LOCAL MATERIAL AVAILABLE FOR THE HIGH SCHOOL BIOLOGY CLASS IN NORTHEASTERN OKLAHOMA

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Bachelor of Science

Northeastern Oklahoma State Teachers College

1934

Submitted to the School of Education

Oklahoma Agricultural and Mechanical College

In Partial Fulfillment of the Requirements

For the Degree of

MASTER OF SCIENCE

1936

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ACKNOWLEDGMENT

The writer wishes to acknowledge the assistance of Dr. Chauncey in the selection of criteria for chossing the content of this thesis; of Dr. Meurman in the suggestions, especially the idea of 'drawings', and of Professor Kezer who has offered <u>many</u> suggestions and helped to prepare this work.

C. D. C.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

CHAPTER I

INTRODUCTION

The problem of utilizing local material in teaching biology in the high school has interested biology teachers since 1930. About that time the high schools of Oklahoma, having their budgets trimmed considerably, began to substitute the course in biology for the more expensive science courses.

Of course, funds being limited, such problems arose as: What local material should be used? When can I collect the material? How can I collect and use this material? And what motivating interest may be utilized? These are problems that the teacher of biology must answer. Utilization of local material is treated in this problem.

The writer is unaware of any publication dealing directly with the subject. However, texts and manuals have some suggested activities in their laboratory directions.

High school texts and manuals, method books, courses of study, and magazine publications, were the materials used in this investigation. The materials selected were those treated in each text and laboratory manual. The technique used in utilizing this material is the result of experimentation. However, the methods may be suggestive and variations may be used with satisfactory results.

No attempt is made to determine its relative importance, nor to state the time for study of different materials.

The writer is convinced that: (1) according to texts, manuals, and research, there is not much agreement upon the relative importance of subjective material; (2) that the order of presentation may vary considerably; and (3) that a great deal of ingenuity, on the part of the teacher, must be exercised in planning field trips, club work, and in collecting and using local material.

CHAPTER II

EQUIPMENT

Lack of equipment is the alibi that all biology teachers should avoid. A great deal of factory equipment is not essential to a resourceful teacher of biology, because much of it may be made and many of the articles may be used for several purposes.

The Disecting Set.--Satisfactory disecting sets may be made by members of the class. The teasing needle is made by cutting the head off a large straight pin and inserting the head end into the end of an all-day sucker stem. The old discarded tweezer can be used. Old razor blades make satisfactory knives. The medicine droppers, more satisfactory than the factory type, can be made by melting one end of a short piece of glass tubing to the desired point and inserting the other end into a piece of small rubber tubing. The rubber tube should be folded over the side of the glass and tied. Old household scissors will serve. The individual kits, once collected, should be cared for as if they were the best factory equipment.

Disecting Pans.--The disecting pans may be made by using any old metal pan of about two inches depth. Worn out bread oven pans are very good for this purpose.

Heat some parafin to melting and then stir in some lamp black. Pour the mixture into the pan and set aside to cool.

Small glass jars and large bottles, especially those with large tops, are useful in the laboratory. These are just as satisfactory as those supplied by biological supply houses.

The most difficult home equipment to supply is the substitute for flasks and beakers that will stand heating. Ordinary old burned-out light bulbs may be used. Remove the metal caps and filament and one has a substitute for flasks and beakers that will stand the heat. (See Figure 1.) Boards with holes in them may be used for holding the bulbs. (See Figure 2.)

Collecting Jars.--The cyanide jar for killing insects is the most satisfactory. Place about one-half of a teaspoonfull of potassium cyanide in the bottom of a wide-mouthed pint jar. Tamp about two inches of dry sawdust in the jar, moisten the sawdust, and cover with about one-quarter inch of thick plaster of Paris. Before the plaster of Paris has time to set, make a small hole in the center of it by inserting a small stick. Set the jar aside until the plaster is thoroughly dry. The hold allows the deadly poisonous fumes

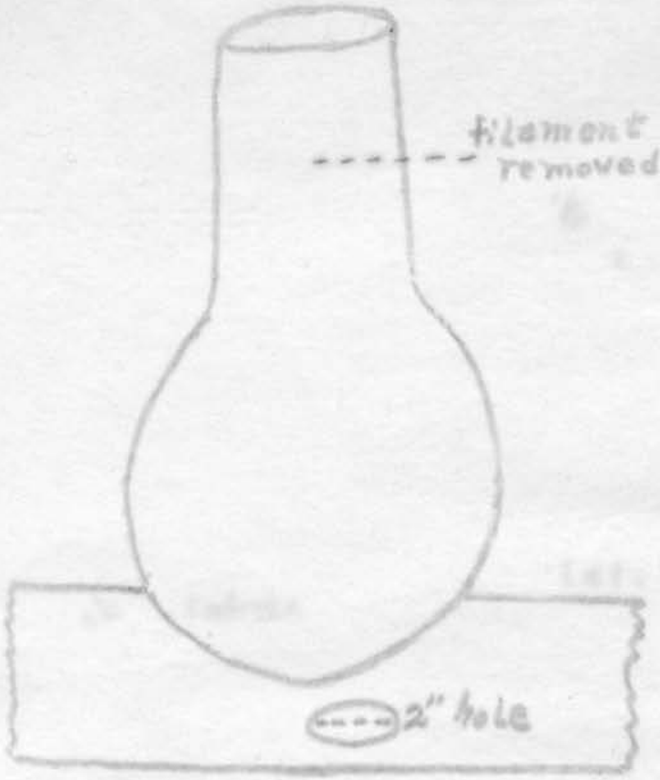

fig. 1.

An electric light bulb may serve for the beaker and flask.

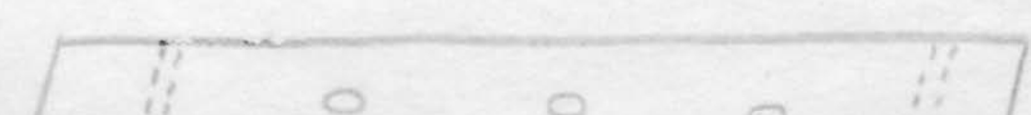

fig. 2.

Board for holding the bulbs

Fig. 3

Cyanide jar for killing insects.

to escape. (See Figure 3.) The jars should be labeled "poisonous" and those handling them should avoid inhaling the fumes because a severe headache will result. These jars kill insects with haste. Soon after they are dead, the insects should be removed to a wide-mouthed, clean, dry, collecting jar.

Nets.--A good insect collecting net may be made by using heavy mosquito netting or cheese cloth, a piece of heavy wire and a cane thirty-six inches long. (See Figure 4.) Bend the wire to a circle and twist the ends together. A wire clothes hanger may be bent circular for this purpose. Sew the cone-shaped netting on the wire and fasten to the cane.

Insect Boards.--Stretching and drying boards for insects may be made by tacking strips of cork, or, for cheaper boards, pieces of corrugated pasteboard on a wooden board. These strips should be about one-fourth inch apart to allow the bodies to fit between the corrugations, to allow the wings to spread, and to make pinning easy. (See Figure 5.)

Insect Boxes.--Attractive display boxes for insects may be made from cigar or other tobacco boxes. Cut the edges to about one inch in depth and cut cover glass from scrap pieces of broken window glass. The

Steps in making an insect net.

