LIVING SPECIMENS FOR BIOLOGY TEACHING IN WESTERN OREGON HIGH SCHOOLS

by

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A THESIS

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R. A. B.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Plan of the Thesis</td>
<td>1</td>
</tr>
<tr>
<td>II</td>
<td>The Plant Kingdom</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Thallophytes</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Bryophytes</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Pteridophytes</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Spermatophytes</td>
<td>22</td>
</tr>
<tr>
<td>III</td>
<td>The Animal Kingdom</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Protozoa</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Coelenterata</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Platyhelminthes</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Annelida</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>Mollusca</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>Arthropoda</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>Crustacea</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>Insecta</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>Arachnoida</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>Pisces</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Amphibia</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>Reptilia</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>Aves</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>Mamalia</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>Rodents</td>
<td>68</td>
</tr>
<tr>
<td>IV</td>
<td>Vivaria and a Herbarium</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>Aquaria</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>Terraria</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td>Insect Cages</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>Rodent Cages</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>Reptilian Terraria</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>A Herbarium</td>
<td>76</td>
</tr>
</tbody>
</table>
THE PLAN OF THE THESIS

The immediate purpose of this thesis is the presentation of a series of suggestions for the collection and the maintenance of living specimens from the plant and animal kingdoms for high school biology laboratories. It is the belief of the writer that there is too little work with actual specimens in many laboratories and too much dependence on textbooks, oftentimes with embarrassing results when the pupils' knowledge is brought face to face with field tests. The study of this thesis should make the gathering and maintenance of living specimens by both teachers and pupils not only more possible than it is now, but it should make more pleasant what is too often a source of worry and irritation at present.

This thesis includes only materials which are available almost everywhere in western Oregon, although a few of the materials are localized in the coastal region or in the southwestern counties. These have been indicated specifically wherever they are listed in the thesis.

The teachers of biology are employing more and more the study of living forms. It is only logical that this very decided trend should become evident since biology is the study of living things. Pupils can not understand this subject unless they are allowed to study living things at first hand. It is true that the dissection and the observation of the parts of preserved forms are important, but they are only a part of the subject of biology. They should be supplemented by the trained observation of plants and animals in habitats that are as nearly like their native habitats as is reasonably possible. This thesis presents a list of some typical plants and animals suitable for laboratory study, with suggestions for their collection and maintenance in order to help carry out this new trend in the study of biology.

Interest in collecting and curiosity about living things are inherent in almost every human being. These, sometimes, remain only as desires because the people do not know what to collect, where to find desirable specimens, or how to care for them when they are found. Many people do not collect because they are afraid of practicing unintentional cruelty and waste of life. This is a pity because nowhere else, either in the province of fact or of fancy, can one find more surpassing marvels than are to be discovered in nature. Among the plants and animals, one may find structures and habits of life that range from the amazing to the fantastic. He may find traits which in some ways seem highly intelligent. He may see remarkable exhibitions of instinctive actions and unique adaptations for purposes of protection, feeding, locomotion, and reproduction.
Many of these wonders are to be found in the plant and animal forms near at hand; others as far afield as one cares to go. Many of these astonishing processes and fascinating life histories can take place in the laboratory before the eyes of the pupils. The observations of some of these remarkable activities may not only stimulate interest and arouse curiosity on the parts of the pupils, but may lead to individual field trips and to deeper knowledge about and appreciation of plant and animal life.

In the future it will probably be more true than it ever has been before that the happiness of mankind will depend considerably on his ability to employ his spare time in some gratifying hobby. There are no more safer, lasting, healthful, and satisfying hobbies than the study of the whole field of biology or some of its special phases.

This study was made to assist teachers, pupils in school, and individual students who are interested in collecting, keeping, and observing plants and animals in the laboratory. The field of living material is so vast and varied that only a few typical forms have been selected for this study. There are innumerable possibilities among the various species which one will find just as suitable for the laboratory as those which have been selected for this paper. These have as many or more interesting structures and habits than those included here. It is hoped that this study will serve as an incentive for further collections and experimentations among plants and animals in the laboratory or on the parts of the readers.

This study is divided into four parts: The Plan of the Thesis, The Plant Kingdom, The Animal Kingdom, and Vivaria and Herbaria. Parts II and III present typical local species of plants and animals. With each there is a brief description, a statement of its dwelling place, the season in which it is found most easily, the reason for its inclusion, and the principal points to know in its maintenance. Part IV deals with the various types of vivaria; aquaria, woodland, marsh and field terraria, insect cages, reptilian terrarium and mammal cages. The section on the herbarium deals with the collection, pressing, mounting, and storing of plants.
Chapter II

PLANT KINGDOM

Plants are classified into four groups: thallophytes, algae and fungi; bryophytes, liverworts and mosses; pteridophytes, ferns, horse-tails, and club mosses; and spermatophytes, gymnosperms, and angiosperms. The first three groups are known as the flowerless or non-seed bearing plants; the last group consists of flowering plants which bear seeds.

I. THALLOPHYTES.

A. Algae.

Algae are simple plants without true roots, stems, or leaves. They possess the green pigment, chlorophyll, which enables all plants to manufacture food and, thus, to live independently. Some species of algae have additional pigments which obscure the chlorophyll by changing color. There is a great diversity of appearance among the algae. They range from unicellular, microscopic forms to those having multicellular, highly differentiated tissues. Most of the algae are aquatic, although some grow upon soil or rocks; and a few on the bark of trees.

1. Green Algae.

Green algae, or chlorophyceae, are distinguishable through the green color and the cell nuclei present. They may be either unicellular, colonial, or filamentous in form, according to the particular kind. Some of the commonest forms of green algae are: protococcus, spirogyra, cladophora, and vaucheria.

a. Protococcus

Protococcus is the thin, green, paint-like coating which occurs on the bark of trees and on rocks. This coating is composed of large numbers of tiny protococcus plants, each of which is a spherical, microscopic cell consisting of a cell wall, cytoplasm, a large chloroplast, and a nucleus. Reproduction in the protococcus is by fission. The resulting cells may adhere to each other in groups of two or four; or of larger numbers which form a colony.

Protococcus may be found on objects which have been in moist greenhouses, such as stones, bricks, or flower pots. It grows, also, on the bark of trees near the base, and most abundantly on the north side, on fences, telephone poles, and the north bases of buildings. The algae are very common in all seasons, but during the summer months they have a gray-green or brown color.

Protococcus represents a most simple plant which carries on
its own life activities of food manufacture and reproduction independently of a host.

b. Spirogyra

Spirogyra is the common pond scum which floats on the surface of ponds and quiet ditches. The filaments are slippery to the touch and are, usually, formed in flocculent mats. When viewed under the microscope, the filament appears as a single row of cells placed end to end. Each cell contains a striking bright green, spiral, ribbon-like chloroplast, which has irregular edges and irregularly spaced pyrenoids, or starch centers. Reproduction in the spirogyra is by cell division and by conjugation. In conjugation, the contents of the cells of one filament flow through the adjoining projections into the opposite cells in an adjacent filament.

Spirogyra is most abundant in the spring and fall months, although it may be found occasionally in the winter. Spirogyra may be used to illustrate conjugation, a more complex unicellular plant, and an interesting type of chloroplast.

c. Cladophora

Cladophora consists of profusely branched filaments, differentiated into bases and apices. The plants are attached to the bottoms of ponds or to objects in the water by holdfasts. Each cell contains many nuclei and chloroplasts with pyrenoids. Reproduction is asexual and is accomplished by means of many large, ciliated zoospores, and is also sexual by means of the fusion of similar gametes to form a zygote. Cladophora grows in stagnant ponds, ditches, pools, and creeks. It is available at any time of the year.

Cladophora may be used to show the way in which differentiation of the sexes may have originated. Ulothrix is the species generally used, but it is not commonly found in Oregon west of the Cascade Mountains. It may, however, be purchased from supply houses.

d. Vaucheria

Vaucheria is a filamentous alga that grows in dense, felt-like masses on moist earth and stones, or in muddy ditches. The filament contains many nuclei and is without cross walls. Specialized branches are developed to produce unlike sex organs. One species of vaucheria is found in greenhouses on the soil or flower pots, but it is found only in the vegetative phase in this situation. This species may be obtained at any time. The vaucheria which reproduces sexually occurs in the spring in ponds and ditches. Vaucheria may be used to illustrate differentiated sex organs.

Brown algae, or phaeophyceae, are marine plants which possess a brown pigment (fucoxanthin). They vary in size from simple filaments to large, many-celled, differentiated structures. The large forms are of a tough, leathery texture and are normally anchored to objects by means of holdfasts. Two common representatives of this group are fucus and nereocystis.

a. Fucus

Fucus is a leathery, flat, ribbon-like thallus, which is attached to rocks by a holdfast. The thallus branches dichotomously or forks at intervals, has a row of thickened cells down the center forming a "rib", and grows by means of an apical cell. At the tip of certain branches are specialized cells or oogonia, within which extremely differentiated sex organs develop.

Fucus occurs in great masses on the rocky shores of the Pacific Coast where they are alternately covered and exposed by the ebb and flow of the tides. The plant is available all year. Fucus may be used to illustrate the fact of dichotomy, a typical brown alga, or its further specializations may be studied for themselves.

b. Nereocystis

Nereocystis, a bladder kelp, is a large brown alga attaining a length of thirty or forty feet, or even one hundred feet. The plant has a long, rope-like stalk, anchored to a rock or other object. This is enlarged into a large, hollow, bulb-like float, on which are borne numerous ribbon-like blades.

Nereocystis occurs in extensive beds below the low-tide level along the Pacific Coast. Plants are often washed ashore and may be collected during any season.

Nereocystis represents a large, interesting form of brown alga.


Red algae or rhodophyceae are almost exclusively marine plants, although there are a few exceptional forms that live in fresh water. A red pigment, phycocyanin, completely or partially conceals the chlorophyll. The body of the red alga is usually a delicate ribbon or finely-branching filament which may live at quite a depth below the surface where the waters are quiet and warm. The reproductive structures of many of the red algae reach a complexity surpassing that of any of the other groups. The group, as a whole, is characterized by non-motile cells. A variety of interesting species, such as coralline, omagloia or nemalion, polysaphonia, and nitophyllum may be collected at marine gardens, or they may be gathered after they have been washed ashore. They may be collected at any time during the year.
COLLECTING AND GROWING ALGAE.

For collecting algae, one needs several small closed containers, such as four-ounce, wide-mouthed bottles in which to carry specimens; and one or two large jars or jugs in which to carry a supply of pond water for the culture solution. For carrying algae, one should fill one-fourth of the vessel with algae and then add the pond water. The algae are likely to deteriorate if the bottles contain too many algae and not enough water.

For the algal aquarium, any glass container, such as a gallon jar, a battery jar, a fruit jar, or glass bowl, or a tumbler, will do. A school might, of course, have a larger one or one more neatly made. Glass covers are needed also. One should put an inch of clean pond dirt, sand, or gravel in the bottom of the vessel, then fill it with the pond water which was brought in. If one has to use tap water, he should let it run for several minutes, then pour off some into a container and allow it to stay for a few days. Chemicals, such as chlorine, and water which has stood in pipes are injurious to most algae. Then additional water is needed, pond or aerated tap water should be added gradually to compensate for the evaporation which has taken place.

A very small amount of material should be put into the jar. A clump of algae the size of a dime to a gallon of water is all that is necessary. It increases rapidly in amount and accommodates to the conditions. Excess material will choke off and decay, and cause fermentation and fouling of the culture.

Healthy cultures have periods of dormancy, and produce spores which will be found at the bottom of the jar. When this takes place, one should allow the plants to become dry, and should cover them and set them aside for a time. After a few months, and when water is added, the cultures will grow again quickly.

Cultures may be started at any time. In addition to the algae, other materials, such as sticks, stones, leaves, or mud from good algal localities, may be placed in the aquarium with the pond water. These objects will usually yield a variety of species of algae. Fruiting conditions in the algae may be induced in many of the algae by using a Knop's solution. (4,212)

Marine algae are difficult to maintain in ordinary laboratories due to the lack of equipment for proper aeration and cool temperature. Marine algae should be dried and put away. When they are needed, soak the plants in warm water to restore pliability. Fucus and small species of red algae can be floated on heavy paper or cardboard, and then dried under pressure. The specimens should be "teased out" into natural positions. There is sufficient mucilage in the plants to make them adhere to the paper indefinitely. Small nereocystis and other small bladder kelps can be mounted in the same way. Nereocystis, however, does not keep long in formalin as it tends to disintegrate within a year.
For collecting terrestrial species, such as protococcus and vaucheria, a stout knife is needed to remove these encrusting forms together with a portion of the substratum, from wood or soil, and from rocks. Wax paper or collophane packets make good containers for transporting collections without too much drying. These algae will live indefinitely in a woodland terrarium, or in a moist chamber.

B. Fungi.

The fungi are plants which lack chlorophyll and are, thus, incapable of food manufacture. They live either as saprophytes upon dead plant and animal material or as parasites upon living plants and animals. Some fungi are colorless; many contain brown pigments in their vegetative parts; and others have a conspicuous color, such as red, yellow, flesh, purple, brown, or black. The plants range in size from the microscopic cells of the bacteria to the larger and more complex forms such as mushrooms. The vegetative body, or mycelium, is composed of loosely or tightly combined filaments, or hyphae, which, under appropriate conditions, produce the fruiting bodies. Spores are developed in various ways in the different species, often in specialized structures.

The following common fungi are suitable for the laboratory:

1. Bacteria.

Bacteria are microscopic, unicellular plants which have three characteristic shapes: rods or bacilli, spheres or cocci, and spirals or spirilli. Individual forms appear colorless, but in large masses the colors may be grayish, yellow, or orange. Reproduction in bacteria is by fission. Bacteria abound everywhere. They are in the air, the water, soil, food, objects, inside of living and dead plants and animal bodies wherever conditions are favorable. Bacteria are either parasitic or saprophytic, or both, and important economically because of the beneficent activities of some kinds and the injurious activities of others.

Bacteria specimens may be used to illustrate the three types of shape, and to show some beneficial and some injurious species.

2. Phycosmycetes.

Phycosmycetes are fungi which are characterized by hyphae lacking in crosswalls; by non-sexual spores in sporangia; and by the formation of zygospores by conjugation. Saprolegnia and rhizopus are common forms of this group.

a. Saprolegnia

Saprolegnia is a water mold that appears as a white coating of radiating lines about the bodies of dead or living insects and fish. The mold often infects inhabitants of aquaria and fish hatcheries. The infected specimens should be removed and given baths in a weak solution of potassium permanganate for fifteen minutes daily. One should use five small crystals of permanganate to one quart of
water. Make a fresh solution each day. Spores of the mold are in stagnant water, such as that in ponds and ditches, and are likely to lodge on the larger inhabitants and to germinate at any time. Saprolegnia may be used to show a water mold which is saprophytic or parasitic.

b. Rhizopus

Bread mold or rhizopus appears in thick, cobwebby patches of hyphae bearing black, dot-like fruiting bodies on the surface of stale bread or similar material, and produces a musty odor. Spores of this fungus are always present in the air, and infect material whenever conditions are favorable. They require moisture and warmth, and prefer darkness. Rhizopus may grow on potatoes, apples, and pears as well as on bread.

