early development of the horse shows it to be a grassy-plains animal. Its protection lies in speed and quick recognition of potential enemies. Its last task before lying down is to look about, or before getting up completely is to see if it's safe to get up. The cow living in a marshy, brushy land sees more readily among the boles of the shrubs than among the maze of limbs; hence it gets down on its front
feet to see if it is safe to lie down. It gets up on its hind legs first so that it may last see if it is safe to get up or where its potential enemy is.)

2. Should you shoot a gun from astride an uninitiated horse you would probably be fourteen hands closer to the center of the earth immediately after the report. This would not be true if you shot the gun from the back of a donkey. What is the most reasonable explanation? (The quick nervous response to noise of the plains animal often saves it from enemies, whereas in “freezing,” the grey donkey from the grey-colored steppeland attained the same end.)

3. What is the best explanation for the featherless, reddish-skinned neck and head of the turkey vulture? (Its featherless head and neck enables it to probe easily through the ribs and flesh of carrion without danger of soiling feathers or getting caught by the feathers, thus dogging the way in retracting its head from close bloody quarters.)

4. A horse is more easily stuck in the mud than a cow. Why?

5. What is the best explanation for a dog barking and a cat purring?

6. The saber-toothed tiger and the cheetah, both members of the cat family, leave track marks showing claws. So does a dog. But the cat, lion, and leopard do not. Can you explain this?

On-Your-Toes Questions

An occasional catchy question not only requires the students to know their biology, but tests shrewdness, lends interest, and provides challenge. An example or two will suffice.

1. If a peacock belonging to Mr. Smith laid an egg on Mrs. Jones’s lawn, to whom does the egg legally belong? (Peacocks do not lay eggs—peahens do.)

2. A boy was apprehended stealing watermelons. While escaping he was shot at just as he was fleeing across a frozen pond. As the report occurred, the boy broke through the ice and was later found dead. Should the farmer be tried for manslaughter?

3. Two women, each with a small boy, were asked by a friend, “Whose are they?” The reply was, “They are our sons, sons of our sons, brothers of our husbands, all in lawful wedlock.” How is this possible?

Using the question types given above usually leads to liberal student contributions of the same. Much learning under challenging circumstances results for both pupils and teachers.
Blank Stories

Still another type of quiz promotes learning, indicates achievement, and provides for repetition. An example is the following fill-in type:

Wedding of the Flowers

Rose consulted her (Poppy) who, upon learning that Red (Bud) was wealthy, said, "Certainly, marry him; here is your chance to (Marigold)."

Red (Bud)’s parents hesitated and asked, "Are you sure she loves you?" He replied "Of course I am because I (Aster). So in due (Thyme) the wedding day arrived.

Rose was beautiful with her (Lily)-white gown, (Pink) cheeks, and natural (Rose)-colored lips. Her feet were encased in neat (Lady’s Slippers) and on her arms and (Fingers) she wore (Fox Gloves). Her bridesmaid’s name was Rose also, but she was so prim with a (Touch-Me-Not) air that you wanted to call her (Primrose). Sue, the dark-eyed flower girl, certainly looked like a (Black-eyed Susan).

When the appointed hour of (Four o’clock) arrived, the wedding guests were shocked when the bridegroom failed to appear. But just as the clock finished striking the hour, who strutted down the aisle but a (Ragged Sailor) wearing (Dutchman’s Breeches) and smoking an (Indian Pipe). At the pulpit he brushed the minister aside and there he stood, a regular (Jack-in-the-Pulpit). He boldly announced in a (Trumpet)-like voice, "The groom’s father says there’ll be no wedding today, but the groom says to tell his would-be-bride, (Forget-Me-Not); we’ll meet again."

Other quizzes popular with the students are:
2. “Science or Superstition” in Reader’s Digest, April 1939.
3. “Nature-Fact or Nature-Fiction” by Alan Devoe in Reader’s Digest, April 1943.

Science Newspaper

To review science progress made in recent months each student in class was appointed science editor of his own newspaper. He planned the make-up, placement of stories, headlines, cartoons, and all other details of his own paper. All available sources of current science news were used for reference. The activity lasted several days giving the students a chance to exercise originality in cartoons, headlines, etc. The best paper was posted.
Biology Diaries

To give the students training in making observations they were given mimeographed sheets of directions for keeping biology diaries. These stressed accuracy, the making of personal observations, and giving credit to those who helped. They also contained suggestions as to what to write about:

1. Examples of biological principles such as the balance of nature, protective adaptations, and energy cycle.
2. Effect of weather and change of season on living things.
3. Identification of living things.
4. How plants and animals carry out the life functions.
5. Scientific discoveries.
6. Examples of good scientific attitudes. (48)

Recording Nature Specimens Brought to the Classroom

One good way to encourage students to bring in nature specimens is to have a system whereby proper credit may be given to such individuals. Cards with the pupil's name on the top are filed alphabetically according to sections and held together by a rubber band. These are kept in the teacher's desk. Whenever a pupil brings in something, identifies it, and arranges it for display, he records his work on the card. Students may also record laboratory materials, pictures, and clippings brought in, as well as outside reading. At the end of the grading period the teacher may go through the cards and give the student credit for all contributions he has made. (30)

Panel Discussions

A procedure which varies classroom activities and fosters sustained group attention in the panel discussion. It is an excellent way to present subject matter in an organized but informal manner. A good panel consists of about seven intelligent students who like to search out information and have a feeling of personal responsibility. In preparation for the discussion they read all the material on the subject, take notes, and jot down questions that might arise.

In presenting the discussion all members are seated at a table and remain seated while talking. It is the duty of the chairman to introduce the members of the panel, state the topic for discussion, and tell the audience that they may take part. It is also his duty to see that each member of the panel has an opportunity to speak, to check long speeches, and to summarize the discussion. Any member of the panel makes a remark which serves to start the discussion.
Other members talk or ask questions in any order; there should be no long speeches. The teacher is in the audience as a source of reference. (45)

Radio Comes to the Classroom

Come to class tomorrow for another exciting episode titled, "No single-celled organism ever lost an ancestor through death."

Be present Monday. We're going to find out how one and one make one instead of two!
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43. Suggestions for school activities. American Biology Teacher 1:9, October 1938.
46. Teller, James D. "Humanizing the teaching of science by using the bulletin board." School Science and Mathematics 41:611-619, October 1941.
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APPENDIX

SOURCE ADDRESSES

American Biology Teacher, Lancaster, Pa. Annual membership, including subscription, $2.50.

American Nature Association, 1214 16th Street, Washington 6, D. C.


National Recreation Association, 315 Fourth Avenue, New York 10, New York.


Nature Games. Mrs. Ruth Wheeler, P. O. Box 201, Angwin, California.

Pictorial Statistics, 142 Lexington Avenue, New York, New York.

School Science and Mathematics, 450 Alnaip Street, Marasha, Wisconsin. Subscription $3.50 a year.

Science Education, 374 Broadway, Albany, New York. Subscription $2.50 a year.


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By Elmo N. Stevenson, Ed.D., Professor of Science Education .... .50
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