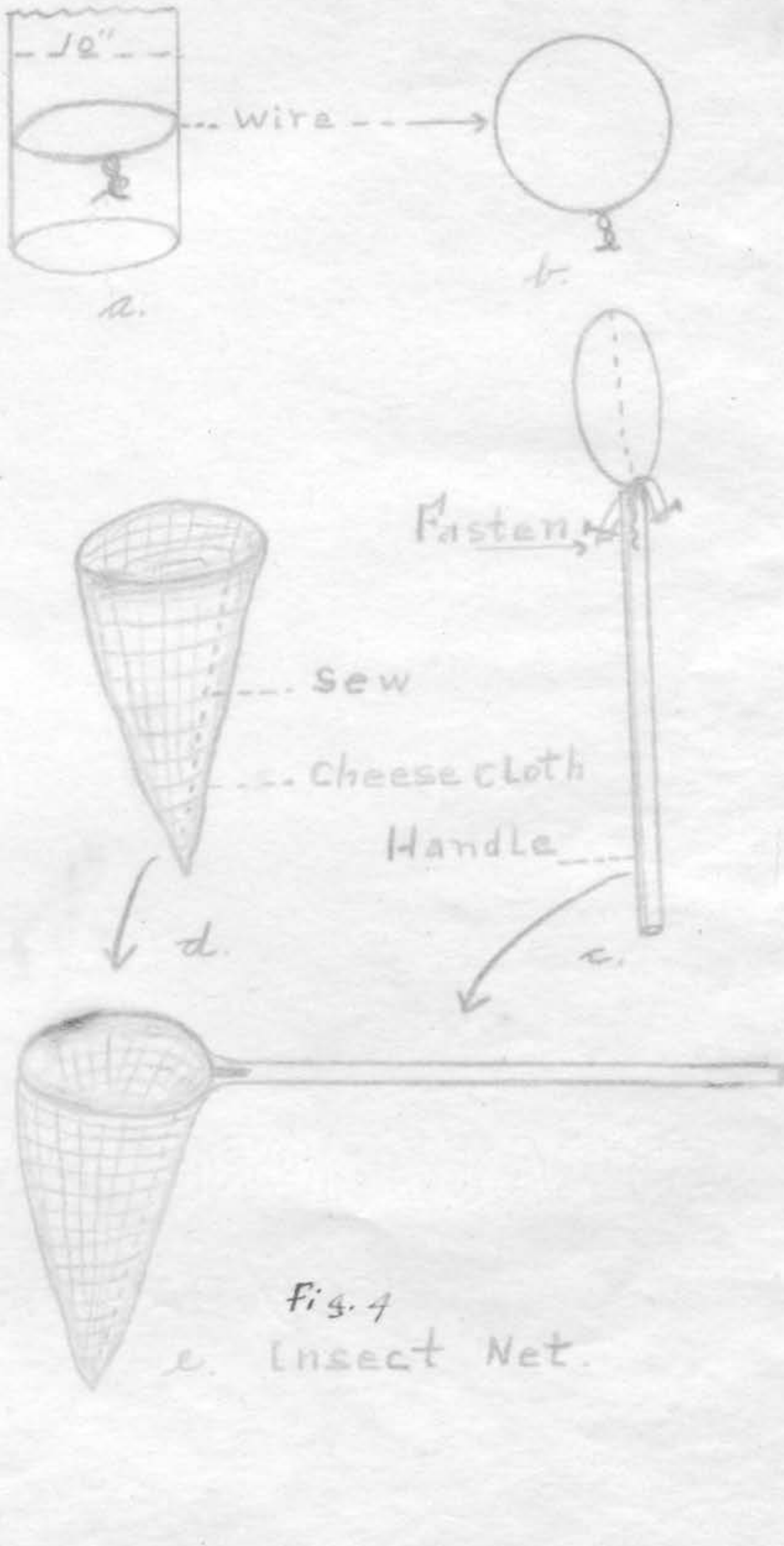

Fig. 4
e. Insect Net.

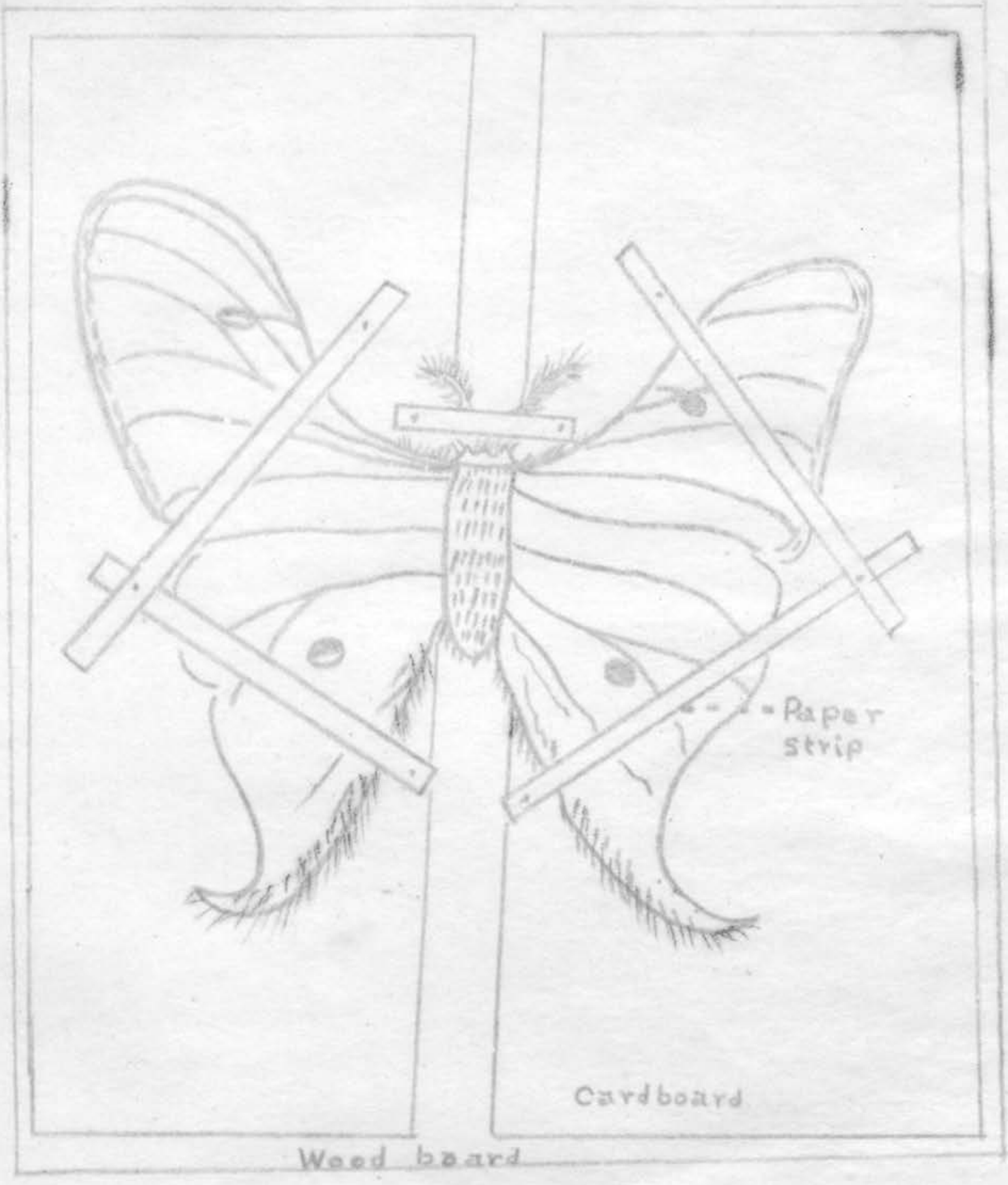

Fig.5. Stretching Board

box may be padded with cotton and the insects placed upon it with proper labels. Also, old picture frames with board backs, padded with a thin layer of white cotton,make attractive cases. Moth balls may be pulverized and sprinkled on the cotton to prevent other destructive insects from injuring the preserved mounts.