Reproduction is done asexually by spores, and sexually by the fusion of plus and minus hyphae to form zygospores. Rhizopus may be used to show the development of a typical phycomycete and the production of spores and zygospores.

3. Ascomycetes.

Ascomycetes are fungi that are characterized by septate hyphae; and by a fruiting body, either closed (perithecium) or open (apothecium), both of which bear sexual spores (ascospores) in sac-like cases or asci. Many species produce asexual spores or conidia. In general, ascomycetes appear in the spring, growing on plant or plant materials. Some of the common forms are yeasts, peziza, powdery mildew, and lichens.

a. Yeast

Yeast is a microscopic, unicellular plant which lives as a saprophyte upon dead vegetable matter. It is characterized by round, colorless cells, and "budding" to form new cells. The cells often adhere to each other forming chain-like colonies. Yeasts are of economic importance because of their by-products, alcohol and carbon dioxide. These are produced in their fermentation or digestive activity.

Yeast plants are obtained most easily from compressed yeast cakes which are masses of dried yeast plants. Yeast may be used to show a budding form of reproduction.

b. Peziza

Peziza is a common cup-shaped fungus which grows as a parasite upon decaying vegetable matter. The cups or discs vary from one-half to three inches in diameter and are generally white although they turn brown with age. Other colors, such as red, pink, or yellow, may occur. The asci are borne on the inner surface of the cup.
Peziza grows in humus, such as that from evergreen needles or decaying leaves, on old wood and fallen prunes. Young plants may be found in the spring and summer, and mature ones in the fall and winter.

Peziza may be used to illustrate an apothecium.

c. Powdery mildew

This is a parasite which is found on the leaves of higher plants. The fungus at first appears in white powdery patches on the surfaces of the leaves. The powder is due to the production of numerous conidia. Later in the season, little black dot-like fruiting bodies or perithecia arise. These are scattered over the leaves. The perithecia, under the microscope, show characteristic appendages according to the species, produce asci with ascospores. The infected leaves are likely to be deformed or stunted in growth. Alder, willow, dogwood, oak, and lilac trees are often afflicted with different species of this mildew. Powdery mildew may be used to show a typical ascomycetes and perithecia with their interesting appendages.

d. Blue-green mold

Blue-green mold lives as a saprophyte as well as a parasite. Penicillium, the commonest species, appears in blue-green powdery patches on various fresh and preserved foods. The color is due to the numerous conidia which are produced. The mold is one of the worst and most common rot fungi, on oranges, apples, grapes, preserved fruits and jellies, smoked meats, and cheese. It develops at any time from spores which are always present in the air. A yellow mold, aspergillus, frequently occurs with penicillium. Blue-green mold may be used to illustrate a food-rot fungus.

e. Lichens

Lichens are extraordinary and complex plants, each composed of an alga enclosed in a mass of fungus hyphae. The fungus is dependent upon the alga for food, and the alga, in return, is kept moist and protected from dislocation by the fungus mycelium. This relationship is known as symbiosis, or a situation in which two plants live together for their mutual benefit. Most lichens are grayish-green in color, but many of them are yellow, orange, light green, or dark green-black. There are three characteristic types of lichens; crustose or scale or crust-like forms, foliose or flat, lobular and leaf-like forms and fruticose or erect or pendant and branching forms.

The powdery particles which appear on some forms are vegetative reproductive bodies or soredia, each of which contains algal
cells enclosed by fungus hyphae. Apothecia are conspicuous in many of the species. These may be bright red, yellow, or green in color.

Lichens are abundant on trees, stones, logs, stumps, fences, and a few live directly on the soil. Specimens may be obtained at any time.

4. Basidiomycetes

Basidiomycetes are fungi that are characterized by septate hyphae and by a club-shaped structure, the basidium, upon the outside of which four spores or basidiospores are borne. In general, these plants are most numerous in the fall months. Some of the common forms are smuts, rusts, mushrooms, and puffballs.

a. Smut

Smut is a destructive parasite of cultivated cereals, especially of wheat and corn. The smut appears in large swellings or tumors on the ears of corn and in the kernels of wheat. The swollen portion at first contains a mass of the mycelium which later produces millions of black, sooty spores or chlamydospores. The spores are shed in the autumn and either germinate immediately or become dormant until spring, according to the conditions of the environment. Smut may be used to show a disease-producing fungus.

b. Rusts

Rusts are destructive parasitic plants which attack a wide range of other plants. Puccinia graminis or the common rust of wheat and oats causes enormous losses to grain farmers in epidemic years. The fungus has a complicated and continuous life history of five stages, during parts of which it lives on alternate hosts. Two stages, the red rust or uredinal and the black rust or telial, occur on the grains; one stage, the basidial, requires no host; and the other two stages, the pycnial and the aecial, develop only on the common barberry. Due to the mild winter climate of western Oregon, the rust can be carried over from year to year by the urediniospores alone, or by the mycelia within the living cereals and without dependence on the barberry as secondary host.

The red rust appears in the summer as long red blisters on the blades and stems of the grain before it matures. Each blister contains numerous red spores or urediniospores. As the wheat plants mature, the same mycelium produces black blisters with black spores or teliospores. The teliospores are dormant through the winter in the stubble or on the soil. The following spring, they germinate and produce the basidium with basidiospores which infect only the barberry.
On hollyhocks, the rust has only two stages, the telial and the basidial; and requires only one host. Other plants which are infected by rusts are asparagus, raspberry, snapdragon, grasses, and pine trees.

The urediniospores occur in the summer, the teliospores in the late summer or autumn, and the basidiospores in the spring. The rusts illustrate pathogenic fungi which have interesting and complicated life histories.

c. Fleshy fungi

The fleshy fungi compose a group of interesting forms in which the fruiting bodies, which are the conspicuous parts of the plants, vary in both structure and manner of bearing spores. Some of the common forms are: mushrooms, brackets, corals, and puff-balls.

1'. Mushrooms

The most familiar mushrooms and toadstools are umbrella-shaped and bear their spores in gills on their under surfaces. The species vary in color and may be red, rose, ochre, purple, or black. Their colors may be determined by making spore prints. To do this, one should remove the cap and lay it with the gills down on a smooth paper, half of which is white and half black. In this way, the dark spores will show best on the white half and the light spores on the dark half. One should cover the cap to prevent the spores from being blown away. Within a few hours, the spores will have been discharged so that an imprint of the gill arrangement is left and the color of the spores can be determined.

Mushrooms grow in humus, in moss, and on stumps in woods and other damp places. Some are found in meadows, in the fields, on lawns, on trees, and on decayed wood. They appear most abundantly after a warm rain, but may be collected at any time when the weather is warm and damp. The mushroom illustrates a fungus that bears its spores in gills.

2'. Bracket fungi

Bracket fungi are found as shelf-like growths on the sides of trees and logs in the woods. They vary in texture, size, shape, and color. The brackets may be woody, corky, leathery, or fleshy. The large forms are fan-shaped and usually grow singly. The smaller kinds cluster and overlap and resemble ruffles or shells. Brackets are colored in shades of white, yellow, brown, or gray. The upper surfaces of many are hard and convex and are marked with concentric bands or radiating
grooves. The undersurfaces bear numerous pores containing spores.

Most of the fleshy brackets live only one season, but may be found in the spring, summer, and fall. The firm woody or leathery forms grow in size from year to year and add a new annual pore layer below and an extrusion beyond their old limits at their outer margins. They may be collected at any time. Bracket fungi illustrate the very destructive, wood-rotting types of fungi which live on either growing or dead trees.

3'. Coral fungi

Coral fungi are coral-like plants with many branches. The tips of these branches are slightly toothed and often brightly colored when young. The spores are borne in the teeth. The species vary in shades of white, cream, pink, ochre, and brown. Corals grow in the damp woods on fallen logs and in humus in moist shady places. They may be collected in the spring, summer, and fall months.

The corals form an interesting type of fungus that bears its spores in its teeth.

4'. Puffballs.

The puffball includes a variety of curious forms. They appear as white pear-shaped balls within which the spores occur in powdery masses. When the sides of the puffballs are pressed, the spores are carried out in clouds by the explosion.

The bird's nest fungus at first looks like a tiny puffball. As the plant matures, the outer part becomes the "nest" and the original covering shrinks and forms the "eggs". The spores develop within the "eggs".

Puffballs grow in grassy places in the woods where there is shade and humus. They appear in early summer and last until winter. Specimens should be collected early in the fall before the spores have been shed. The bird's nest fungus grows on old wood, such as boards, bridges, board walks, logs, twigs, and old wood piles. The plants appear in May, and may last through the winter.

Puffballs and bird's nests are interesting forms of fungi which develop their spores within enclosed bodies.

RAISING FUNGI IN THE LABORATORY.

Some fungi, such as bacteria, the yeasts, rhizopus, peziza, and the fleshy forms are raised readily in the laboratory.
Bacteria may be maintained in either of two ways. In the first, one may expose a sterilized Petri dish containing sterile nutrient agar to the air of the laboratory for ten minutes and then cover and seal it with paraffin, and place it in a warm dark place for two days. The dish should be sterilized to prevent the growth of unwanted bacteria. Colonies of bacteria will usually develop on the surface of the agar. Bacteria may also be cultivated in sealed sterile test tubes that contain a nutrient, such as agar. In the second, decay bacteria may be cultivated in a hay infusion. One should cut the hay into pieces an inch or two long and put them into a battery jar or other similar container, holding water. They should be covered with a piece of glass and left to stand in a warm place until a scum is seen on the surface of the water, or until a sediment has formed in the bottom, or until the liquid has become decidedly cloudy. This will require from two to eight days.

Cultures of saprolegnia may be made by placing a few dead flies in a jar of pond or ditch water. Within three or four days, the mold should appear about the flies. The water should then be changed every day to prevent bacterial growth. Ant larvae, termites, castor beans, or pieces of meat may be substituted in place of the dead flies.

To make a culture of rhizopus, one should expose a piece of moist, but not wet, bread to the air for about three hours; and then place it on a plate under a bell jar or a glass tumbler. He should put the culture in a warm, but not hot, place. A crop of mycelium will usually develop in a day or two, and black fruiting bodies in four or five days. Pure cultures are made in the same way except that the moist bread is sown with known rhizopus spores and other bacteria are kept out as far as possible. Zygosporae will not be formed unless plus and minus strains of mycelium are present on the bread. The two strains may be purchased from supply houses, or one may experiment with cultures until the two strains are obtained. Zygosporae are formed, when they are present, after four to seven days.

To prepare a yeast culture, one should put a piece of compressed yeast cake into a jar containing a cup of tepid water and a teaspoonful of molasses or sugar. He should let the jar stand in a warm place, about seventy to ninety degrees, Fahrenheit, for a few hours while growth and budding occur. A smaller amount of the mixture will grow very well in a test tube.

Peziza with a portion of its substratum will live in a woodland terrarium or a moist chamber for several weeks just as it is brought in.

Leaves with the conidial stage of powdery mildew may be collected in the late spring or early summer and those with fruiting bodies in the later summer or fall. One should preserve the infected leaves by drying under light pressure. They may be stored in this condition indefinitely. When needed for examination the leaf should be soaked in warm water for several minutes, after which the perithecia may be scraped off and mounted in water.

Oranges or apples with blue-green mold may be obtained at any time.
Lichens, with a piece of their substratum, will live in a terrarium or a moist chamber for many weeks just as they are brought in. Some of the brightly colored species will add to the beauty and interest of the terrarium.

One should collect portions of plants showing smut-infected areas in the summer or early fall before the spores have been shed. The specimens may be dried and stored in boxes or packets. The spores of oat smut and of "bunt" of wheat will germinate in one or two days and produce mycelia. The resultant germinations may be used to show how the mycelia may infect the plants.

Plants with red rust should be collected in the summer, and those with black rust in the autumn. They may be dried under light pressure and stored in packets or boxes. Specimens of the barberry with the pycnial and aecial stages may be secured from a supply house. They may be used to show the two phases of the wheat rust cycle which occur on the secondary host.

In collecting fleshy fungi for the laboratory, it is important to secure a portion of the substratum which contains the mycelium and furnishes the food. Delicate forms should be wrapped in leaves or moss and carried in boxes or baskets. In the laboratory, one should place such specimens as mushrooms, puffballs, corals, bird's nests and small brackets in "moist chambers" which are set in a warm shady place. They may also be arranged and planted in a woodland terrarium. Large brackets may be dried and stored. To add interest, one may bring in bits of decaying wood or humus containing mycelium from regions where various species grow and put them into a moist chamber or a woodland terrarium, where fruiting forms will develop. Mushroom spawn may be purchased from seedmen and raised in the same manner.

II. BRYOPHYTES.

The bryophytes constitute two classes, the liverworts or hepaticas and the mosses or musci. Both are largely terrestrial, and have a distinct alternation of generations. The conspicuous and familiar form of the bryophyte is the gametophyte or sexual plant upon which the sporophyte or asexual plant is dependent.

A. Liverworts.

Liverworts grow in very moist situations, usually on soil, the bark of trees, and occasionally on rocks. There are two types of liverworts; those having flat thallus bodies, and the leafy form whose leaves lack midribs. The plant is generally prostrate, with root-like rhizoids. Some of the thallus species produce little cups on their dorsal surfaces in which tiny buds or gemmae are borne. The gemmae may produce new plants. In some plants, the sex organs are borne on specialized branches. Lunularia, marchantia, and porella are some of the common liverworts found in western Oregon.
1. Lunularia and Marchantia.

These are small dichotomously branches thallus-forms, which lie close to the ground. Lunularia may be recognized by crescent-shaped gemmae cups. The plant grows abundantly in greenhouses on the soil under benches, but only in the gammosferous state. It may be secured at any time, and may be used to show a thallus-shaped liverwort with interesting gemmae cups.

2. Marchantia.

The marchantia is characterized by its leaves with midribs, and by specialized erect branches bearing the sex organs. The antheridial branch bears a shallow lobed disc, and the archegonial branch a disc between the drooping rays. The sporophyte consists of a capsule, stalk, and foot. The gemmae grow in cups which have dentate margins. Gemmiferous plants may sometimes be found in greenhouses, growing among the lunularia. The marchantia grows along wet banks near rivers or streams or in bogs, and may be collected in any season. Plants with antheridia and archegonia appear in the spring; and occasionally with sporophytes in the summer. The marchantia may be used to show a thallus-shaped liverwort with specialized branches bearing sex organs, and interesting gemmae cups.

3. Porella.

The porella is a leafy liverwort. The axis bears three rows of leaves, two on the dorsal side, and one on the ventral. The dorsal leaves are unequally two-lobed, with the smaller bent under, giving the appearance of five rows of leaves on the ventral side. The porella is dioecious. The male plants are smaller than the female. The sex organs are borne on short lateral branches; the antheridia in close sacate bracts and the archegonia at the apexes concealed in envelopes of leaves or perianths, appearing as small buds. The maturing sporophyte elongates and ruptures the perianth, which rolls back. The capsule, which opens by four valves to shed the spores and elaters, resembles a brown flower.

The porella grows abundantly in western Oregon and occurs in dense mats on the branches and trunks of alder, oak, and vine maple trees. The rainy season is the best time to collect the material. The plant dries and appears dead during the summer. Plants with sporophytes are most abundant in the winter and spring. The porella represents a leafy form, with interesting flower-like sporophytes.

B. Mosses.

Mosses inhabit a wider range of less moist situations than the liverworts, and are more abundant. The plants consist of rhizoids, root-like structures, and leafy axes with spirally arranged leaves.
The leaves are somewhat willow-shaped, with either smooth or serrate margins and, in some, there is a row of elongated cells resembling a midrib. The protonema or the early stage produced from a spore is an algal-like filament from which buds arise that grow into leafy shoots. The sex organs develop at the tips of the leafy branches. The antheridia is borne in a cushion-like head surrounded by a rosette of leaves which, in some species, appear reddish. Clusters of archegonia are produced in a head of slightly bunched leaves. From an archegonium in the head a sporophyte develops. The sporophyte consists of a long stalk and capsule. Each capsule is provided with a hood or calyptra which falls off at maturity and a lid or operculum which opens when the spores are ripe. A row of teeth or peristome, lying beneath the operculum, regulates the dispersal of spores. Mnium, polytrichium, and hypnum are a few of the common larger mosses.

1. Mnium.

One of the common mniums may be recognized by the large, roundish, tongue-shaped leaves, and by the erect capsule which forms the terminals of the main axis and which has a beaked operculum. The leaves are light green in color, with rows of elongated cells forming the margins and the midribs. The leaves are very thin, shrivel in drying, and become reddish in color. The archegonial heads are large. Mnium forms dense mats on trees, stone walls, soil, logs, or fallen branches. Other plants grow in lawns and in moist shady corners. The plants are available in all seasons except in the dry summer months.

Mnium may be used to show the typical moss archegonial head.

2. Polytrichum.

Polytrichum is the hair-cap or pigeon-wheat moss. It is distinguished by the long, dark green, needle-like leaves that are sheathed at their bases. In dry weather, the leaves fold up against the stems to prevent rapid evaporation from their surfaces. The reddish antheridial rosettes of this species are large and conspicuous. Polytrichum grows in clumps and forms thick carpets in the fields, meadows, and woodlands. Plants may be obtained in all seasons. Forms with sporophytes appear in the spring and fall. Polytrichum may be used to show a typical moss antheridial head.

3. Hypnum.

The hypnums are slender, prostrate or creeping mosses with irregular branches. The capsules are cylindrical and slightly curved. They are erect, and terminate in short side-branches. The plants are among the most common mosses, growing in thick mats in any moist shady place, such as on the bark of trees, and logs, on fences, or on stones. Hypnum may be collected in any season. The capsules
mature in the fall or winter, and may last until spring. They may be used to show a typical moss sporophyte.

4. Sphagnum.

Sphagnum is a moss which is distinguished by its pale gray-green color, and by the arrangement of its branches, which either grow straight out from the stems or are pendant. Antheridia and archegonia are borne on short branches at the apices of the stems, and may be monoecious or dioecious. A female plant bears clusters of sporophytes. Due to the presence of large, colorless, porous cells among the ordinary leaf cells, the plant is able to absorb great quantities of water. For this reason sphagnum is used extensively in greenhouses and nurseries as packing material for plants. The plant grows in bogs, swamps, and extremely wet soil. It may be obtained all year.

Sphagnum may be used to show an interesting type of moss, and may be used for the bottoms of terraria and moist chambers in the laboratory.

RAISING LIVERWORTS AND MOSSES IN THE LABORATORY.

In collecting liverworts and mosses, one should secure a portion of the substratum, such as bark or soil, with the plant. In the laboratory, one should place the Marchantia, Lunularia, and the soil mosses in a woodland terrarium. He should add small twigs covered with moss, pieces of bark bearing bryozoan, and small moss-covered stones to the collection to make it appear more natural.

The liverworts and mosses will also grow in a moist chamber. The Marchantia and Lunularia will grow in covered finger bowls. Sphagnum will thrive in a bog or swamp terrarium.

III. PTERIDOPHYTES.

The pteridophytes comprise the most highly developed flowerless plants, and show a marked advance over the primitive structures of the mosses. It contains the ferns, horsetails, and club-mosses among its most common forms.

A. True Ferns.

The true ferns have a distinct alternation of generations. The sporophyte form is the large conspicuous plant that is the familiar fern. The gametophyte or prothallus is a small, flat, heart-shaped structure which is seldom over a half-inch in diameter and bears the sex organs. The plant is differentiated into root, stem, and leaf, each of which possesses a well-developed vascular system. Sporangia, which are borne in clusters or sori on the under surfaces of the fronds, have an interesting method of discharging their spores.
The beauty of the fern is in the leaf or frond. Some fronds are small, delicate, and feathery. Others are large, leathery, and spiny. Many have protective scales or felts of hair. A few of the common varieties in western Oregon which will thrive in the laboratory are: licorice, sword, shield, deer, maidenhair, spleenwort, and lace fern.

1. The Licorice Fern.

The licorice fern or polypodium occidentalis has slender fronds, two to eleven inches long. The leaflets are lance-shaped, and are divided almost to the midrib. The yellow round sori are arranged in rows on each side of the midveins and on the upper half of the frond. The rhizome has a licorice taste. The fern is very common in the woods where the air is humid. The rhizome is found under moss or detritus on almost any kind of substratum, such as logs, trunks of trees, stumps, soil, and rocks.

The leather-loaf fern or polypodium acouleri is found in the coastal regions on logs or living trees, without the licorice taste. Specimens may be collected at any time.

The licorice fern is a small fern which is abundant and readily adapted to indoor culture. The plant illustrates one type of leaflet and sorus arrangement.

2. The Sword Fern.

The sword fern, polystichum minitum, is an evergreen that is sometimes called the Christmas fern. The long fronds are often used for decorations. The leaflets are long, narrow, and pointed, and resemble a short broadsword. There is a single large tooth on the upper edge of each leaflet near the midvein. The margins are sharply doubly serrate. The sori are arranged in a row on each side of the midvein and half way to the margin. The sword fern is one of the most common ferns and grows in very shady, moist, rocky places in the woods and on hillsides. This fern is available all year.

The sword fern is a hardy fern for the laboratory and has interesting leaves and sori.

3. The Shield Fern.

There are several common species of shield fern, dryopteris, which, in general, may be characterized by small to medium, one to three compound fronds, many of which are evergreen, spiny, and bear scales on the stems; and by the large round sori located mostly on the backs of the veins.

One form, the wood-fern, d. spinulosa variety dilatata, abounds in shady moist woods or hill slopes. Another, the coastal wood-fern,
1. The Deer Fern.

The deer fern, 

2. The Oak Fern.

The oak fern,

3. The Shield Fern.

The shield fern,

4. The Deer Fern.

The deer fern,

5. The Maidenhair Fern.

The maidenhair fern,

6. The Spleenwort Maidenhair Fern.

The maidenhair spleenwort,
7. The Lace Fern.

The lace fern, *cheilanthes gracillima*, fronds are from four to ten inches long with two to three divided leaflets, and bearing thick, wooly, rust-covered mats of hairs on their undersurfaces. The spores occur along the reflexed leaf-margins. The lace fern grows in sandy soil and around rocks and crevices in the mountains of southern Oregon. It is available in the spring, summer, and fall.

The lace fern illustrates a fern with protective hairs. It is excellent for rock gardens. The fern sporangia may be used to show an interesting method of dehiscence.

B. Horsetails.

Horsetails, *equisetum arvense*, are interesting plants and are related to the ferns. The plant consists of aerial, jointed, bamboo-like shoots which are hollow; and are marked with longitudinal ridges. At each node, there is a whorl of small, scale-like leaves that are united to form a sheath about the stem. There are two sets of shoots—the fertile, spore-bearing shoots, and the vegetative foliage shoots. The fertile shoots, which appear in early spring or usually in March or April, are light green. They have brown leaf-sheaths, and each bears a conical-shaped structure or strobilus at its tip. The cone is composed of six-sided leaf-like structures or sporophylls, which bear sporangia containing spores and elaters. As soon as the spores are shed, the stems wither, and the vegetative shoots appear. At each node a whorl of slender green branches arises, forming the bushy body from which the plant is named. The green shoots wither in the fall and turn brown. Horsetails grow along railroad embankments and banks of streams and ditches; and are abundant in the wet places in the coast regions. Stems with cones may be collected in March or April. Bushy vegetative shoots will be found during the summer and fall.

The elaters are excellent for illustrating hygroscopic movements. The plant may also be used to show the development of the cone.

RAISING FERNS IN THE LABORATORY.

Ferns can be transplanted successfully at any time during the growing season although the early spring or late fall (October) are usually considered best as the roots are then least likely to be disturbed. When collecting ferns for the terrarium, one should select plants of a size that fit the capacity of the container. Generally, plants not over six inches tall are the most desirable. For ferneries or flowerpots, the larger species will do well. In transplanting them, one should lift the roots carefully, and with some soil clinging to them. He should wrap them immediately in waxed paper or moss to prevent the drying of the rootlets, and should
place the fern in a basket or box. One should secure sufficient soil from
the place where the fern was growing for planting purposes.

In the laboratory, one should provide the ferns with surroundings as
nearly like their natural habitats as possible. There must be proper drain-
age, sufficient water, and a humid atmosphere. Woodland terraria and bottles
make ideal places for raising small species of ferns, such as licorice,
spleenwort, lace and young or dwarf forms of sword, shield, maidenhair, and
der ferns:

The larger, hardier ferns will thrive in flower pots, window boxes,
or ferneries if the conditions are reasonably favorable. Such ferns as the
sword, shield, deer, maidenhair, licorice, and spleenwort may be potted. To
make a bed for the potted ferns, one should secure a clean flower pot or
similar container, and put two inches or more of broken crockery, shells, or
pebbles with a few pieces of charcoal on the bottom to insure good drainage.
Over this a layer of manure or leaf mold may be placed. One covers this with
sifted soil which was secured from the fern habitat. After planting the
fern, one should cover the surface of the soil with live moss. It should be
watered thoroughly, but not too frequently and whenever the top soil shows
signs of drying. It is best to place the potted fern in a saucer of water,
so that the water can soak the soil through the bottom of the flower pot.
The fronds should not be weighted down with water, because they will decay.
If the fronds turn brown at the tips, the humidity is too low in the room.
This can be corrected by putting pans of water on the register or radiator.

Native ferns indoors are subject to the ordinary plant pests, aphids, and
slugs. Confined fumes of tobacco will answer for the one, and whale-oil soap
suds for the other.

PROTHALLIA CULTURE.

Fern prothallia may be found growing naturally at the bases of plants
in the fields or woods or in flower pots and on benches in greenhouses. Pro-
thallia are greatly raised from spores which can be obtained at any time
of the year from the wild ferns or from those in greenhouses. Spores from
the brackens and many other ferns produce abundant supplies of antheridia
three weeks after sowing and archegonia appear soon afterwards; but it is
expedient in all cases to sow six weeks before the material is needed. Care
should be taken that the spores are not sown too thickly, otherwise only
antheridia will be formed on the plants. Pteris longifolia, a common green-
house fern, is usually good for the cultures of prothallia because it devel-
ops so rapidly. Antheridia in this species may be produced in two weeks;
archegonia in three or four weeks; and in five or six weeks there may be an
abundance of sporophytes in various stages.

One method of raising prothallia has been devised by Costello (4:296).
Select a clean flower pot, as porous as possible, and fill with sphagnum
or wood moss. Obtain a bell jar and a saucer, into which the flower pot
may be placed. Sterilize all parts by using hot water. Allow the sphagnum
filled flower pot to cool, and then invert it into the saucer so that the lower part of the pot is covered for about an inch with water. Scatter spores over the wet surface of the pot. Cover the whole with a bell jar to prevent evaporation and to maintain a humid atmosphere. If mildew or "damping off" occurs, water the plants with a weak solution of potassium permanganate, by placing a crystal of the compound in a tumbler of water.

Another method is to secure an earthen brick which will readily absorb water. Immerse it in water, and while its surface is still wet, hold it close to the fern plant, the leaves of which have ripened spore cases. Shake the leaf and then stand the brick with the unseen end in a dish which contains two or three inches of water. Cover it with a bell jar and keep the dish and the brick in a warm place which is neither in direct sunlight nor in darkness. After a few days prothallia will appear.

Horsetail spores (4:302) germinate readily as soon as they are shed, but they will not a month later. Because of this the prothallia are difficult to grow in the laboratory. If fresh spores are obtained, sow them in the same manner as for fern prothallia. If they are kept alive for three weeks, there may be male prothallia with antheridia, but they generally die before the female prothallia with archegonia appear, because of attacks of fungi. Wetting with .005% potassium permanganate solution may keep down the infection.

Horsetails cannot be successfully transplanted. The fertile and sterile shoots can be dried and stored in boxes or packets.

IV. SPERMATOPHYTES.

The spermatophytes or seed plants, include the highest group of plants which are commonly known as the flowering plants. The group is characterized by the complexity of the practically independent sporophyte, the formation of pollen tubes, and the production of seeds. There are two great divisions of this group: the gymnosperms or cone-bearing plants which bear exposed seeds; and the angiosperms or the flowering plants, which bear enclosed seeds.

A. Gymnosperms.

Gymnosperms or conifers are trees with needle-like leaves. With two exceptions, the Yew and the Juniper, the trees of this group are all cone-bearers and, with one exception, are all evergreen.

1. Pines.

The pines or members of the pinus group are all evergreen trees and, with one exception, bear thin needle-like leaves in bundles of two to five. The small bud-like stamine flowers cluster at the bases of new branches. The ovulate flowers are produced either singly or in clusters. At their maturity in the second year, they are reflexed and pendulous with long woody scales. Ripe cones vary in length from one to twenty-
four inches.

a. The lodgepole pine

*Pinus contorta* is a tree with two needles in a bundle. The beach form is scrubby and distorted, with dark reddish brown bark which is furrowed and cross-checked. The inland species is tall and slender, with a rounded crown and pale grayish-brown, smooth bark. The needles of both forms are one to three inches long, grouped in bundles of two, and are dense on the branches. The cones mature in late August or September, and may either shed their seeds or remain closed for a number of years. Open or closed, the cones adhere to the trees for four or five years or more.

Beach lodgepole or shore pine, as it is sometimes called, is abundant along the coast. The inland lodgepole pine grows in the Cascade Mountains.

b. The western yellow pine

The yellow pine, *Pinus ponderosa*, has three needles in a bundle. It is a massive tree with a narrow crown and scattered branches upturned at their ends. The bark of the young trees is blackish with narrow furrows; that of mature trees russet-brown with broad plates or scales. The yellow-green leaves, three in a whorl, are four to eleven inches long. Clusters of leaf bundles appear brush-like at the ends of bare branches. Long shiny purplish-brown cones, two to five inches long, mature early in August of their second year, and shed their seeds in September. In breaking from the branch, the cones leave some of the basal scales.