Cages.--The cages for moths or other insects should be small. They may be solid so that it will hold dirt, leaves, and plenty of moisture. Screen wire cages for larger reptiles and mammals may vary in size, depending upon the size and habit of the animals. The essential features are stability and safe door latches. Of course, squirrels and more active animals need more room than smaller, less active ones, such as snakes.

The Aquarium.--The aquarium, which is probably the greatest single teaching factor in the laboratory, may be constructed in a number of different ways. (See Figures 8A and 8B which show how one may be constructed.) More than one aquarium is recommended. Excess collections may be kept in extras for laboratory use. Large glass jars ranging from one to five gallon capacities may be used but are difficult to balance. The care of the balanced aquarium will be discussed.

Preventive Measures.--[1] Most new aquarium tanks are free from troublesome contaminants, but even in these sterilization is advisable. A strong brine solution or alternate treatments with slaked lime and potassium permanganate should be allowed to stand in the container several hours. Carefully rinse the tank after either treatment.

Covers should be provided to prevent contamination and evaporation.

Uniform temperature is desirable. North windows are best because direct sunlight stimulates growth of algae and raises the temperature. Warm water does not hold as much air as cold water; therefore, suffocation of fish accompanies overheating.

If the laboratory windows are located on the south, the aquarium may be protected from direct sunlight by shading with cardboard. Remember that, in the natural habitat, the plants receive their light from above, only. Too much light should be avoided and nature imitated as much as possible.

Filtered pond water is best for aquarium use, although tap water may be used with success if allowed to remain in open containers for some time before

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[1] Turtox News Series, Vol. 12, No. 8, August, 1934, p. 190. (General Biological Supply House)

Aquarium Parts

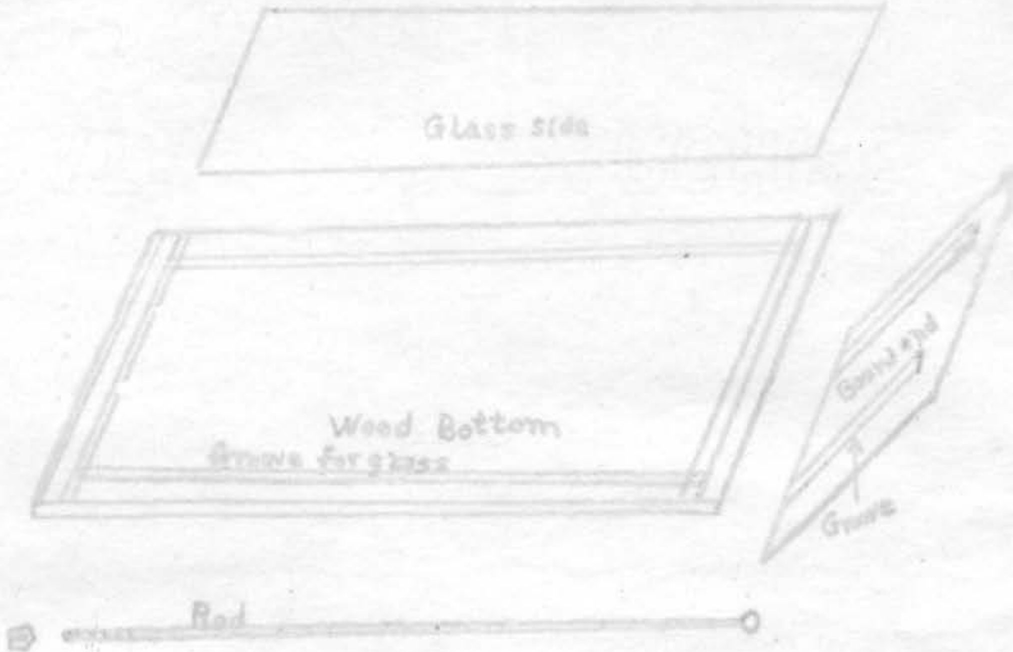

Fig. 8 a.

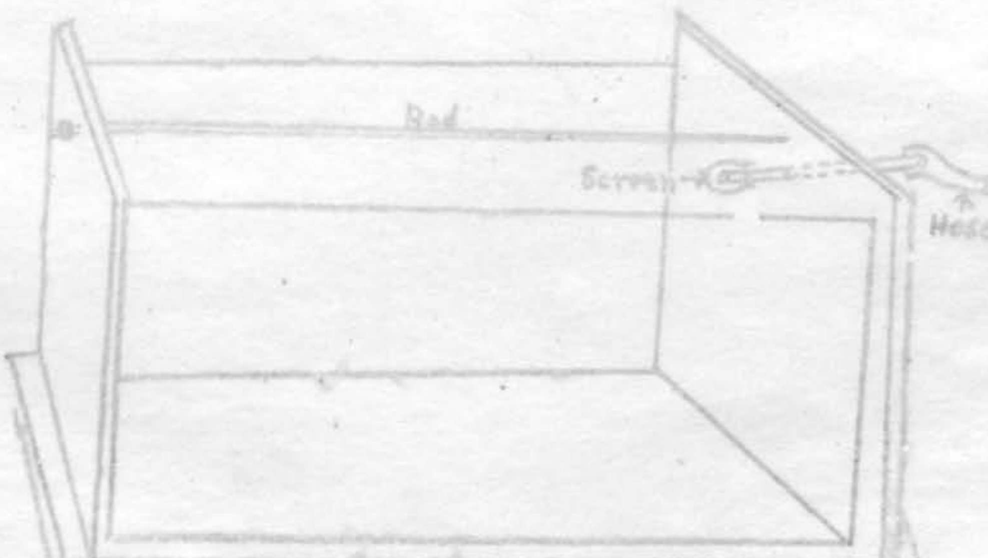

Fig 8

Fresh Water Aquarium

using. It is best to filter any water before using because gases and minerals are harmful.

The sand used should be washed in running water and boiled to remove dust and other contaminants.

Plant growth should be started a few days before adding animals. Everything used in connection with the aquarium should be clean. Before adding plants or animals they should be placed in a weak solution of potassium permanganate for about one hour, then rinsed in running water. This removes parasites.

Feeding should be systematic. A feeding every alternate day, of oatmeal or soda crackers, is sufficient. If, at any time, food remains uneaten, it should be removed at once to prevent contamination of the water.

Snails should be kept because they act as scavengers.

Models.--Other equipment, such as models of internal anatomy, is a part of a well equipped laboratory. Good substitutes for models are found in preserved body organs.

The entire brain, liver, kidney, heart, lungs and various other organs may be removed from small disected animals and preserved in museum jars. After removal they should be washed in running water and preserved in ten percent formalin. They may be partly disected, so that the parts can be observed, and mounted on small boards and placed in the jars.

Conclusion.--The equipment mentioned in this chapter is by no means a complete list for use in biology. These are not the only ways of making this equipment. This chapter is suggestive of some of the things that may be done.

CHAPTER III

AUXILIARY AGENCIES

Such agencies as the laboratory museum, field trips, science clubs, posters, books, magazines, etc., may be called auxiliary agencies in that they supplement the texts, lectures, and other routine procedures. These agencies serve to motivate the work in biology.

"The impulse to do work, to learn, to be active is called motivation."[1] Often the material is provided but the child does not work. The class often presents as many interests as there are pupils in the class.

"The beginning of teaching should begin with actual things."[2]

"In general, never substitute the sign for the thing itself, save when it is impossible to show the thing......"[3]

"Sense impressions of nature is the only true foundation of human knowledge."[4]

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[1] Geo. W. Hunter, Science Teaching, p. 269.

[2] E. R. Downing, Teaching Science in the School, pp. 5-7.

[3] Emile Rousseau, Book 111.

[4] Pestalozzi, The Method, p. 316.