The yellow pine is common east of the Cascades and in southern Oregon. On the west side it occurs occasionally in small groups scattered throughout the Willamette Valley, and sometimes along the Coast Range in the highest places.

c. The sugar pine

The sugar pine, *Pinus lambertiana*, has five needles in a bundle. It is a large white pine with a massive symmetrical trunk and reddish-brown bark, deeply fissured with long plates. The leaves, in bundles of five, are from two to four inches long, and deep blue-green with a whitish tinge. The cones, unique in their huge size and form, are from twelve to sixteen inches long, and two and a half to three and a half inches in diameter. The tips of the scales are shiny and pale reddish-brown. The inner parts are a deep purplish-brown. The cones are few, pendulous, and borne on the tips of the branches. They ripen during August of the second year, shed their seeds by October, and seldom fall until the third spring, summer, or autumn. The sugar pine grows in southwestern Oregon from the Cascades to the coast.
2. *Pseudotsuga.*

The members of this family are not true firs. In these trees, the leaves are usually distinctly spirally arranged. The cones are soft to the touch and have three-pointed bracts. The needles are not borne on woody projections.

The Douglas fir, *Pseudotsuga taxifolia,* is a large tree with a pyramidal crown and smooth thin brown bark in the young trees. In the older trees, the bark is thick, rough, and deeply furrowed. The leaves are about one inch in length, flat, pointed, and deeply furrowed. The staminate flowers are enclosed in reddish-brown bracts; the ovulate flowers are green or purple. The reddish-brown cones are pendulous, two to four inches long, with three-pointed bracts extending beyond the scales, which do not fall apart when mature. The cones ripen in early August, shed their seeds in September, and drop from the trees a few weeks later. The Douglas fir is the most common conifer throughout western Oregon.


The cones of the spruce, or *Picea,* are harsh to the touch and are without the three-pointed bracts. The needles are borne on woody projections. The trees are conical evergreen trees with long sharp-pointed needles, spreading in all directions and borne on woody projections, which remain on the tree after the leaves fall. The staminate flowers are terminal, erect or nodding. The ovulate flowers are erect and terminal. The pendulous cones, which are scattered on the upper part of the tree, have thin papery scales and bracts. The bracts are shorter than the scales. The cones mature during the first autumn.

a. The Sitka spruce or tideland spruce

The Sitka spruce or *Picea sitchensis* is a tall tree with dark reddish-brown bark. The distinctly flattened needles are so stiff and sharp-pointed that they hurt the hand when the twig is grasped. The tip of the tree is stiff and upright, and the branches have many hanging side branchlets. The dull brown cones, with crinkly papery scales, are two to four inches long. They mature in the early fall. The seeds are shed in a short time and, within a few months, most of the cones have fallen. The Sitka spruce is found along the coast and in valleys up to the foothills of the Cascades.

b. The Engelmann spruce

This spruce, *Picea engelmannii,* is very similar to the Sitka spruce, but is smaller. It occurs occasionally on the west side of the Cascades below the timber line. It is found around Mt. Hood.
4. The hemlocks.

In these trees, the cones are less than an inch long and are pendulous. The hemlocks are evergreen trees with soft, flat or angled leaves, which appear two-ranked, and grow on woody projections that remain on the branch after leaf-fall, and give the branch a rough appearance. Pendulous staminate flowers, with anthers tipped with a short spur, are borne from the axils of winter buds. The erect, ovulate flowers are terminal on year-old branches. The pendulous cones, bearing thin, rounded, overlapping scales, mature in one season.

a. The western hemlock

The western hemlock, _Tsuga heterophylla_, is a large tree with slender, drooping branches and branchlets. The bark is smooth and russet-brown in young trees; thick, deep russet-brown and deeply furrowed in mature trees. The glossy, yellow-green leaves are flat and blunt, appear two-ranked, and are borne on small distinct stalks. The small few-scaled cones growing at the tips of the branchlets mature from the middle to the end of August. The reddish-brown cones, which are oblong and from three-fourths to one and a half inch long, open rapidly, and shed their seed during September, and fall before spring.

Western hemlock is found on the west slopes of the Cascades to the coast, but not in the Willamette Valley.

b. The mountain hemlock

The mountain hemlock, _Tsuga mertensiana_, is smaller and somewhat different from the western species. It has graceful drooping branches, giving a pyramidal appearance. The dark bluish-green leaves are blunt-pointed, rounded, and plump, growing out around the branches. The cones are much larger, from one and a half to three inches long, and shed their seeds in late September or October.

Mountain hemlock is found mainly at the timberline of the Cascades. It grows on Mt. Hood, and about Government Camp.

5. The firs.

The firs are lofty, evergreen trees with straight trunks and branches in regular whorls. The leaves, spirally arranged on the branches, are flat, rounded, or blunt, not prickly at the end, and appear to grow from two opposite sides, or from the top of the branch. Staminate flowers are borne on the underside of the upper branches; the ovulate flowers on the underside of the topmost spreading branches. The erect cones, with thin, closely packed and overlapping scales, mature in the first autumn, and fall to pieces on the tree.

a. The lowland white fir

The lowland white fir, _Abies grandis_, is a large tree with
a straight tapering trunk and branches which have a distinct down-
ward and upward swing. The bark is smooth or slightly broken, and
is a grayish-brown. The leaves appear two-ranked, and are dark yellow-
green above and silvery beneath. They are from one and a half to
ten inches long, flat, blunt, and notched at the tips. The slender
yellow-green cones are from two to four inches long with notched,
squarish, slightly tipped scales which fall apart when the cones are
mature in the autumn.

The lowland white fir is common in the low hills and valleys and
in the higher altitudes from the coast to the Cascades.

b. The noble fir

The noble fir, *abies nobilis*, is a large tree with short stiff-
looking branches and with purplish-brown bark. The leaves are pale
to bluish-green, with a silvery tinge. The leaves on the upper
branches are short, and stiffly incurved; those on the lower branches
are longer, flat, and four-ranked. The erect purplish cones are from
four to six inches long, with pointed bracts extending beyond the
scales. The cones mature in September. In October, they begin to
break up and fall from the trees. The noble fir occurs on the
western slope of the Cascades, and there are a few on the Coast Range,
as at Mary's Peak.

6. The cedars

Cedars are trees with scale-like leaves and small cones. They vary
greatly in size and shape.

The red cedars or the *thuja* are aromatic evergreen trees with very
small, flat scale-like leaves that are overlapping and are four-ranked.
The lower clusters are monoecious and terminal. The cones are oblong,
with eight to twelve small opposite leathery scales. They mature in
their first autumn. The red cedars are described as having oval cones.

The western red cedar, *thuja plicata*, has a decidedly conical
trunk, is "swell-butted", and is fluted at the base. The bark is thin,
cinnamon-brown, and shredded. The long, graceful, curving branches
bear bright green, scale-like leaves that are flat, sharp-pointed, and
pungent. Small, brown cones which curiously resemble "Dutchman's Pipes"
grow on short stems. The cones mature by the end of August and, after
shedding their seeds, remain on the trees until the following spring or
summer. The western red cedar grows on the Coast Range, chiefly on
the west side, and on the Cascades but not in the Willamette Valley un-
less as a cultivated tree.

*Chamaecyparis* are evergreen trees with flattened, two-ranked
branchlets bearing small, thick, scale-like leaves which are soft to the
touch. The monoecious flower clusters are terminal. The cones are
small and spherical, and mature in their first year.
Port Orford cedar, chamaecyparis lawsoniana, has graceful drooping branches, and a pyramidal form. The bark is broken into narrow ridges, and is brown with a reddish tinge underneath. The minute scale-like leaves, closely pressed to the twigs, grow in flat sprays, and are soft to the touch. Small, reddish-brown cones, with four to seven scales, mature during the latter part of September or early in October. Some of the cones remain on the trees until spring.

The Port Orford cedar grows near the coast from Coos Bay southward. Because of its beautiful form and graceful foliage, the cedar is much used for ornamental planting.

B. Angiosperms.

1. Deciduous Trees.

a. These trees have their buds, leaves, and young branches arranged in pairs along the stem, the two in each pair usually on opposite sides. This is called opposite branching.

1' Trees with compound leaflets

Ashes are deciduous trees with opposite pinnately-compound leaves. The flowers, which appear in early spring, are very small, inconspicuous, and densely clustered. The staminate and pistillate flowers are either borne on separate trees, or both on the same tree, and appear before the leaves. The fruits, one-winged seeds, are borne in branched clusters.

The Oregon ash, fraxinus oregona, has a long narrow trunk, with distinctly opposite branches, and with pale brown deeply checked bark. The leaves are from six to twelve inches long, with five to seven thick tapering yellow-green leaflets, that are downy underneath when young. The winter buds are large and chocolate-brown. The seeds, from one to two inches long, are borne in large clusters, and mature in early fall.

The Oregon ash is common bordering creeks and streams of western Oregon.

2' Trees with palmately-lobed leaves

Maples are deciduous trees or shrubs with opposite, simple or compound, leaves. The flowers which appear before, with, or after the leaves are, in some trees staminate, in others pistillate, and in still others may be both pistillate and staminate. The flowers are borne in long clusters. Each fruit is composed of a pair of one-winged seeds joined together. These mature in the spring or late summer. Those that ripen later remain on the tree until fall or winter.
a. The broadleaf maple

The broadleaf maple, *Acer macrophyllum*, is a large broad


dense tree, with a rounded top and profuse branches. The bark is

ash-gray to brownish-gray, and is roughly ridged in old trees.

Winter buds are large, with few over-lapping scales. The large

five-palmately-lobed leaves are pale green beneath. They are from

seven to fourteen inches long, and are smooth, and somewhat shiny

on their top sides. The large, drooping clusters of fragrant,

yellowish or greenish, flowers appear in the spring after the

leaves are grown. The winged fruit is tawny brown when ripe and

the body or seed part is covered with short, bristle-like hairs.

The trees are very beautiful in the fall when the foliage has

turned reddish-yellow. The broadleaf maple is the common maple

in moist situations west of the Cascades.

b. The vine maple

The vine maple, *Acer circinatum*, is a very sprawling shrub,

with smooth, grayish-brown bark tinged with red. The mature

leaves are smooth above and paler beneath, with minute tufts of

hair in the angles of the veins. They are three to five inches

long with seven to nine sharp serrate lobes. In the fall, the

leaves are beautifully colored reddish-yellow or bright scarlet.

The fruit also becomes a bright red at maturity. The vine maple

grows in moist locations in dense woods and along streams.

3. Trees with leaves single, and not lobed

Dogwoods are trees, shrubs, or herbs with opposite simple point-

ed leaves which are veined and which are clustered at or near the

ends of the twigs. The small flowers are in heads, surrounded by

white or greenish bracts which gives the whole appearance of a single

flower with white petals. The fruit is berry-like, and appears in

clusters at the ends of the twigs.

The western dogwood, *Acer negundo nuttallii*, is a small to moder-

ately large tree with smooth dull reddish-brown bark, which is scaly

in old trees. The leaves, which are from three to five inches long,

have prominent deeply impressed straight veins and wavy margins.

The winter bud is small, pointed, scaly, and is clasped by two oppo-

site long narrow scales. The flowers are in close button-like heads,

surrounded by four to six large conspicuous petal-like bracts. The

bracts are white or greenish, from one and three-quarters to two and

three-fourths inches long, and abruptly sharp-pointed. The flowers

appear with or before the leaves, and occasionally in the fall with

the fruit. The shiny red berries which are usually in dense clus-

ters mature in the late summer or early fall.

The dogwood is common in western Oregon, growing in the low-

lands, on the lower mountain slopes, in the valleys and coves, or
along the borders of streams. It often appears as a cultivated tree.

b. Trees with buds, leaves and young branches arranged singly along the branch, first on one side, then on the other. This is called alternate branching.

l'. Trees with lobed leaves

Oaks, or members of the genus *Quercus*, are trees or shrubs of slow growth and hard wood. The flowers are small, green, or yellow, and appear with the leaves. The staminate flowers are in pendulous clusters, or on a short separate cluster. The fruit is a nut, borne in a cup composed of scales.

The Oregon white oak, *Quercus garryana*, is a sturdy tree with a short crown of small, heavy, wide-spread branches, and grayish deeply checked bark. Winter buds are rounded, angled or pointed, and scaly. The thick leathery leaves are smooth. They are shiny green above, and paler and hairy beneath. The leaves range from two to four inches in length, are pinnately divided into five to seven lobes, and are shed in autumn. The shiny, smooth nut is round and sweet, fits into a short shallow cup of scales, and matures in one season. The Oregon white oak is common in groves in the valleys, on the hillsides, and on the plains of western Oregon.

2. Trees with thick, leathery, evergreen leaves

The flowers of these trees are small, pink or white, and are borne in terminal clusters. The fruit is berry-like, but has a roughened surface.

The madrona, or *Arbutus menziesii*, is a stately tree with red shining bark. In the older trees, this peels off in long thin strips. Its winter buds are small, pointed, and scaly. The leaves are shiny, leathery, and from two-and-a-half to five inches long. The brilliant orange-red, berry-like fruit ripens in the fall. The berries are from one-third to one-half inch in diameter, with flattened, glandular surface. The madrona is common both along the coast and inland on the Coast Range.

3. Trees with sticky buds

Cottonwoods are trees with soft wood or are shrubs with scaly resinous buds, and broad or narrow leaves with falling stipules. They have pendulous staminate and pistillate flowers, bear bnanally fringed bracts. The flowers are borne on separate trees, and appear before the leaves. The stamens and pistils are both borne on discs. The seed has a conspicuous cottony tuft of hair that serves for it spreading, sometimes, far from the parent tree.
The cottonwoods, or populus trichocarpa, are trees of average height. They have short upright branches, and yellow-gray bark; deeply furrowed. The buds are reddish-yellow; are as much as three-fourths of an inch long; and are covered with fragrant yellow-brown resin. The broad, pinnately-veined leaves are thick and leathery; are rounded at their bases; and taper to a point. They are shiny green above, and silvery white beneath. The seeds have long tufts of silvery hair. The black cottonwood is found chiefly in the Coast and Cascade Mountains, and in valleys on the borders of streams and rivers.

4'. Trees with conspicuously straight-veined leaves

Alders are deciduous trees or shrubs with alternate, simple, straight-veined leaves, appearing with or after the flowers. The pistillate and staminate flowers are borne in separate clusters; the pistillate flowers are erect and become woody at maturity, the staminate flowers are pendulous and from two to six inches long.

The red alder, alnus rubra, is a tall tree with a straight trunk; smooth grayish to whitish bark; rounded top; and slender, profuse branches. The twigs are shiny and red, with stalked winter buds which are deep-red and downy. The leaves are smooth, are deep yellow-green above, sparsely hairy, and paler beneath. They are coated with rusty hairs, which are heaviest on the veins. The leaf is from three to six inches long, elliptical, pointed at the apex, and has notched edges. Mature cones, which shed their seeds in the autumn and are persistent, vary from one-half to one inch in length. They are dark brown, and have thin, narrow, wing-like margins. The ends of the cone-scales are blunt and squarish. The red alder is common along streams and lower slopes in western Oregon.