> One of the men who exerted the most potent influence for the introduction of science in the schools of this country was Louis Agassiz. His motto, placed conspicuously in his laboratory, "Study Nature not Books," was forced upon his pupils by example as well as by precept. [5]

Other motivating factors such as interest and attention, assignments, the teacher, and grading may determine the success of a biology teacher. Only those motivating principles that involve local material will be discussed here.

Workbooks.--The good workbook which is recommended by more than sixty percent of the biology teachers,[6] should be used because: (1) it provides for individual differences; (2) it is a time saver for teacher and a guide for inexperienced teachers; (3) it helps the pupil to use and organize his knowledge; and (4) it provides for motivating activities such as picture clippings, notebook covers, and posters for the bulletin board.

The workbooks accompany the texts, and the laboratory period is used for the solution of problems. Much

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[5] E. R. Downing, Op. Cit., p. 9.

[6] Florence Weller, "High School Biology Content as Judged by Thirty College Biologists," School Science, and Math, April, 1932: 411-24.

school time is wasted unless the work is well planned and assignments are carefully made. Too much emphasis is placed upon gathering facts for workbooks instead of for sought conclusions. The observations should be easy and the goal should always be in sight. The purpose of an experiment or exercise should not be obscure.

The Bulletin Board.--The bulletin board should be made the interest spot of the laboratory. This may be done by selecting pupils to have charge of the board display for certain periods. Display materials may include news and magazine clippings, pamphlets, and posters and articles by students. The class may be divided and class contests conducted on the use of the bulletin board display.

All members of the class should contribute to the board display by selecting related topic clippings. A very good plan is to have manilla folders for filing the clippings, after they are used, for future reference. Each student's clippings may be filed separately and a grade given for the scrapbook at the end of the semester.

The Library Reading Room.--The library of the biology room should consist of multiple texts, references, manuals or guides for the study of plants and animals, pamphlets, and illustrative material from companies. The relative cost is small. The multiple texts may be obtained by exchanging the out-of-date texts with other schools. Some companies furnish sample copies of new texts for use by the pupils. The Federal Government will furnish, free to schools, pamphlets on almost any subject of biology. Other materials such as back magazine numbers, catalogues, etc., may be obtained by asking the companies for them. The reader is referred to Enriched Science Teaching in the High Schools, a source book for the teaching of science in the high schools,listing chiefly free and low cost illustrative and supplementary material, by Woodring, Oakes, and Brown, published by the Bureau of Publications, Teachers College, Columbia University, New York City. This is a volume of three hundred sixty-nine pages, containing only the names of the companies and their products.

These books and reference materials should be kept in the science reference room because they are needed frequently in connection with laboratory work. Magazines may be kept in the general library because they may be used at leisure and by other classes.

A recent national survey of education[7] shows an encouraging use of the school library. Of 350 reporting, 203 have the classroom library in use, 179 allow

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[7] National Survey of Education, The Secondary School Library, Bulletin 17, 1932. (Office of Education, United States Department of Interior).

students to leave the classroom individually and come to the library for study, 158 allow classes to go to the library for group study, and 43 lend books to the classroom for the study of units.

Advertising schemes should be used in the reading-room to stimulate interest. This should be a place for the assimilating of knowledge. When carefully-planned reading programs are made by the teacher, many problems of discipline, of interesting pupils, and of presenting subject-matter will be eliminated.

The Museum and Field Trips.--Collections for the laboratory museum will be discussed in the following chapters. Assuming that the museum collections are made according to the directions given later, one may expect the greatest motivating interest. Every field trip will reveal new specimens for the museum. Pupils take pride in collecting and preserving museum materials. The fact that it is common in the community makes it more appropriate and more valuable for laboratory study. Laboratory directions on the study of local museum materials are more effective than those on distant museum materials that are not common to the locality.

The collecting idea, once started, will survive. Even parents and other members of the family enjoy collecting material as indicated by their frequent visits to the laboratory. When the idea is started the problem is to properly prepare and preserve specimens. However, the biology students will take care of this, if given a chance. The following page contains pictures of the material collected and studied by the biology class during the school year, 1935-36.

Science Clubs.--Clubs, which are so numerous in many schools, are important. If too many clubs do not already exist in the school, a science club should be organized to capitalize the social spirit.

> Groups have opportunity for individual discussion in the exploration of individual interests and hobbies. The club gives variety of program from the classroom or laboratory and allows for specialization along the line of individual interests. It trains for leadership and self-expression. Thus it makes definitely for motivation.[8]

The club may contribute a great deal of material to the museum by collecting, preparing and preserving museum collections of plants and animals, life histories, and other data. Such activities as supervising sanitation projects, assisting in laboratory work, and giving assembly programs are among those of the science club.

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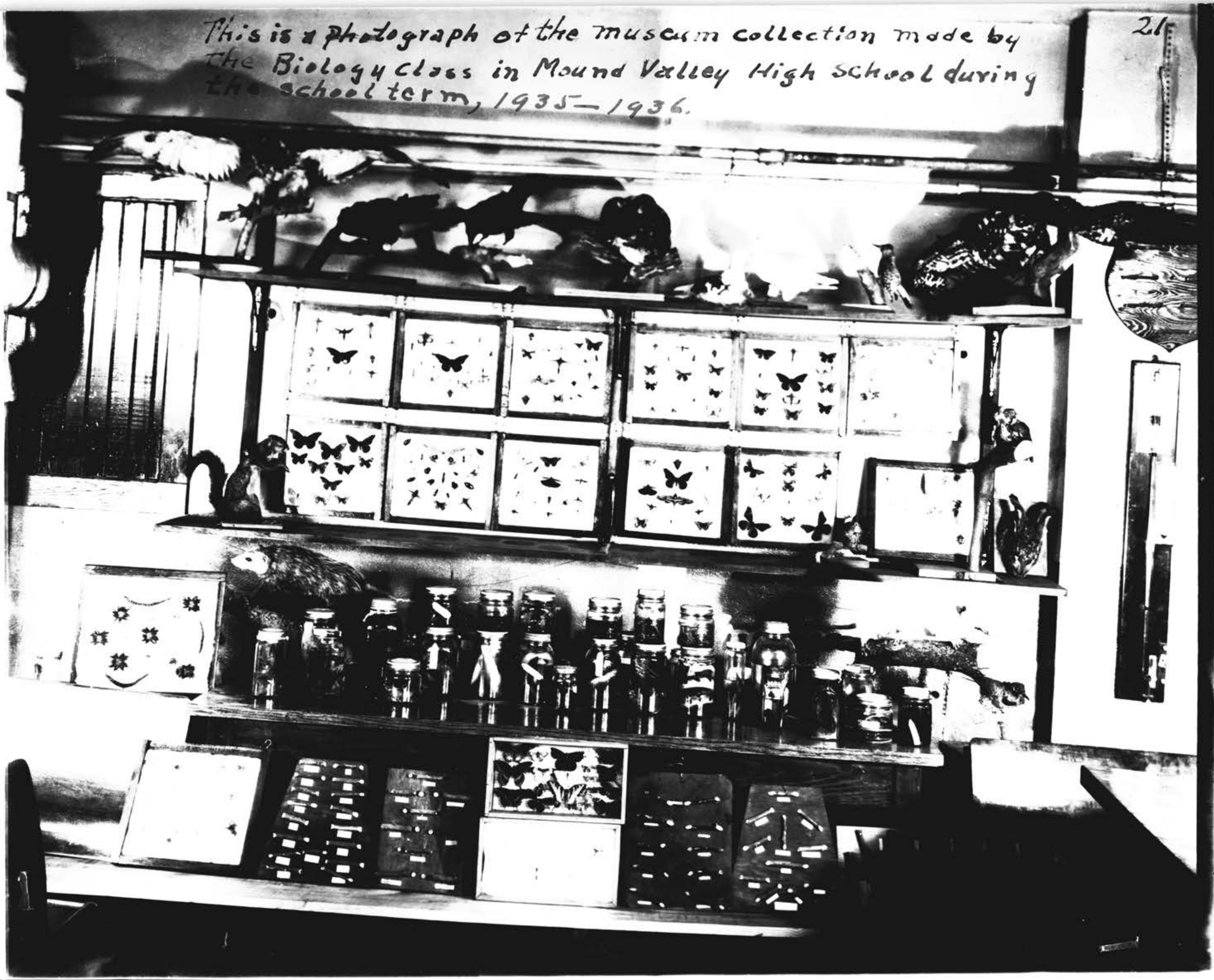
[8] Geo. W. Hunter, Science Teaching, p. 285.


This is a photograph of the museum collection made by
the Biology Class in Mound Valley High School during
the school term, 1935-1936.
21

CHAPTER IV

PLANT LIFE

Young people can best become interested in simple classification through museums and field trips, not through formal use of the text. After the interest is established through the motivation of the excursion, then it becomes natural to use the text as a key to identify the larger groups.

One who attempts to have children memorize and reproduce scientific terminology is not getting the most out of science for his pupils and is, in addition, doing much to encourage dislike of science on the part of the pupils.

Thallophytes

The simplest plants have no roots, stems, nor leaves. Algae, molds, mushrooms, and lichens belong to this group. A field trip will reveal the importance of this group of plants.

Examine large rocks and trees or fence posts for brown, red, black, or green lichens. Bring the lichens to class for study. They may be kept in a box for a long time. The box should be covered with a glass and contain a sponge soaked in water.

Lichens are used to demonstrate the most dependent association - symbiosis. The lichen is made of algae and fungi. Algae manufacture food and the fungi absorb moisture for growth. The two plants may be observed under the microscope by teasing a lichen in some water on a slide.

Bread Mold.--Moisten a piece of bread, place it in a container and set in a dark warm place. Favorable conditions for growth may be demonstrated by subjecting pieces to different conditions. Examine the culture and note the root-like structures (mycelium) developing throughout the bread. The sporangium, which turn black when mature, may be ruptured and spores planted on other bread to demonstrate the enormous number produced. These plants that do not manufacture their food but obtain it from non-living matter are called saprophytes.

Algae.--Take the green colored skum from ponds or fresh water brooks, examine them with the microscope. The most common is the spyrogyra which will represent beauty not so rare but seldom noticed. The method of reproduction, chlorophyll, and cell structure will not be overlooked.

Fungi growths which are known as rusts, blights, and mildews, may be observed on the field trip. Their results are more convincing of their importance than is their structure and appearance.

Bryophytes

Mosses are slightly more complex than algae, fungi and other thallophytes. Their external appearance resembles other higher plants, but they have no roots, stems, nor leaves. They are the mosses.

A moss plant may be found almost any place but especially in damp shady places. Mosses are used to demonstrate alternation of generations, the first sexual reproduction in the plant kingdom, and the very rudimentary structure resembling stems, roots, and leaves, which are characteristic of higher plants.

Take some of the moss with some of the soil, and place it in a small box. If the moss is sprinkled with water sufficiently to keep the soil moist, it will grow and all of the stages of the life cycle may be observed.

Pteridophytes

Ferns have true roots, stems and leaves. Wild ferns may be found near fresh water in rocky places and especially in mountainous areas and moist shady places. The green part, which is above the ground, is really the leaf of the plant. Some ferns may be transplanted and kept alive in the laboratory a long time.

One may observe on the under surface of the leaflets of a fern small brown spots which contain the sporangia, or spore cases, which contain asexual spores that ripen, germinate, and produce the sexual generation. The large feather ferns, commonly grown among the house plants, is probably the best and easiest to study.

Spermatophytes

The gymnosperms include evergreens of which cedars and pines are the most common. These may be observed on a field trip.

The angiosperms include all plants which bear true flowers. They are divided into two classes, the monocotyledon and the dicotyledon.

Seeds

Monocotyledonous Seeds.--Collect the seeds of wheat, oats, barley, rye, corn, sugar cane, rice, and other grasses. These may be mounted in a case made by boring holes one-jalf inch in diameter in a board and fastening a glass for a cover. The seeds are placed in the holes and properly labeled. Then fasten the glass and insert hooks so that the case may be placed on display.

The seeds of other monocot families may be mounted likewise.

Dicotyledonous Seeds.--The seeds of some dicot families may be mounted the same way as the monocots.

However, the variations in size, as in the nut family, make another method of mounts easier and more attractive.

For the nut family, use a shallow case about one and one-half inches thick. This may be made by trimming the edges of a cigar box and cutting glass to fit from broken window panes. Loose paper should be placed in the bottom and a layer of white cotton on top. This should be thick enough to press the nuts against the cover glass so that they will remain in place. Carefully label and place on display.

Various kinds of seed collections may be made attractive and very useful in the study of angiosperms. A little supervision in the mounts is valuable because the grouping into the same class and family, makes comparisons easier.

A few of the seeds should be planted separately, in containers, the number depending upon the container. One square inch should be the minimum space for each seed. Observe the seeds to determine the period of germination and the class. The container, preferably a number two can, should be labeled with the date of planting and the kinds of seed planted. Sometimes it is desirable to subject the seeds to different conditions to determine the favorable and unfavorable conditions of growth.

Place some seeds in an oven at various temperatures and note the temperature at which the embryo is destroyed.

Notice that the cotyledons of the monocot (corn) remain under ground while that of the dicot (bean) is raised above the surface and may develop chlorophyll. Take some germinating seed up and note the position and form of the developing embryo. Allow the seeds to grow and study the leaves.

The Leaves

The distinguishing feature of monocot and dicot leaves is the venation. Note that the veins of the monocot (corn) run parallel to the midrib while those of the dicot (bean) branch from the midrib.

Leaves should be studied further by experiments.

Clamp a cork over a leaf to shut out sunlight and allow the plant to stand in sunlight a few hours. Remove the leaf from the stem and clamp from the leaf and place the leaf in alcohol and boil to remove the green coloring (chlorophyll). Wash the leaf and make the iodine test for starch. This convinces one that sunlight is essential, that starch is manufactured in the leaf, and that circulation takes place in the leaf.

Necessity respiration may be demonstrated by placing the plant in a large wide-mouthed jar.

Transpiration is demonstrated by waxing the stoma, the under side of most leaves, and balancing with an unwaxed leaf.

A field trip will reveal a wide variation of leaf forms and arrangements. The rosette arrangement may be found in the devil's paintbrush and mullin, which are common in most localities. Palmately compound leaves are found on the common poison ivy and woodbine, serrate margin and pinnately netted venation on the elm, and the deeply lobed simple leaf on the oak. Leaves spirally arranged are the elm and pairs opposite are on the maple.

Leaves may be mounted for study in notebook form. The leaf is picked while green, pressed, and dried. Paste two of the same kind on each sheet, one with the top side up and the other with the bottom side up, label the leaf, and give the essential facts regarding the life of the plant. It is recommended that the leaves of the same class and family be grouped together.

Stems

Monocot and dicot stems are different in structure. This difference may be demonstrated by using the stems of young growing plants. Pour a little ink or carmine stain in a beaker of water, cut the stem above the root and set the plant in the beaker. Set aside for a few hours and then slice some very thin slices of the stem and examine under the microscope or hand lens. The fibrovascular bundles are well stained and can be seen scattered throughout the stem of the monocot and having a very definite circular arrangement in the dicot. This arrangement of fibrovascular bundles enables one to distinguish all monocotyledonous and dicotyledonous plants. By splitting the stem the bundles may be traced the entire length.