5'. There are several kinds of willows, whose leaves are characteristically long and narrowly pointed, and with ear-shaped leaf-like appendages at the bases of the leaf stems. They are very difficult to tell apart, and are not included. They are, however, worth some attention.

Most of the study of trees should be done out-of-doors. In collecting specimens for the laboratory, the following items may be included:

1. Branches to show the method of branching and arrangement of leaves, leaf scars, and bud scale scars
2. Cluster of winter buds
3. Clusters of staminate flowers
4. Clusters of ovulate flowers, or young cones
5. Clusters of older cones with seeds
6. Seeds and seed clusters if they can be found
7. Seedlings for the terrarium

2. Herbs.
   a. Aquatic plants

   Aquatic plants are used as oxygenators in the aquarium. They add to the beauty and interest of the tank, and provide food and resting places for insects and small animals.

   1'. Arrowhead

   Arrowhead, or sagittaria latifolia, is a water plant which has either arrow-shaped leaves which are raised above the water or float on it, or strap-like leaves which are submerged. It bears three-petaled, waxy-white flowers in whorls of three that appear in the summer. The plant grows at the margins of lakes, sluggish streams, and rivers, or in shallow muddy places in them. It is available at any time.

   The arrowhead has interesting leaves, and is easily raised in an aquarium. It is one of the best oxygenators of all aquatic plants.

   2'. The spike rush

   Spike rush or cleocharis is a tufted, grass-like plant which has triangular stems. The leaves are long narrow sheaths, but are not split at their bases as they are in the grasses. The flowers are borne in single terminal spikelets. The plant is commonly found in ponds and pools or at the margins of slow flowing streams. The spike rush, which blooms only in the summer, may be secured at any season.

   Small forms of the rush are good plants for the aquarium.

   3'. The water buttercup

   The water buttercup, ranunculus aquatilis, is a submerged plant with finely divided, thread-like submerged leaves and, occasionally, broad, three-lobed floating leaves. The minute white flowers are solitary and floating. The buttercup grows in ponds, sluggish streams, creeks, and ditches. It is available all year, but blooms only for a few weeks, generally in April. It makes a good aquarium plant.
The hornwort, *ceratophyllum*, is a submerged aquatic plant with close whorls of rigid, three-times-forked, thread-like leaves. It is common in quiet streams, ponds, and lakes, and is rarely found in flower. The plant is available all year. It makes an interesting plant for the aquarium.

Duckweed or leana is a very small, floating disc-like plant without true leaves. The plant body consists of a bright green leaf-like stem or thallus, and a tiny rootlet which hangs down into the water. It propagates by the division of the thallus into flattened branches which soon break away to form new plants. The plant is very common and abundant on the surfaces of ponds and lakes. Duckweed must be used sparingly in the aquarium as it quickly covers the top of the water and shuts out the light. About six to eight plants to a gallon of water is a good proportion to use. It is very interesting because it differs in three ways from other aquatic plants: the absence of true leaves, the presence of a flattened stem thallus, and vegetative propagation by the thallus.

Watercress, *raddula nasturtium-aquaticum*, is a rank growing plant in slowly flowing streams, marshes, or springs in the mountains. The edible leaves are pinnately divided and are smooth. The terminal leaflet is larger than the others. The flowers are white and grow in clusters. Plants may be gathered at any time. They are often cultivated under the name of "watercress".

Watercress is an edible aquatic plant which grows well in the aquarium and is attractive in appearance on account of its freshness and sturdiness.

Woodland plants

These include annual, biennial, and occasional perennial flowering plants, grasses, and herbs. Some of them may be transplanted successfully to a terrarium, but many of them do not do well out of their native habitats. Plants under six inches in height are usually the most desirable for the terrarium. The following are some plants which are suitable for the terraria, and may be transplanted successfully:

Wood sorrel, *exalis oregana*, is a small plant from three to six inches in height. It has a distinctive acid juice. The three leaflets which it bears on each branch are clover-leaf in shape, and neatly folded when in the bud. The leaves have the interesting habit
of closing on dark days and at night. The five-petaled flowers are white, often veined with purple, and each flower grows singly on a flower stem. The blossoms occur in the spring, summer, and autumn. The plant is found in moist open woods. A yellow-flowered species, oxalis subarana, is found at the edges of cultivated fields, in meadows, and in waste places. Wood sorrel may be used to illustrate a plant with leaflets which are sensitive to the absence of sunlight.

2'. Fotid adder's tongue

Fotid adder's tongue, acoliopus hallii, is a peculiar little plant with two thin, oblong leaves, from three to five inches long, that are sheathed at their bases just below the surface of the ground. The three-angled sepals are greenish, blotched with purple; and are strongly recurved. Pretty tiny green and purplish flowers are borne singly on curving stems, and have a faint, but disagreeable odor. The plant grows in coniferous woods along moist streams. It is one of the first to bloom in the spring, sometimes as early as January and February, and is available in winter for the terrarium when other plants are not. Fotid adder's tongue belongs to the lily family.

3'. Evergreen violet

The evergreen violet, viola sarniontosa, has a pale yellow flower, sometimes purple-veined, rising with a cluster of leaves from a rootstalk. The heart-shaped leaves, with rounded teeth, are deep green above, often rusty beneath and, in age, become brown-dotted. The violet is common in the open woods. The leaves remain green during the winter. The plant blooms early in the spring—from April to May—and is a pretty plant which is available in the winter.

4'. Spring queen

Spring queen, synthris reinformis, is a very small plant, from two to eight inches tall, and with basal, kidney-shaped leaves that are hairy. They are green above and reddish below, and are coarsely lobed with three to five conspicuous veins from the base. The blue flowers are four-lobed bells, borne on short stems. The plant is found in early spring, blossoming upon sunny banks, and sheltered southern hill slopes. Later it is found in the cool woods, almost covered with leaves. The blooming period is long—January to June—and, for this reason it makes a very good terrarium plant.

Spring queen may be used to represent the figwort family and an interesting type of flower.
5. Youth-on-age

Youth-on-age, or leptaxis menziesii, is an unusual and interesting herb because of the manner in which the young plants appear. These miniature plants, resembling the parents both in form and beauty, are borne on the bases of many of the leaf blades. As the old leaves die, they send rootlets to the ground and produce a new generation. The leaves are heart-shaped, with five to thirteen serrate lobes. The flowers are purplish-brown, with curved thread-like petals, and are borne on graceful stems. The plant grows in the moist woods on the banks of streams, and appears in the spring--blooming from April to June.

Youth-on-age may be used to represent the saxifrage family and to illustrate vegetative reproduction by means of adventitious buds on an old leaf.

6. Wild lily-of-the-valley

The wild lily-of-the-valley, maianthemum bifolium, has two glossy, triangular, heart-shaped leaves. The minute, cream-colored flowers are borne on short terminal stems. The plant is from four to fourteen inches tall, and has strong, sweet scent. It grows in the moist woods where the soil is rich and non-acid, in rich soil along the margins of streams and in the coastal regions. It blooms from April to June.

The lily-of-the-valley belongs to the lily family. It has flower parts in groups of two or multiple of two, and thus differs from most members of the lily family which have flower parts in groups of three.

7. Minor’s lettuce

Minor’s lettuce, montia perfoliata, may be recognized by its two unusual upper leaves which are completely united to form a two-angled shield-like disc at the top of the stem. From the center of this disc rises a stem with tiny, white flowers growing on one side. The plant grows in the open woods and in fields and meadows. The blooming period is from April to June.

Minor’s lettuce is a member of the purslane family. It is interesting on account of its united leaves.

8. Fawn lily

The fawn lily, erythronium oregonum, has a pair of spear-shaped, brown-scaled or clear leaves. There are one or more large, pale, cream-colored flowers with orange centers and recurved perianth segments, which turn pinkish with age. This lily grows in the open fields and brushlands. The blooming period is from March to May. Fawn lily may be used to illustrate a typical lily.
c. Swamp and bog plants

1. Sundew

The sundew, Drosera rotundifolia, is small and brown, with leaves arranged in a rosette close to the ground. The leaves are covered with long, red, glandular hairs, which secrete a sticky reddish substance, resembling dew drops, that cause the leaves to glisten in the sun. When an insect alights on a leaf, these hairs act as a trap and enfold and crush their prey. The soft body parts of the insect are dissolved by the plant juices, and are absorbed. The leaf then unrolls and the undigested portions of the insect are dropped. The sundew is common in bogs along the coast and in the mountains. The plants may be found at any time.

They may be used to illustrate the insectivorous plants. They make curious and interesting plants for the terrarium.

2. The pitcher plant

The pitcher plant, Chrysanthemum californica, uses a different method from that of the sundew to catch insects. The leaf of the pitcher plant forms a tube or pitcher which is enlarged above and hood-like, with an opening beneath, somewhat hidden by a forked, tail-like lip. The inner surface of the pitcher is partially filled with stiff, downward projecting hairs, which prevent the insect from escaping. The bodies of the insects decompose and are then absorbed by the plant as food. The pitcher plant grows in bogs and marshes along the coast in southwestern Oregon, from Coos Bay southward.

The pitcher plant illustrates one type of insectivorous plant.

3. The marsh marigold

The marsh marigold, Caltha biflora, is a small plant with basal leaves and flower-stems. The leaves are kidney-shaped and have serrate lobes. The basal lobes overlap or turn up. The undersides of the leaves are veined with purple. The flowers are white and showy, with five to ten petal-like sepals. There are no petals. The plant grows in marshes and wet meadows in the mountains, and is available in the spring, summer, and fall. A yellow-flowered species grows in the coastal marshes and bogs. These plants may be secured in the spring, summer, and fall, also.

The marsh marigold belongs to the buttercup family and may be used to illustrate the marsh plants.

4. Bunchberry

The bunchberry, Cornus canadensis, is a charming little plant
from three to six inches tall. It has a whorl of conspicuously veined leaves near its top. From the center of this whorl arises a stem, bearing a tiny greenish flower cluster surrounded by four white petal-like bracts. The whole flower cluster appears to be a flower. There are two blooming periods for the bunchberry, one in the spring and the other in the late summer. The bunchberry grows in the margins of bogs and marshes in the mountains and along the coast. It may be collected in the spring, summer, and fall.

It belongs to the dogwood family, and may be used to show the characteristic flower clusters of this family.

5'. The marsh violet

This, viola palustris, is a creeping plant with a bearded, pale blue violet-type flower. It grows in the swamps and marshes in the mountains. The blossoms appear very early in the spring. It may be used to illustrate a swamp or marsh species of violet, and is available when many flowers are not.

Field plants

1'. The purple-tinted cudweed

The cudweed, or gnaphalium purpureum, is an interesting small, dense silvery wool-covered plant with long narrow leaves. The white flower-heads are in small clusters at the ends of the branchlets, and are surrounded by many small brown or purplish paper-like bracts imbedded in the loose wool. The plant grows in the dry fields, on the hillsides, and along railroad tracks. It blooms in the fall. It may be used to illustrate a wooly type of the composite family.

2'. Shepherd's purse

Shepherd's purse, capsella bursa-pastoris, has a basal rosette made up of slender deeply-cut leaves that spread from the base and of slender upper leaves which are broadly clasping at the base. Tiny white flowers are borne on long stems. The unusual seed pods are flat and heart-shaped with a partition in the flattened sides, thus resembling the purses from which the plant received its name.

The plant grows in fields, gardens, orchards, woodsides, and waste places. It blooms from March to December.

Shepherd's purse may be used to show a member of the mustard family and an interesting form of seedpods.

3'. Wild strawberry

The wild strawberry, fragaria cuneifolia, is a small, flat,
spreading plant from one to four inches tall. It sends out runners that lie close to the ground. The leaves are basal, and are divided into three leaflets each. These are heavily veined and are hairy beneath. The white flowers are borne on leafless, densely hairy stems. The fruit is fleshy and edible, and becomes red and sweet in flavor when ripe.

The plant is common in fields, hillsides, and meadows, and may be gathered all year. The blooming period may be as early as January, but is generally from April through May. The wild strawberry belongs to the rose family. It may be used to show propagation by runners.

4°. Pussy's ear

Pussy's ear, calochortus tclnici, is a pretty little plant from six to nine inches tall. It bears flowers with petals that range from deep lavender to white, and are very hairy on their inner surfaces. They bear noticeable smooth glands at their bases, as well. The slender pointed sepals are green, but are often dark purple on their backs, and are without glands. The tall sheath-like basal leaf is bluish-green, conspicuously parallel-veined, and somewhat curved; the other leaves are similar but shorter and narrower.

Pussy's ears are common in the Willamette Valley in moist fields and roadsides which are shaded by grasses and shrubs. The blossoms appear in the spring, usually April and May.

Pussy's ears may be used to illustrate a member of the lily family whose flowers have unusually hairy petals.

5°. Johnny-jump-up

The Johnny-jump-up, hairy violet or viola nuttallii, is a yellow violet with upright, oblong to ovate leaves. These are covered on both sides with soft white hairs. The petals are hairy. The lower and side petals are veined with black or brown. It grows on hillsides, in meadows, and in moist places under shrubbery. The blooming period is from March to May. It represents a yellow field violet.

6°. The western blue violet

The western blue violet, viola adunca, has small heart-shaped leaves, and violet-purple flowers which are bearded in the throat and grow on stems which are taller than the leaves. It is common on the western slopes of the coast hills and in fields near the coast, and is found in some parts of the Willamette Valley. It blossoms from March to May. The western blue violet represents a species of blue field violet.
7'. The shooting-star

The shooting-star, Dodecatheon hendersonii, is distinguished by the pretty flower clusters which have reflexed purplish-black petals and sharp beak-like clusters of stamens and pistils. The leaves form a flat basal rosette. The plant grows on dry hillsides, and blooms from March to April. The shooting-star may be used to show a member of the primrose family which has interestingly formed flower parts.

8'. The stone-crop

The stone-crop, Saxifraga spathulifolia, has rosettes of thick, flat, fleshy leaves which spread mat-like over stones and into crevices. Sometimes reddish stems arise from the rosettes, and bear one-sided clusters of yellow flowers and fleshy bracts. The plant grows on stony places on hillsides and is usually gregarious. It is available in the spring, summer, and fall.

Stone-crop may be used to illustrate a succulent type of plant. It is often called "hen-and-chickens".

9'. White clover

Trifolium repens is a small clover bearing clusters of fragrant white flowers which become reflexed at maturity and turn brown. The plant is very common, growing in fields, meadows, along roadsides, and on hillsides. The blooming period is from May until the late fall. It may be used to show an irregular butterfly flower type and nodules of nitrogen-fixing bacteria on the roots.

10'. Scorpion grass

Scorpion grass, Alopecurus scouleri, is a small slender plant with hairy stems and long leaves. Clusters of fragrant white flowers which have throats with yellow appendages grow on a stem that resembles a scorpion's tail. This is folded in the bud and slowly uncoils as the blossoms progress upward.

The plant grows on low ground which is very dry in the summer and very wet in the winter. It is especially abundant on the "white lands" of the Willamette Valley, where the flowers cause the fields to appear white. The blooming period is from May to June. Scorpion grass belongs to the borage family and may be used to show an uncoiling bud stem.

11'. The douglas aster

The aster douglasii is a purple aster which has leaves that taper at both ends and are broad in the middle. It has many star-like flowers, forming loose clusters in a head and surrounded by purple ray flowers. The aster is very abundant, growing in moist fields,
along roadsides, and by railroads. It blooms from summer until late fall or winter. It may be used to illustrate a flower cluster type of the compositae family.

RAISING FLOWERING PLANTS IN THE LABORATORY.

The best time to transplant wild flowers is in the fall, winter or early spring when they are dormant although most of them can be moved at any time. In the transplanting there are several rules to observe, e.g., always take up enough soil about the roots when moving the plant that the roots are not broken; never allow the roots to dry out; wrap the soil which is around the roots in damp burlap or moss as it is lifted.

It is best to secure a quantity of soil from the places where the plants are found for planting purposes. Select plants for size according to the capacity of the terrarium. Plants from coniferous woods require a soil mixed with evergreen needles; those from deciduous woods need abundant leaf mold in the soil. One should collect sparingly. Many of the lilies and violets, the shooting-star, and youth-on-age are becoming scarce, and are facing extinction. Only one or two of each species should be taken.

The collector should reset the plants in the terraria as soon as possible after digging, using the methods that are given for fern planting. Plant woodland species in a woodland terrarium, bog forms in a bog terrarium, and field plants in a field terrarium.
Chapter III

ANIMAL KINGDOM

Animals are classified as invertebrates or animals not having backbones, and vertebrates or animals having backbones. All animals of a lower form than fishes are invertebrates, and all of higher form than fishes are vertebrates. The protozoa are the simplest form of animal life.

I. PROTOZOA.

Protozoa consist of microscopic, one-celled animals, or of a colony of cells. They exhibit a variety of adaptations without special organs that enable them to perform all of the fundamental processes of the higher animals effectively but in a simple way. A few of the most common forms which will appear in a protozoa aquarium are: amoeba, paramecium, vorticella, euglena, and stentor.

A. Amoeba.

Amoebae are microscopic unicellular animals, about one-hundredths of an inch in diameter. Under the microscope, they appear as irregular masses of colorless jelly, which change their shapes by flowing extensions of protoplasm called pseudopodia. As they have no distinctive mouth, they engulf food as they move or flow along.

Amoebae will be found in the ooze in the aquarium or on the lower surfaces of the leaves of aquarium plants. Some will be present in the silt and on the plants from ponds. They are available at any time. The amoebae may be used to illustrate most simple unicellular animals and pseudopodial movements.

B. The Paramecium.

The paramecium is a microscopic, complex, unicellular, slipper-shaped protozoa. It swims rapidly by means of cilia with the blunt end of its body forward. The animal has definite feeding structures. Reproduction is both by fission and conjugation.

The paramecium is present in the scum from pond water. In the aquarium, it will be found at the surface of the water. It may be secured at any time. The paramecium may be used to show specialization, or division of labor within a single cell, and reproduction by conjugation.

C. Other Species.

Other species of interest which may appear in the culture are:
euglena, an elongated form which swims by means of a flagellum; vorticella, an animal with bell-like body that is attached to a contractile stalk; and stentor, a green trumpet-shaped form which contracts when disturbed.

PROTOZOA AQUARIUM

A protozoa aquarium may be made either as a mixed aquarium or from a hay infusion. A mixed aquarium is readily started, and will last for three or more months. Many interesting forms will appear intermittently, complete their life cycles, and disappear. To make the aquarium, bring in some pond or ditch water, and a few aquatic plants with mud clinging to their roots. Pour the pond water into a battery jar or other similar glass container, and add the aquatic plants. Two or three small plants to a gallon of water is a good proportion. Allow this to stand out of direct sunlight for several days. The temperature should be sixty-five to sixty-eight degrees Fahrenheit. A variety of forms will appear.

A hay infusion aquarium may be made by soaking some finely chopped timothy hay in a shallow glass dish or small glass jar with boiled pond or tap water. Allow it to sit in a warm place near a register for three to four weeks. To hasten the development of the paramecia, add a little beef extract. The paramecia are generally more abundant than the amoebae. Pure cultures may be made from this infusion.

To make an amoeba pure culture (30), use a sterile pipette and a culture dish. Place boiled pond water or tap water in the dish to a depth of an inch. To maintain this water level, add about ten cubic centimeters of boiled pond water each day. To transfer the amoeba, use the pipette in getting material from the bottom of the hay infusion to the dish, being careful not to pick up any of the hay. To each culture (30:2), add two pieces of boiled timothy hay stems, each an inch long, or three grains of boiled wheat. The amoebae should be fed this amount every two or three days. The animals will live from two to four weeks in the aquarium. They will thrive best at a temperature of seventy-two to seventy-five degrees Fahrenheit.

In making a paramecium pure culture, one uses the same methods as in starting an amoeba culture, except that one fills the finger bowl half full of boiled pond water, and uses the pipette to transfer the material from the surface scum of the infusion. Paramecia cultures require more food than those in which amoebae grow. Add five or six kernels of boiled rice or wheat, or twelve to fifteen pieces of timothy hay stems every two or three days. The animals will live from two to four weeks in the aquarium at ordinary room temperatures.

A banana culture (30:2) may be used for the creation of interest. To make this culture one may place a piece of very ripe banana in a battery jar nearly full of water, and allow it to stand for six to eight hours. Then remove the piece of banana and allow the jar to stand for several days. Afterwards, inoculate it with paramecia.
II. COELENTERATA.

The phylum, coelenterata, consists of radially symmetrical animals with single body cavities but no anus and having tentacles and stinging cells. The hydra is a common form of this group.

The hydars are simple metazoa of green tubular form about five-tenths of a millimeter in length. They can be seen with the naked eye. They have four or more contracting tentacles on their free ends, which are used for locomotion and for capturing food. These tentacles bear stinging cells. Reproduction is done asexually by the production of fertilized eggs.

The hydra lives, attached to plants and rocks, in ponds and slow flowing streams. It is most abundant in the fall, but may be found in other seasons.

It may be used to represent the coelenterata group, to show specialization of tissue, and the budding type of reproduction.

September is the best time to collect the hydars, as their appearance is uncertain in other months. Look for them in sunny places on submerged water plants. Gather and place a few plants in a glass jar, and examine the undersurfaces for tiny jelly-like lumps with tentacles hanging down or for the extended forms. When specimens have been found, collect a quantity of the plants to which they are attached, and an extra jar of water for future supply. The animals may be placed in a large balanced aquarium or in a separate small one. The number of plants will depend on the size of the plants and of the aquarium. Keep the aquarium in a cool, shady place. The hydars may be seen suspended from the plants, or on the sides of the container. Tap water containing strong chemicals should not be used because it kills these animals.

Hydars feed on daphnia and other small crustaceans which are abundant in the aquarium water. They will live for several months if the temperature remains about constant and if there is plenty of food for them.

III. PLATYHELMINTHES.

The platyhelminthes constitute a group of flat, unsegmented worms with bilateral symmetry, definite anterior and posterior ends, and further cell specialization beyond that of the hydra and amoeba. The planaria is an example from this phylum.

The planaria is a common little flat worm about a half an inch in length. It is composed of three distinct cell layers, and bears an eye-spot near the front. The mouth is near the middle of the ventral side. From the mouth a muscular pharynx or proboscis extends, which facilitates the capture of food. The planaria has developed muscular, nervous, digestive, excretory, and reproductive systems. Reproduction in planaria is both by fission and by the conjugation method.

The planarians exist on the undersides of plants and stones in ponds,
streams, ditches and lakes. They are available in all seasons. They have remarkable powers of regeneration, and interesting experiments may be made and abnormalities brought about by cutting into or cutting off various parts of its body.

THE CARE OF PLANARIANS IN THE LABORATORY.

Planarians will live in a small balanced aquarium, crawling over stones, plants, and glass sides of the tank, generally hiding in the daytime. The planarians for experimentation should be kept in a small pan or opaque bowl half full of pond water and covered with a dish or tin lid to keep out the light. Feed the worms every two or three days by placing in small pieces of crushed liver. After two or three hours they will leave the meat. The remaining food should then be removed and the water changed if it contains any decaying organic material. Agitate the water so that the worms will drop to the bottom, clean the sides of the tank and decant all of the water. Then pour in fresh pond water.

IV. ANNELIDA.

The annelida phylum consists of segmented worms with bilateral symmetry; anterior-posterior, and dorsal-ventral differentiation; and bristles for locomotion. The earthworm is a common example.

A. Earthworm.

The earthworm, lumbricus terrestris, has a long segmented body with a thin moist skin. The worm is brown, from three to twelve inches long, and bears on each segment, except the first three and the last one, four pairs of bristle-like projections or setae. A knob-like projection or prostomium extends forward from the first segment, and may be used in identifying the anterior end of the worm. The earthworm has a thickening of the body wall from segments thirty-two to thirty-seven which secretes a case, clitellum, that is used in reproduction. The nervous, circulatory, digestive, excretory, and reproductive systems are well developed and distinctly specialized structures.

Earthworms appear most abundantly in the spring in grassy places, such as on lawns, or in gardens or around piles of old leaves, especially after heavy warm rains. They also occur under objects such as logs, stones, and leafhold of woods, pastures, and fields.

The earthworm may be used to show the structures and habits of an annelid, and the first appearance in the ascending scale of the animal kingdom of the coelom, which is present in all of the animals higher than the earthworm.

B. The Tubifex.

The tubifex is a small, reddish worm about a half inch long that lives
in a tube of its own manufacture. It occurs in patches on the mud of the aquarium, ponds, and streams. It keeps its head buried in the mud, and the posterior end of the body, which protrudes from the tube, is waved constantly back and forth. The movement is probably for aeration. The tubifex is an unusual aquatic worm on account of its tube. It may be used, also, as food for aquarium and terrarium animals.

C. Enchytrae Worms.

Enchytrae worms are small, white, thread-like worms that occur both in the soil and in the water. They may be found at any time. The worms are excellent food for aquaria and terraria animals.

COLLECTING AND RAISING ANNEKIDS.

The best time to collect lawn inhabiting earthworms, or night crawlers as they are sometimes called, is during a warm rainy night in the spring or fall. Use a flashlight, and move it slowly to locate the worms. The worms are sensitive to strong light and vibrations, and move rapidly into their burrows when they are disturbed, hence the collector must move lightly and quickly. Put the worms in a container containing moist earth and keep it in a cool place over night. Cover it with a bound cloth so that they can not crawl out.

In the laboratory, place the worms in a wooden box filled with sifted, moist soil, and cover with a glass top, or a board to retain the moisture. Set the culture in the basement, or in a cool room having a temperature of approximately sixty-five to seventy degrees Fahrenheit. Earthworms may be fed by scattering food an inch or two below the top of the soil and covering it with soil. Such food as boiled oatmeal, bread soaked in milk, boiled potatoes, coffee grounds, and cornmeal may be used. Feed them about once a week, a pint of food to a hundred worms. Remove the soured and uneaten food.

One or two cultures of enchytrae worms should be maintained during the year to provide food for the other animals on hand. The worms may be cultivated in the same manner as earthworms, and fed the same kind of food every three or four days. Be sure that the soil has been sifted to free it of stones, grubs, and earthworms, and moistened before the worms have been put in. Rinse the worms in a finger bowl of water to rid them of dirt before they are fed to the animals.

V. MOLLUSCA.

The phylum, mollusca or clams and snails, etc., comprises a group of unsegmented animals in which the body is enclosed in a calcareous shell and having a muscular foot and mantel.

A. Clams.

The sphaerium is a common little fresh-water clam about two inches long. The body is enclosed in two shells which are hinged together by muscles.
The clam crawls along the sandy bottom of some ponds and streams by means of a muscular foot. It may be found in all seasons, and may be used to show the structure and activities of a bivalve, and the inhalent and exhalent syphons of this species.

B. Snails.

1. Aquatic snails

There are several species of aquatic snails. All have a spiral shell that encloses the visceral organs. The head and feet are free, but may be withdrawn into the shell. The snail moves along with a gliding motion, leaving a film of slime from a slime gland just beneath the mouth. The slime makes its travelling easier. Snails live in ponds, streams, or lakes, and may be found anytime of the year. They may fasten themselves for a time to stone and water plants.

They represent another type of mollusk, with interesting structures and habits.

2. Land snails and slugs

Land snails are similar in appearance to aquatic snails. They are found about moist places, on the ground or in rotten wood, under logs, boards, stones, leaves, or flower pots.

Slugs are without shells. They are found with land snails, and are generally nocturnal. The projecting and receding eyes and eyestalks of the snails are generally interesting.

COLLECTION AND RAISING MOLLUSKS.

To collect clams, one should find a pond or stream that has sandy bottoms, and should scoop with a long handled water net along the bottom. Select the smallest specimens and place them in a jar containing pond water and one or two small plants. In the laboratory, place only one or two clams in a large balanced aquarium.

Snails are obtained by sweeping among aquatic plants and stones, with a long handled water net. Eight to twelve snails may be placed in a large balanced aquarium. They will last for a long time without special care if they are fed lettuce occasionally. Small clusters of transparent eggs will be laid on the glass, stone, or plants. The eggs will develop and hatch in two weeks. Snails are valuable scavengers in the aquarium and help to keep the glass clean of algae.

Land snails and slugs should be kept in a woodland or field terrarium. They will feed on the vegetation there, and occasionally may be given bits of lettuce.
VI. ARTHROPODA.

The arthropods comprise a large group of bilaterally symmetrical animals. The body is divided into segments, bears paired and jointed appendages, and has an exoskeleton containing chitin. The phylum is divided into several classes, the crustacea, insects, arachnoidea, and others.

A. Crustacea.

Most crustacea are aquatic. They breathe by means of gills, have two pairs of antennae, and at least five pairs of legs. The crayfish, daphnia, and the sowbug or pillbug are examples of crustacea.

1. The crayfish

The body of the crayfish is covered by an extremely hard chitinous article which is flexible at the joints. The body consists of two parts—the cephalothorax or head and thorax, and the abdomen. There are nineteen pairs of jointed appendages, which are of three types—head, swimming, and walking. The first pair of walking legs bear the large pincers which are used for seizing and holding prey. The body contains all the important systems of organs characteristic of the higher animals. The eggs of the crayfish are attached to the swimmerets of the mother by a glutinous secretion. Later, when the eggs hatch, the young are also carried by the swimmerets, until they are a week or more old.

Crayfish abound in fresh water ponds, streams, ditches, or pools. During the day they hide under stones, in crevices, and in the mud or in burrows. They back into those places, and leave their big claws out, ready to capture wandering prey. The animals may be obtained at any season of the year.

Crayfish may be used to represent the crustaceans and two environmental adaptations—the power of regenerating lost parts, and autotomy or a definite breaking point of the walking legs.

2. Daphnia

The daphnia is a minute, red, "water flea", which has one eye and two large, rapidly beating antennae. The antennae are used in a peculiar jump-like swimming movement. The body is transparent and, under the microscope, the movements of the internal organs are easily seen. It occurs abundantly in fresh water ponds, ditches or streams; and are often found in aquaria. The animals may be found any season.