The internal structure of a dicotyledonous stem may be observed in the young growing bean. From the stem slice a thin piece, place it upon a microscope slide, and add a drop of iodine. The pith and the fibrovascular bundles are plainly visible. They may also be stained with ink, carmine, eosin or other stains, as described above for monocots.

An interesting activity is that of making a collection of tree stems. Branches about three-fourths of an inch in diameter are sawed transversely on one end and obliquely on the other end. The pieces should be cut about four inches long and mounted on wire or laths. The pupil should be required to label the stems, thus becoming acquainted with the trees of his community. Stems of the same class and family should be grouped together for comparison.

Other activities are used in vitalizing the study of plants. Response to light (phototropism) may be demonstrated with any house plant by changing the position of the plant. If the leaves be pulled from the Irish potato, the vine turns green and new leaves are produced by the auxiliary buds. A tube is made for an Irish potato vine by rolling sheets of heavy paper. Keep the cylinder raised near the top of the plant and it will grow to a height of five to eight feet, depending upon growing conditions.

Allow an Irish potato to grow upright and then place the container, bottom side up, in a position above the light source and compare the geotropic and phototropic influences. The goetropic force is greater for the stem, but the leaves assume a position for light.

Take a willow branch from a tree in midwinter and place it in a jar of water. Set it aside in the laboratory and observe from time to time. Note the green leaves and roots that appear. As spring approaches, the plant may be planted and observed.

Other means of propogation may be demonstrated. Budding, layering and grafting, which are beyond most biology teachers, are practiced in the nursery, and most nursery officials welcome visitors. They usually are delighted to carry on demonstrations for the public and will bring the demonstrations to the school if the class is unable to visit the nursery.

Roots

The structure of the roots may be demonstrated by sprouting some corn in water-soaked cardboard. An onion set on a glass of water will sprout a root set that is useful. After observing the external appearance, one may cut their slices, mount on slides, and stain with iodine for temporary use with the microscope.

Place a funnel in one end of a box about eight inches long, filled with soil. In the other end transplant a plant. Partially plug the funnel and fill with water. Moisture is admitted slowly. After a few days, remove the dirt and observe the roots extending toward the moisture.

Pour some mercury in a beaker, cover with water, and place a young growing plant on the mercury. After about two days, one will find that the roots have penetrated the mercury, thus illustrating geotropism.

Variations and extent of root system are best studied in their natural habitat. A class period in the field with some digging will reveal unusual variations in root systems.

A booklet of very small root systems is made by digging the root system, washing the roots very carefully, drying while pressed, and fastening on the paper by gluing small strips of paper over the roots. The roots should be grouped and carefully labeled.

Flowers

A collection of flowers is perhaps the most interesting activity in the biology class. The flowers should be picked about the time that the pollen matures. They may be carefully laid in old magazines or books and weighted so that they will dry pressed.

A box or case may be made several different ways, but the essential feature is a removable glass cover. The cover permits examination of flowers, insertion of new ones, and label changes.

The pressed flowers may or may not be dipped in paraffin. Dipping preserves the color but if they are placed in a tight box and not placed in bright sunlight, they retain their natural color for a long time. All mounts should be grouped and labeled.

The fresh flowers from the field are more useful in all the laboratory work where detailed structure is being studied.

CHAPTER V

ANIMAL LIFE

The usual procedure is to follow the classification of animals for natural sequence and thereby make the survey of the animal kingdom simple. This procedure gives one the'bird's-eye view' of the evolutionary plan and helps the pupil to see that he is at the top and, therefore, softens the idea of being called an animal.

Upon examination of six recognized texts and six manuals, the writer has placed the animals common to all these in the proper phylum which, according to Negner,[1] are:

Phylum	Animal
Protozoa	Amoeba, Paramecium
Coelenterata	Hydra
Platyhelminthes	Planaria, Flukes, and Tapes
Nematyhelminthes	Trichinella (spiny-headed worms)
Anelida	Earthworms and Leeches
Mollusca	Clams and Snails
Arthropoda	Crayfish, Grasshoppers, other insects
Vertebrates	Amphibia, Reptiles, Fishes, Birds, and Mammals

Protozoa

The Amoeba.--A culture for study may be prepared by collecting a few pond weeds or lily leaves, placing them in a flat dish and immersing them in pond water, or water from an old cellar or well. Observe these daily. If amoeba are present, they should appear in about two weeks. They may be found by pipetting a few drops of the sediment onto a slide and examining with the microscope.

Amoeba do best with a moderate temperature(about 75 degrees F.), diffused light and very little food. Direct sunlight is harmful to amoeba and may cause more vigorous protozoa to appear in the culture. Wheat kernels and small pieces of timothy hay, which have been boiled about five minutes, make good food for them.

After about three weeks, amoeba may be seen as tiny white spots on the bottom of the dish. They are easily pipetted off and studied alive in a drop of water on a microscope slide or in a small watch-glass.

The Paramecia.--The amoeba culture will probably later develop paramecia. A culture may be prepared, with very little debre', by boiling some water with a few grains of wheat and setting aside in a jar after innoculating with a few drops of pond water.

In about one week paramecia should be found in the top skum around the edges of the jar. Pipette a few drops of the water to a slide upon which a few fibers of cotton have been placed. The fibers prevent too much movement of the paramecia and allow detailed study with the microscope.

Coelenterata

The Hydra.--The hydra are found in the fresh water of most streams, especially those fed by springs. They may easily be seen clinging to sticks, rocks, and leaves of slow moving water. The depth that hydra occupy depends upon the temperature. They cannot stand high temperatures and will be found in deeper water in summer. It is difficult to culture hydra and it is, therefore, advisable to study the fascinating animal whenever it is found.

Platyhelminthes

Planaria.--The planaria is easily collected by syspending a piece of raw beef, attached to a string, into a fresh-water stream. They are attached to rocks, leaves, and plants in slow moving water. Since they are very fond of beef, they fasten themselves to the meat and may be gently raised out of the water and shaken off into a container of fresh water. They may be kept several weeks by occasional feedings with beef liver. They cannot live in stagnant water, therefore, the water should be drained off occasionally.

Planaria may be studied in a watch-glass. Their remarkable power of regeneration makes them fascinating as well as illustrating the rudimentary gastrovascular cavity which is more highly developed in higher animals.

Flukes.--The many kinds of flukes, including liver, lung, and blood flukes which are very important parasites of man, may be illustrated by a fluke found frequently in the turtle. Most any turtle will have some specie of liver, lung or blood fluke.

These may be obtained by disecting the turtle and examining the lungs or liver in a finger bowl of tap water. The body organs are torn or teased apart in the water and the fluke will be found free in the water. It should then be examined in a watch-glass with the microscope or hand lens.

Tapes.--There are many kinds of tapeworms, several of which are important parasites of man. Almost any cat or dog harbours enormous numbers in the small intestine. These may be obtained by disecting the animal and taking them from the intestine.

The tapeworms should be carefully removed to be sure the head (scolex) is obtained. Place the worms in a bowl of water and wash them. After washing they should be killed in fifty percent boiling alcohol and stained for study. The staining and mounting is easy and may be done in most laboratories. However, the general nature and structure of the worm may be studied without mounting.

Nematyhelminthes

Spiny-headed Worms.--The spiny-headed worms to which the trichinella and pinworms are similar may be obtained by disecting an amphibian or reptile. A frog is desirable for this purpose. Disect the frog and examine the large intestine and mesentary. They will be found with the spiny thread-like head woven into the tissue. These are round worms and resemble a shepherd's staff. They may be killed in hot fifty percent alcohol and stored in a mixture of ninty-five percent alcohol and glycerine. They do not require staining, but are then ready for detailed study. They may be stored in glycerine for later use.

Anelida

Earthworms.--The earthworms may be found by spading along old fences or buildings where there is some decaying vegetation. In wet weather they may be found in most soil. Since they respire through the skin, care must be exercised to prevent drying. This feature accounts for their presence on top of the soil in the early morning of damp weather and on cloudy days after rain. They do not dry so rapidly and are able to live on the top soil.

By a little searching, the localities having the very large forms may be located. The worms should be collected and placed in a container with plenty of moist earth to prevent drying and knotting. They should be taken to the laboratory.

If the class is ready for the study of earthworms or soon will be, the worms should be placed in a jar, preferably a stone or brown jar, containing a little water and plenty of water-soaked towel paper. Then set the jar aside in a cool dark place. In about ten days the worms will have passed the soil and the paper will occupy the digestive tract. They are then very clean and responsive to experimentation.

Leeches.--Other anelids useful and interesting for study are the leeches. They are found on rocks, sticks, plants, and often burried in the mud in dark places of lakes, ponds, and sluggish muddy water. They are often found attached to turtles and other marine animals. After collecting the leeches, they are easily kept in the fresh-water aquarium or in muddy soil. They require little food and if once well fed will remain in the aquarium for months without further attention. They crawl on the side of the smooth-surfaced glass and make study amusing and easy.

Mollusca

Clams.--The fresh-water clams, so much like the oyster and other important marine food animals, are found in the bottom of fresh-water streams partly buried, head downward, in the mud or sand. They may be picked up, placed in a container of fresh water, and carried to the laboratory for study.

Observation in the aquarium will reveal the very peculiar method of locomotion and anchorage made possible by the muscular pad, the foot. In a clumsy manner, the clam plows through the sand. The method of food-getting may be demonstrated by dropping some ink or stain near the posterior end where the siphons are located. One of the siphons has an inward flow and the other an outward flow of water.

By disecting one of the clams, one finds peculiar structural arrangements not found in other animals.

Snails.--The little slow-footed home owners are more numerous and more common than clams. They may be found in ponds, lakes and streams, usually near the edge on weeds or leaves. They are easily kept in the fresh-water aquarium for long periods.

Study of the snails reveals soft twisted bodies that fit the shells when retracted. The muscular-padded foot is the organ of locomotion and attachment.

Students observing the snail will note the creeping movement along the side of the glass caused by the wave-like contraction which starts at the posterior end and moves backward. The progress is constant on smooth or rough surfaces due to the secretion of the pad. By using hand lens, the eyes on the ends of the two tentacles may be seen. A little disturbance causes the snail to recede into the shell for protection.

Arthropoda

Crayfish.--Crayfish furnish very unusual adaptations of appendages. They may be found in streams and crawling on land in grass marshes. The fascinating animal may be kept alive in the fresh-water aquarium for a long time; they may be kept a few days in a container with a little water and some moist soil, leaves, or towel paper; or they may be preserved in ten percent solution of formalin.

The crayfish are best for study while being kept in the aquarium. Here the external structure, adaptations and use of the appendages, and the method of feeding may be observed. The preserved crayfish are useful for disection and internal study.

On a field trip is perhaps the best place to study other arthropoda. Here the most hideous of living creatures may be observed in their natural habitat. One may observe the scorpion inserting its poisonous sting into a beetle and see the beetle, as he valiantly fights for life, weaken, shiver, then crumple in death. Some zoologists claim that no animal can die of its own poison. However, reports have been made of scorpions being tortured by fire and, rather than to suffer burns, thrust his sting into his back and die--a case of self-inflicted death.[2]

The carnivorous spiders, the spinners, weavers and builders, may be observed in their natural habitat and seen, in their artistic weaving, fixing traps for other insects. Since the spiders are equipped for seeing both night and day, they may be seen at work both night and day weaving those geometric constructions with infinite accuracy.

The grasshoppers, the typical insects, are plentiful, and sufficient study of his natural habitat and protective coloration will be done in collecting them. They may be taken to the laboratory and disected. The large size and well developed parts make it the most desirable for laboratory study.

The life cycle of a representative insect may be demonstrated in controlled experiment with Cecropia moths.[3]

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[2] A. O. Baker and L. H. Mills, Dynamic Biology, p. 374.

[3] Turtox News Series, Op. Cit., Vol. 13, No. 3, March, 1935.

Moths are found in many trees, most commonly in maple and willow trees, in the fall. They should be gathered and placed in an orange crate covered with screen. Place a layer of moss in the bottom of the crate and lay the cocoons on the moss. The box should be kept outside in snow and sunlight to imitate nature as much as possible. The moss helps to regulate the moisture.

When spring comes, move the box to a leaf shade where it will be well drained. The moths will hatch about the latter part of May, crawl up the wood crate, and dry in about an hour.

In about twenty-four hours mating will have taken place. The eggs are laid immediately. They may be gathered and placed in a jar with some leaves. They will hatch in about two weeks. The caterpillars should be put in dry jars, four or five to the jar. Change the leaves and dry the jars daily. Avoid moisture as it causes molds, the natural parasite of the larvae in captivity.

After feeding and maturing the larvae forms a cocoon and the procedure may be followed for another generation.

Elementary classification may be begun by insect collections. The collecting equipment described in Chapter I may be used.

Some skill in the use of cyanide jars, nets, and stretchers will be acquired with practice. Since the powder scale of moth and butterfly wings is easily removed by touching with the fingers, it will be necessary to practice handling the insects with tools.

Assuming that one has the scaled-winged insects in the net, lay the net upon the ground with the mouth downward over the cyanide jar, remove the lid, and bring the part of the net containing the insect near the mouth of the jar. It will fall in with ease.

Allow the insects to remain in the jar a short time. They soon die and should be removed to another dry container and stretched for drying as soon as possible.

Stretching should be done with tools to avoid touching the insects with the fingers. First stick a pin through the thorax into the board in the desired position, spread the wings to flying position and fasten by pinning narrow strips of paper over them. Then set the board aside for a week or more.

After the insects have completely dried, they may be placed on display in cases in groups according to class of family with the proper labels for future use.

Some of the soft-bodied insects, such as spiders and larvae, cannot be successfully stretched and dried.

They should be preserved in museum jars in five percent formalin. Stronger solutions extract the color.

Some hard-winged beetles make better mounts by leaving the wings folded and spreading the legs so that they are visible from the dorsal side.

Vertebrates

Amphibians.--The forg, a slick, slimy-skinned amphibian that starts life in the water and then moves to land, is perhaps the most frequently used vertebrate for laboratory work. Its habits and number make it easily obtained, its development is characteristic, and its structure is desirable for laboratory purposes.

As soon as spring rains begin, frog eggs may be found attached to sticks and grass in shallow water near the shores of ponds and lakes. This large jelly-like mass may be found eight to twelve inches under the surface of the water.

The females lay the eggs in the shallow water, after which they are fertilized by the male. They may be gathered and placed in the laboratory aquarium. Here the cleavage and embryonic development may be studied with the hand lens. The early grassfrog is best because of the large size of embryonic cleavage and the comparatively short period of development.

The class may observe, in a short time (about ten days), the small tadpole emerge from the jelly-like mass. He swims about freely and feeds upon the algae and other vegetation in the aquarium.

The young tadpole will have external gills for breathing, a tail for swimming, and a pair of rough jaws for chewing bits of vegetation. Within eight or ten weeks the full-grown tadpole develops. Then the gills begin to disappear and he assumes the appearance of an adult by development of lungs, absorption of the tail, and development of both pairs of limbs. This procedure is forcefully taught in the laboratory.