They may be used to show an interesting form of crustacean; and they make excellent food for other aquatic insects and animals.

3. The sowbug or pillbug

The sowbug or oniscous asollus, is a small flat grey crustacean
about three-fifths of an inch long, and is very abundant in damp places. The females carry their young about for a time in a pouch between their legs. They are found on land about water-soaked wood, under logs, bark, leaves, and stones. Sowbugs are common at all times.

They represent a terrestrial crustacean. They are often called pillbugs because, when disturbed, some species can roll up, curving their heads and tails together and forming a ball or pill.

COLLECTING AND RAISING CRUSTACEANS.

In collecting crayfish, turn up stones and logs in ponds and streams. Use a dip net to scoop them up in. Select the smallest specimens and put them carefully into a jar or pail of pond water until they are in the laboratory. Then, place one crayfish in a large balanced aquarium that is provided with a rock retreat for a hiding place, and the others in small separate aquaria. In early spring and late fall, the females carrying eggs or young on their swimmerets may be found. It is interesting to keep a mother crayfish in the aquarium to observe the development of the young. She should be removed when the young leave her swimmerets.

Feed the crayfish sparingly with bits of raw meat, termite larvae, small pieces of earthworm, egg, or bread. Remove all uneaten portions.

It is best to collect daphnia in sunny weather, as they are then easier to find. Sweep the water with a fine cloth net, pick out the captured specimens carefully and put them into a vessel containing pond water. They may also be dipped out with a small jar. Daphnia may be raised in small jars at average room temperatures. Several jars should be maintained as a food supply for other aquatic animals. It is better to have several small cultures than one large one as it is hard to culture them in large numbers. Feed them occasionally with bits of boiled lettuce and small pieces of liver.

Sowbugs will live for a long time in a woodland or field terrarium. They will feed on the vegetation. Now and then they may be fed bits of lettuce.

2. Insecta.

Insects are the most highly developed arthropods. They exhibit remarkable developments of the external skeleton. Insects are distinguished by their three body regions, three pairs of walking legs on the thorax, and a pair of true antennae. Frequently they have wings. Insects breathe by means of tracheae. They are found in both aquatic and terrestrial forms.

1. Aquatic insects

Aquatic insects are very abundant and diversified, and are found in any pond, stream, ditch, or slough. Except for some coleoptera and
hemiptera, aquatic insects live in the water during their immature stages, spend their adult lives away from the water, but return to the water to lay their eggs. Some species are entirely aquatic.

The following aquatic insects may be kept in the laboratory:

a. Mayfly nymphs

Mayfly nymphs, ephemeræ, are distinguished by the presence of paired leaf-like gills on the sides of the abdominal segments. The nymphs will be found climbing on the pondweeds, burrowing in the sandy or muddy bottoms, or clinging to stone and logs in the water. The nymphs are available in all seasons.

The mayfly nymphs are interesting larvae to observe, and may be used to show a remarkable peculiarity in their development called the subimago phase. After the adult form is assumed, it melts again.

b. Odonata or dragonfly and damselfly

1. The dragonfly nymphs

The dragonfly nymphs are stout-bodied, unattractive, stiff-legged creatures with wide abdomens and large gill chambers in their rectums. The rectal gills act as organs of locomotion as well as of respiration. The nymphs have remarkable extensible jaws which are quickly thrust out to their prey and then folded back beneath the head. The naiads are generally found on the bottom silt or among plants of ponds and streams. They are available all year. Dragonfly nymphs may be used to show an interesting gill placement and an intriguing method of capturing food.

2. The damselfly nymphs

The damselfly nymphs have long slender bodies with narrow abdomens which bear, at the tips, three flat gill plates. The naiads swim by sculling with these gill plates. They may be found clinging to the water plants of ponds, streams or ditches. The insects are available at any time. Damselfly nymphs may be used to show peculiar type of gill placement and interesting swimming movements.

c. The caddis worms

The caddis worms, or trichoptera, which are the most suitable for the aquarium are caterpillar-like in shape. They build portable cases in which they live and which they drag about wherever they go. Only the front ends of their bodies project beyond these cases. These cylindrical cases are built of sticks and fragments of bark, held together by a network of silk secreted by the worms. The log-cabin type of case is composed of sticks, grass and sand, and placed crosswise of the case. The caddis worms with their cases are found
crawling on plants and on the bottom silt of ponds and slow-flowering streams. They may be secured in any season.

Caddis worms are fascinating insects to observe and may be used to illustrate case builders.

d. Hemiptera

1'. The water-boatman

The water-boatman of the corixidae family has a body which is flattened on top, and swims on its ventral surface with quick, darting motions. It uses its long, ear-like posterior legs for these movements. The body is almost completely enveloped in a thin film of air which glistens like silver. The insect is found at any time in ponds, ditches, and streams. The water-boatman exhibits posterior legs adapted for swimming, and a method of carrying air.

2'. The back-swimmer

The back-swimmers, notonoe stidae, are distinctive in the fact that they swim on their backs. Their bodies are deep and boat-shaped and are equipped with long hind legs fitted for swimming or, apparently, rowing. Back-swimmers carry air in air chambers beneath their abdomens in fringes of hairs. The insect may be collected all year, from ponds, streams and ditches.

The back-swimmer illustrates an unusual superficial structure, an unusual method of swimming, and a somewhat unique way of carrying air.

e. The giant waterbug

The giant waterbug, belostomatidae, is the largest of the water beetles. Its body is flat vertically and round horizontally. It has forelegs equipped for grasping and hind legs adapted for swimming. At the posterior end of the body there is a pair of retractile, strap-like respiratory appendages. The beetle is present in ponds, streams and ditches all year.

The giant waterbug may be used to show interesting feeding habits. The prey is held with the front legs while the bug extracts the body fluids by means of its sucking tube. In one species, the female lays the egg on the back of the male, who carries and protects them until they hatch.

f. The water-strider

The water-strider, gerridae, has an elongated body and long, slender middle and hind legs which enable it to walk over the surface of the water without breaking through the surface film. The striders
often congregate in large numbers on the surface of quiet ponds and pools. They may be collected in any season. The water-striders have hairy lower leg developments adapted for skimming over water.

g. Coleoptera

1. The diving beetle

The diving beetle, dytiscidae, is a large, oval, brownish-black insect. It has thread-like antennae and long hind legs fitted for swimming. Diving beetles have a habit of hanging head downward in the water with the tip of their abdomen at the surface of the water. The spiracles are located beneath the elytras on the abdomen. By raising the elytras slightly, a pocket of air which the beetle can breathe as it swims about is formed.

The larvae of the diving beetles are known as "water-tigers" because of their fiercely carnivorous habits. They are long, spindle-shaped grubs which have large sickle-shaped jaws fitted for holding prey. The beetles and larvae abound in streams and ponds, but are more common in quiet pools of standing water. They are available at any time. The diving beetle has interesting resting and breathing habits. The larvae have curious jaws.

2. The whirligig beetles

The whirligig beetles, gyrinidae, are recognized by their agile manner of darting round and round, tracing graceful curves on the water. Their bodies are oval and flattened, and have a metallic luster. The forelegs are long and slender, while the middle and hind legs are broad and fitted for swimming. Their eyes are divided; the upper half for looking into the air, and the lower part for seeing into the water. The beetles secrete an ill-smelling whitish fluid. The larvae are long and narrow with conspicuous tracheal gills on each segment. These cause them to resemble small centipedes. Full-grown larvae leave the water and spin gray paper-like cocoons attached to some object near the water.

The beetles are social in habit and are found in large numbers, either swimming together or resting on the quiet waters of ponds. They may be collected at any time.

h. Diptera

1. The mosquito larvae

The larvae of culix, or culicidae, are called "wrigglers" or "wigglers" because of their wriggling motion in swimming through the water. Their heads and thoraxes are large, but their abdomens are slender. An air tube appears on the eighth segment.
of each; and, when the larvae is at rest, it hangs head downward into the water with the opening of the tube at the surface. The pupae are called "tumblers" because of their quick, odd movements. The heads and thoraxes of the tumblers are greatly enlarged, while their abdomens are slender and flexible. They have two pairs of breathing tubes on their thoraxes and a pair of leaf-like appendages on the tips of their abdomens which are used in swimming.

The larval stage lasts seven days and the pupal stage two or three days.

Larvae and pupae are found in almost any stagnant water, such as pools, ditches, rain puddles, troughs, sloughs, or rain barrels. They appear in the spring and early summer.

The mosquito larvae may be used to illustrate the metamorphosis of a diptera.

2°. The rat-tail maggot

The rat-tailed maggot, syrphidae, has a peculiar long tail-like air tube which extends to the surface of the water while the maggot is submerged. The tail is telescopic and can be lengthened or shortened as the larvae needs it. On the ventral side of the larvae are several pairs of spined tubercles which are used as prolegs. The maggot lives in foul water in ditches, ponds, and sloughs, and may be found in the fall, winter, and early spring.

The rat-tailed maggot may be used to show an interesting form of diptera larvae.

COLLECTING AND RAISING AQUATIC INSECTS.

Insects which live in water may be collected with heavy dip nets swept through the water at various levels and through the mud and debris at the bottom. In shallow water, logs and stone should be turned over and leaf tufts pulled apart.

Small wide-mouthed jars with lids make good collecting containers for all sorts of insects. Fill each jar three-fourths full of water, leaving an air space at the top. Do not put too many insects in one jar. A small aquatic plant should be added to each vessel. Large jars are needed to bring back sufficient water to fill the aquarium. Predacious forms should be placed in jars by themselves. Insects such as dragonfly nymphs, back-swimmers, giant waterbugs, and the diving beetles are predacious.

Mayfly nymphs will live for a short time in a balanced aquarium. They are herbivorous, feeding on decaying stone and leaves of aquatic plants. Dragonfly and damselfly nymphs are hardy and will live for quite a while
in a balanced aquarium. They are both predacious, feeding on smaller insects, such as mosquito larvae and other small diptera. Dragonfly nymphs will often attack small fish and tadpoles. They may be fed daphnia and wrigglers.

Caddis worms live well in an aquarium. They feed on water plants. It is advisable to put only two or three caddis worms in the aquarium as too many would eat all the vegetation.

An interesting experiment may be made by removing a larva from its case and putting it into a vessel with clear water. Drop in bits of mica. The caddis worm will build a new tube with the mica. Their breathing movements, methods of anchoring themselves to the case, and other interesting reactions can be clearly observed through the transparent mica.

Water-boatmen and back-swimmers live well in an aquarium. The water-boatman feed on plant materials and protozoa from the ooze at the bottom of the aquarium. The back-swimmers are predacious, feeding on small crustaceans and protozoa which are in the water. They may also be fed daphnia, tadpoles, and mosquito larvae.

The giant waterbug is a hardy aquarium insect. It should be kept by itself and fed daphnia, mosquito larvae, termites and protozoa.

Water-striders will live indefinitely in the aquarium, feeding on flies, or other insects such as termites, enchytrae worms, or wrigglers that are dropped upon the water for food. Diving beetles are voracious insects which should be kept in a separate aquarium and fed any kind of raw or cooked meat, daphnia, enchytrae worms, mosquito larvae, or termites. The "water-tigers" or larvae may be kept with the adults and fed the same materials.

Whirligig beetles are excellent specimens for the aquarium. They may be fed by dropping small flies, beetles, termites, enchytrae worms, or fish food on the top of the water. Mosquito larvae are very good specimens for the aquarium, and are easily raised. They feed on the organic material in suspension in the water, or settled or growing upon the bottom. The pupae take no food.

Rat-tail maggots may be placed in a large balanced aquarium or in a separate one. They feed on decaying vegetable matter.

Directions for making an insect aquarium are given in the vivaria section.

2. Terrestrial insects

Terrestrial insects are greatly more abundant, more diversified, and found in more varied situations than aquatic insects. Some of the common forms which are suitable for rearing in the laboratory are:

a. Aphididae

Aphids are tiny insects which are sometimes miscalled plant
lice. They are very small, with soft, green, purse-like bodies, with or without wings. They secrete a sweet substance, known as honeydew, which is attractive to ants, bees, and wasps, sometimes bringing about a sort of symbiotic relationship between the aphids and other insects. Aphids cluster in colonies along the stem of plants. They thrust their piercing and sucking tubes through the bark and suck the plant juice. Aphids may also be found on the leaves, blossoms, fruits, and roots of various plants, such as rose cabbages, willows, fruit trees, and snowballs. The eggs are found during the winter, and adults in spring, summer, and fall.

Aphids may be used to show an insect pest of plants which often lives in association with other insects, and an interesting complex life history.

b. Dermaptera

Earwigs are recognized by the forceps at the tips of their abdomens. The female has straight forceps, while the male has curved ones. They generally have two pairs of wings: the fore wings small, leathery, meeting in a straight line along the back when at rest, and the hind wings large, and folded beneath the fore wings. Earwigs are nocturnal, hiding in the daytime among leaves, under rocks, or in crevices, and emerging at night to feed. They will be found in the spring, summer, and fall. In the early spring, a nest with a mother and eggs may be found just under the surface soil near plants or trees. The eggs are oval and are in pearl-white masses.

Earwigs may be reared in the laboratory to show gradual metamorphosis.

c. Wireworms

Wireworms, or elateridae, are the larvae of click-beetles. Their bodies are long, narrow, and very even in width, with a hard shiny cuticle. They are brown or yellow, and appear worm-like. Wireworms are found in old rotten logs or stumps, under the bark of trees, or in the ground, feeding on vegetable material. The larvae may be found in the fall, winter, and spring.

Wireworms may be reared to show an interesting form of larvae which emerge as click-beetles that have a curious habit of clicking or throwing themselves.

d. The dermestids

Dermestids, or dermestidae, are oval, plump beetles with pale brown or gray markings, which are formed of minute scales that will rub off. The larvae are small, yellow-brown, hairy grubs. One species, the museum pest, is often found in stored collections of insects, plants, and animals. Their presence is indicated by a fine
dust that falls to the bottom of the case from the infected specimens. Another species, the larder beetle, infects dead animal matter such as furs, ham, bacon, and cheese. The insects may be found at any time of the year.

Dermestids are destructive pests which have a curious habit of feigning death when they are disturbed. The insects will roll over on their backs with their legs folded, and will lie still for a long time.

e. The grain infesters

There are many small beetles which infest various grains and seeds. Some of them are pea and bean weavils, snout or granary beetles, and cucujid beetles. The eggs are laid within the seeds and the larvae, upon hatching, feed upon the inner parts of the grain, leaving only the hulls. Infected seeds may be obtained from seed stores, granaries, pantries, or mills. One may collect the seeds in the fall and winter months. One example of this class is the meal worm.

Meal worms are the larvae of the tenebrio beetle. They are hard, waxy-yellow, round worms, from two to eight inches long. They are found in all kinds of flour, meal, cereals, and bran. Meal worms may be found at any time. They may be reared to supply food for various aquaria and terraria insects and animals.

f. The blow-flies

Blow-flies, or calliophora, are greenbottle or bluebottle flies which have metallic, green, blue, or copper colored abdomens. The flies are large, and make a loud buzzing noise as they fly about. They generally live out-of-doors, but often come into dwellings in search of material to lay eggs on. Their eggs are laid on meat, cheese, and other moist provisions. The flies appear in the spring and fall. They are of the calliophora family.