If time will not permit this procedure, a toad may be used. The same procedure should be followed and the time will be much less. Frog and toad eggs may be distinguished by the fact that the frog eggs are laid in mass while toad eggs are laid in strings of the jelly-like substance.

Reptiles.--The snakes, turtles, lizzards, and toads are familiar reptiles of most localities. They may be collected and preserved for the laboratory museum. The adaptations make them very useful laboratory subjects. Their protective coloration is probably not excelled by any other group of animals, not even by birds or insects. This is realized when one tries to find a treefrog on a tree's trunk.

The live specimen should be kept in the laboratory in a screened cage. By feeding and observation, pupils will usually change their opinion of the horribleness of reptiles. They will discover that, although a few are poisonous, many are helpful to man.

Specimens for the laboratory museum and disection should be placed in small, wide-mouthed, museum jars and covered with a ten percent solution of formalin. If the animal is very large it should be injected with some of the solution by using an injection syringe. If this instrument is not available, a few incisions may be made along the mid-ventral line. This allows the solution to penetrate and preserve the flesh before decomposition begins. Some larger animals may be placed in stronger solutions for about twenty-four hours and then removed to weaker solutions, from two to ten percent. Stronger solutions often absorb the color, a very desirable feature to have in preserved specimens.

Fishes.--A trip to the creek or pond by the class for fish is not recommended. If members of the class are interested sufficiently to volunteer to make a fish collection, some may be assigned this task.

The fish should be placed in fresh water glass containers for study. Such characteristics as the color markings, shape of head and body, and the position, shape, and structure of fins should be noted because of their use in classification.

Some of the collection should be disected. A very good procedure is for the teacher to disect one large fish for demonstration, explaining the structure and function of various parts. Then, if any members wish, allow them to disect some. Since it is easy to overcrowd the fresh-water aquarium with fish, most of the remaining ones should be killed and stored in museum jars with proper labels, which should include the name of the fish, time and place of collecting, and the name of the collector.

The canabalistic nature and 'survival of the fittest idea' may well be demonstrated by placing several small fish of different kinds and sizes in an aquarium. Data on the kinds of food used, their growth, and survival should be kept. This demonstration works best if the amount of available food is gradually decreased. Any fish which die should be removed immediately.

The writer has an experiment being carried on by a biology student.

The Experiment: Eight very small minnows, about one and one-quarter inches in length, were placed in a one-gallon capacity, round, glass bowl in November, 1935.

During the first month fresh water was added every four days, then the changes were made less and less frequently. At present, the water is changed every fifteen days.

The fish are fed plenty of soda crackers and occasionally some fresh meat such as beef liver or earthworms. This full meal is given a few hours before the water change, because the change removes excess food material which should not remain in the bowl. Twice between each change they are fed a small feed, not more than will be completely eaten.

Today there are five of the original fish living, (three died the first month), which are about twice as large as they were when the experiment began. The round bowl, which is a good magnifier when filled with water, is an excellent container in which to observe the fish. Their bodies have become so clear that the gills, heart-beat, digestive tract, and the skeletal system may be observed as in an ex-ray picture of the bony system.

The experiment was carried on in the laboratory until the end of the school term, when it was removed to the home of the biology student. It will be returned to the laboratory when school begins in September. Further results may not be accomplished but the project has given more pleasure to the students than feeding goldfish could have given, and the writer is sure that a great deal more knowledge of the fishes' anatomy and adaptive ability has been attained.

Birds.--Birds are best observed by small groups on field trips. The groups should visit various places at different times during the year and observe the birds in their natural habitat. Notebooks should be kept containing descriptive data on their habits, appearance, song, nesting, etc. A good manual should be used on these excursions. Since study in solitude is desirable, the most satisfactory study is made in groups of three or four, or even less in number. One or two pupils should use the key or manual as guide and the others should take the notes.

Students may be taught by one demonstration how to skin and mount birds for the laboratory museum. The first attempts at skinning the birds are usually not successful, but these skins are not wasted because they can be used in study. Pupils delight in taxidermy work and take a great deal of pride in preparing life-like mounts. This is a great motivating interest and a very good method of teaching the general anatomy of birds.

Predatory birds should be used for the taxidermy work. Very few, if any, song birds or those beneficial to man should be used because conservation of these is important. It is recommended that pigeons, crows, and bluejays be used by beginners.

Other effective methods of teaching the nature of bird life are by making bird charts on the arrival, stay, and disappearance of migratory birds and by making bird books. Pictures for the books may be obtained from magazines and from other sources mentioned in Chapter II.

Mammals.--One often thinks of local material as being rather limited because he has no monkeys, lions, elephants, nor many other wild animals in his locality to study. However, the dog, cat, hog, sheep, cow, horse, goat, rat, opossum, squirrel, rabbit, etc., so numerous in most communities, make much more desirable subjects for study.

For study of the domesticated animals, a trip to a nearby stock farm with notebooks and carefully planned laboratory directions will prove most successful. These farm animals may seem very familiar to the casual observer, but when such questions are asked as: Do sheep have horns? Which end does a horse or cow raise or lower first when getting up or down? Does a cow have front teeth on the lower and upper jaws? One finds many who have really never seen a farm animal. With the proper laboratory directions, individual home study may suffice in some communities but too much should not be inferred. To understand our surroundings should be one of our objectives.[4]

The wild mammals of the community, opossum, squirrels, rats, etc., may be caged and observed. Some of these may be killed and their skins mounted in life-like form. This is the most effective means of teaching their general anatomy and a great motivating force because of the satisfaction that comes to the student. These mounts should be added to the laboratory museum. They will prove beneficial in the study of mammals because live ones are not always available.

Whenever possible, the class should visit a zoo for a supervised study of the unusual animals. The instructor should visit first, confer with the keeper, and plan the trip. In this way there is a minimum time loss and the visit is most interesting and effective.

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[4] Kansas Department of Education, Course of Study, Part V--Science, p. 34.

CHAPTER VI

CONCLUSION

Laboratory manuals based upon texts should be suggestive. No one should attempt to follow these and expect to teach the biology of his community. Theoretically, the ones which attack the problem from the standpoint of evolution would make scientific classification and the knowledge of the plant and animal kingdoms a very simple matter. Psychologically, the one who attempts biology by beginning with the immediate surroundings and allows the interest of the class to determine the subject matter should have better results.

Very little money is needed to equip a biology laboratory. This does not mean that equipment is not essential. Many articles, not being used in the homes of students, may be substituted and serve satisfactorily in the place of expensive laboratory equipment.

There are many ways and means of arousing interest in the biology class. Of those attempted, a few have proven successful. These are discussed in this chapter. Perhaps more research or experimentation will be carried on in this phase of biology teaching than in any other, because teachers may have an abundance of equipment and subjective material. But if they lack the interest of the child, which these auxiliary agencies are designed to attract, they may expect failure.

The experienced teacher of biology should confine himself to the subject matter of the local community and attempt to organize units of work that will be seasonal. In later life very few pupils will enjoy equipment equal to that of the average biology laboratory. Therefore, a scientific procedure of thinking about one's immediate environment would contribute most to help him adjust himself to his environment.

The making of equipment and using the subject material at hand should develop the resourcefulness, an essential characteristic of a scientific thinker. Pupils are more interested in things which they can sense. Surely more benefit will be derived from an understanding of the things about them than from descriptions of things that they may never encounter.

The methods of utilizing local material, as described herein, encourage the collecting instinct and lead to the development of interesting hobbies which are educational, economical, entertaining and socially elevating.

One does not need to follow the usual procedure as the arrangement of the material herein would suggest, but it should be taken up more from the regional and seasonal standpoints.

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