Blow-flies make excellent material for the demonstration of complete metamorphosis because their life cycle span is only three weeks. The larvae and adults make good food for aquaria and terraria insects and animals.

g. The gall insects

Insect galls are abnormal growths or swellings of plant tissues caused by certain insects which develop inside of them. The galls are made by the plants on account of the activities of members of various families of insects, such as the trypetidae of the diptera family; the syrphidae also of the diptera family; the aphidae of the hemiptera family; and the cynipoidae of the hymenoptera family. The galls may be found on willow, wild roses, oaks, golden-rod, and
thimble berry. They will be found in the fall and winter months.

Galls may be used to illustrate curious growth formed on account of insects. Sometimes the parasites which emerge from the galls do not seem to resemble the characteristic insect.

h. Lepidoptera

Caterpillars are the familiar larvae of moths and butterflies, which are found feeding on the foliage of plants. They vary in form and color according to the species. The following are a few forms which are readily kept in the laboratory:

1'. Polyphemous

This is a moth caterpillar and is green with oblique yellow lines on each segment except the first and the last. Yellow tubercles arise from red spots on each segment. The caterpillars are fairly common on maple, alder, willow and fruit trees. They appear in the summer and early fall.

Their pupae are enclosed in leaves; and may be found sometimes in the winter, suspended from branches in fruit orchards.

This caterpillar may be used to show complete metamorphosis and a typical moth.

2'. Tomato-worm

Tomato-worm, or sphingidae moths, are green with showy, oblique, white stripes on the sides and bright marks around the spiracles. Distinguishing characteristics are the short, curved, red horn on the dorsal end; and the favorite attitude of slightly raising the fore end of the body. They are found on or around the leaves of tomato and potato plants. They appear in the summer and early fall.

The pupae form cocoons with curious handle-like projections. They are found in the surface soil during the winter.

Tomato-worms may be used to show a caterpillar with an interesting horn and habits.

3'. The cabbage butterfly

These caterpillars are green with yellow dorsal bands and coverings of fine hair. They are very small, and are found on the leaves of cabbage plants during the spring, summer and fall.

The pupae form pale green chrysalids and attach them to the plant or other objects, such as fences, barns, or posts that are
near. Cabbage butterfly larvae are good to show the life cycle of lepidoptera because they cover it within three to six weeks.

i. Ants

Ants, or formicidae, are easily recognized by the well known form of the body. The most distinctive features are the pedicel on the abdomen and the elbow-like antennae. Ants are social insects. Each colony consists of three castes: the males, females or queens, and the workers. The workers are modified females and are wingless, while the males and queens are winged although these shed their wings after their one flight. Ants are available at any time.

Ants may be reared to demonstrate the various castes, and to show complete metamorphosis. The various habits of feeding by regurgitation, the carrying of eggs and larvae, the moving of sand and wood, and their cleaning of their bodies of dust are of great interest.

j. Termites

Termites are white ants which somewhat resemble true ants in form and habits. Their bodies are white, cream, or gray in color; and lack the thin waists that true ants have. There are four castes: the king and queen, with wings which are shed after the nuptial flight; secondary or substitute kings and queens; sterile, wingless, blind workers; and sterile, wingless, blind soldiers which possess large heads and jaws. White ants live on dead wood almost exclusively. Colonies may be found in rotten stumps and logs or in the fence posts at any time. They are destructive if they enter dwellings.

Termites may be reared to show the four castes and gradual metamorphosis. They make excellent food for aquaria and terraria insects and animals.

k. Hymenoptera

There are several species of solitary female wasps and solitary bees that overwinter in hollow blackberry and other bramble bushes. The solitary bees are mostly ceratinae, the little carpenter bees, that are steel-blue in color and quite small. They are found in round cells near the ends of the twigs that have been pruned. The true bees may be found in the winter.

l. Cockroaches

Cockroaches, or blattidae of the orthoptera group, are small black oval insects with flattened bodies. Their heads are bent down beneath their thoraces and their legs are fitted for fast running. They have a fetid odor. The eggs are enclosed in purse-like capsules which the female often carries protruding from the end of her abdomen. In nature, cockroaches live under stones, sticks, and other objects. In houses, they are pests about sinks and water pipes, or
in rubbish in basements. They are also found in laundries, bakeries, and storerooms. Cockroaches may be found all year. They may be used to illustrate gradual metamorphosis and interesting egg cases.

Grasshoppers

Grasshoppers, or locustidae of the orthoptera family, are well known insects. They have short antennae and two pairs of wings. The leathery forewings cover the large folded hind wings when the insect is at rest. They have specialized ears or tympania, one on each side of the first abdominal segment. Their long hind legs are adapted for jumping. The females have well developed ovipositors or structures capable of penetrating the ground to deposit the eggs. Some species make holes in fence rails, stumps, and logs and then, after the eggs are laid, they cover the holes with a gummy secretion. There is generally only one generation of grasshoppers a year, and in most cases, the eggs are dormant during the winter. Grasshoppers occur in great numbers in any region where plants grow. They are available in the spring, summer and fall. They may be reared to show gradual metamorphosis; feeding; and, if possible, egg laying habits.

COLLECTING AND REARING TERRESTRIAL INSECTS.

Small boxes and jars with lids are needed as temporary containers for ground and log dwellers, burrowers, and running forms. A small axe is handy for splitting logs and stumps. When collecting larvae and adults, always bring back a supply of the food plant. This should be carried in an air tight container.

A plant, such as cabbage, infected with aphids may be potted and brought into the laboratory where it should be made into a lamp-chimney cage. Various stages of the development of the aphids can be found on the plant at one time. It is best to keep the pot on an outside windowsill, where it can be in a natural atmosphere and humidity. Twigs, from various plants infected with aphids, may be placed in covered glass jars, or corked bottles and kept in a cool place until the adults emerge.

If an earwig mother and a nest of eggs are found, place them in a covered Petri dish containing moist soil. The mother will brood over the eggs until they are hatched. Feed the earwigs fresh lettuce or cabbage leaves every two or three days.

For habit observation of root infesters, plant a few corn kernels in the soil of a glass root cage. When the plants are growing, put ground dwelling wire-worms into the cage. They will feed on the roots, pupate in the soil, and emerge as adults in the spring.

Wire-worms that are found in rotten logs may be kept in a covered Petri dish or finger bowl, with a portion of the wood in which they were found.
Place dermestid larvae in a covered Petri dish with some of the material upon which they were feeding. They may also be kept in a corked bottle.

Grains and seeds infected with weevil larvae may be kept in corked bottles or covered Petri dishes. Various insects will emerge in the spring.

Meal-worms are easily reared in the laboratory. Several jars should be maintained to provide food for other animals. Fill a glass jar nearly full of bran, place some meal-worms in it, and cover. They will feed on the bran.

To start a life cycle of blow-flies, expose a piece of fresh meat where the flies are able to lay eggs on it. Put an inch layer of sand or dirt in the bottom of an insect cage, such as a wide-mouthed jar, and add a piece of wet sponge. Place the exposed meat on the sand and cover with a lid or fine piece of cheese cloth. In a few days, the eggs will hatch into soft, white grubs or maggots, which have no legs, eyes, or antennae. The maggots will burrow into the soil to pupate. The skin becomes a brown capsule-like case. A week later the adults will emerge from the cases.

Place the insect galls in a gall cage and keep it on an outside window-sill until the adults emerge. A single insect may appear from one gall, or a series of different species may appear at intervals. Some may be parasitic forms.

Caterpillars may be kept in insect cages, such as those of the lamp-chimney or cereal-box types, and fed appropriate leaves until they pupate. Pupae which have been brought in may be kept in covered cardboard boxes on an outside window-sill. In February or March, put the pupae in an insect cage so that the adults will not escape when they emerge.

For a cabbage butterfly demonstration, place a potted cabbage plant in a garden near other cabbage plants where eggs will be laid on the leaves in a short time. Bring the pot in, cover the plant with a lamp-chimney, and place the pot on an outside windowsill. The larvae will hatch in a short time and will be seen feeding on the leaves. Two weeks later, they will pupate in the soil, and emerge as adults within two weeks.

In collecting ants for the laboratory, obtain the following types: queens (at least one), workers, males, eggs, larvae, and pupae. Place the ants, with some soil in the large chamber of an artificial ant nest, and add a moist sponge. Ants may be fed sugar, bread, bits of apple, seeds, dead flies, or boiled liver. Feed sparingly and remove unconsumed portions to prevent decay.

A covered glass battery jar is sufficient for wood inhabiting ants. Place a large piece of the rotten wood in with the ants. Occasionally, feed them bits of bread, apple, sugar, or seeds.

Termites, with a portion of the wood in which they were found, may
be placed in a covered glass battery jar, tall museum jar, or similar container. Several jars of termites should be maintained to furnish food for other animals in the laboratory.

Place twigs containing the tiny solitary bees or wasps in corked bottles or covered jars and place them on an outside windowsill until the adults emerge in the spring.

Cockroaches will live for a long time in an insect cage or a glass jar that has an inch of sawdust in the bottom and a ring of vaseline around the top to prevent the insects from crawling out. Cockroaches may be fed bread soaked in milk, lettuce, oatmeal, or bits of apple. Give them plenty of water in a watch glass or other shallow dish.

In collecting grasshoppers for the laboratory, try to secure some females and allow them to lay their eggs in an insect cage or glass jar containing a layer of light, moist earth. If the earth is kept moderately moist, the eggs will hatch. They may then be transferred to a terrarium containing young grass, or grass seed may be planted in the terrarium containing the eggs, about two weeks before the nymphs emerge. If well fed and cared for, they will pass through their nymphal stages and reach adult development. Grasshopper nymphs do not grow as rapidly as cockroaches, and are not easily reared. Young nymphs may be kept in insect cages and fed green plants or wheat plants.

3. Spiders

The spider, or arachnoidea, is a small animal that has four pairs of walking legs, no antennae and no true jaws; but does have a pair of modified mandibles, and special glands which secrete a mild poison with which it paralyzes its prey. Each spider has three pairs of spinnorets from which a sticky thread is spun for the construction of its web. Some spiders do not spin webs, but hunt actively for insects or lie in wait for them. The spider eggs are laid in a silk cocoon, afterwards attached to the web, to a plant, or carried about by the female. The young leave the cocoon as soon after hatching as they can run about.

Spiders are abundant almost everywhere. They may be found at any time. They may be used to illustrate a part of the arthropod group whose members are very different in structure and habits.

COLLECTING AND RAISING SPIDERS.

In collecting spiders, look for them on or near their webs. Place the captured spiders in terraria containing plants or a few tall sticks so that they can have places to spin their webs. A female with eggs on her back makes an interesting specimen. Feed the spiders flies, termites, or other small insects.
Fish are characterized by streamline bodies which bear scales, fins, tails, gills, and have long bony skeletons. They are cold blooded animals with two-chambered hearts. Fish abound in fresh and salt water, but usually each species has to remain in either the fresh or the salt water. There are many kinds of small fish which are suitable for the aquarium, such as minnows, catfish, sticklebacks, and goldfish. The catfish, minnows, and sticklebacks are quite common in the ponds and streams of western Oregon.

A. Stickleback.

The stickleback, or gasterosteus, is a tiny fish, distinguished by the three spines on the fore part of its dorsal fin. Its color varies from greenish-brown to bluish-black on the back. The throat and breast are pink except in the male at breeding time, when they turn a vivid red. The stickleback is a voracious and pugnacious fish. Its reproductive habits are very unusual. The male selects the place for the nest and constructs the nest among the plant stems. It is the size of a hickory nut and is composed of vegetable matter, such as pieces of sticks and stems, bound together with a silky substance which the male secretes. The nest is made with two side openings so that the water can flow through and aerate the eggs. The male lures the female to the nest, in which she lays yellow eggs the size of poppy seeds. After the eggs are laid the male drives the female away and guards the nest jealously. He cares for the young after they have hatched until they are able to shift for themselves.

The stickleback fish may be found in ponds, creeks, and larger streams, and is common all year. It may be used to show peculiar reproduction habits; and is, generally, an excellent aquarium fish.

B. Catfish.

The catfish, or bullhead, has an amusing appearance. Its head is flat and adorned about the mouth by eight long whiskers or barbels which are organs of touch. The barbels resemble cat whiskers somewhat. Its body is slender, smooth, blackish in color, and from one to a few inches long. The catfish lives in ponds, creeks, and the quiet waters of larger streams. It is available all year. It is well adapted for aquarium life and exhibits interesting whiskers.

KEEPING FISH IN THE LABORATORY.

When collecting fish for the aquarium it is advisable to get very small specimens from quiet ponds and creeks. They should be caught with a fine net and transferred to a container carefully so as not to remove the body slime or to injure them. In the laboratory, keep one small fish to each gallon of water. The sticklebacks should be kept in a separate aquarium because of their pugnacious habits.
Placed in an aquarium in March, a pair of sticklebacks will soon spawn. The female should be removed soon after the eggs have been laid because the male will probably kill her otherwise. Remove the male soon after the young leave the nest since he might devour them, as well.

Fish need a variety of food. They like live food, such as daphnia, mosquito larvae, termites, and enchytrae worms. They will also eat bits of earthworm, hard-boiled eggs, or bits of cooked fish. Prepared fish food may be used sparingly. It is better to underfeed than to overfeed fish. Generally every other day is often enough to feed them. A small glass feeding ring which floats on the top of the water is often used. The food is placed inside of the ring. This prevents the scattering of food and facilitates in its removal. All material that is not eaten should be removed to prevent its fouling the water.

Overfeeding and overcrowding cause sickness among fish. The sick fish should be removed from the tank and placed in salt baths. The following directions for a salt bath are suggested (42): three-fourths of a teaspoon of table salt and one-fourth of a teaspoon of epsom salts to each gallon of water.

Fish may be left in this salt bath for twenty-four hours without harm. For a half hour treatment, use the same proportions except for a tablespoon for measuring.

VIII. AMPHIBIA.

Amphibia are animals that spend part of their lives in water or in damp places and part on land, or that are able to alternate between them. Most of the amphibian animals lay their eggs in the water, and the young immature forms develop there. These usually, or at least often, breathe with gills. The commonest kinds of amphibia are frogs, toads and salamanders.

A. Frogs.

1. Frog eggs

Frog eggs appear in transparent gelatinous clusters on the surface of the water and attached to plant stems. Toad eggs are laid in long strings which are wound over sticks, grass and water plants. Frog eggs are found in quiet creeks, ponds, or permanent pools. They may be found from January until March.

Frog eggs may be used to show amphibian metamorphosis and, if they have been laid recently, they may be used to demonstrate cleavage stages.

2. Tree frogs

The tree frog, hyla regilla, is about two inches in length, and
is easily recognized by the small suction discs on the ends of all of its toes and by the presence of a dark streak on its head. Its color varies from gray to green or black. The males may be heard singing throughout the year. Their song is a melodious trill aided by a fully inflated vocal sac. The tree frogs hide in all sorts of shelters in damp places. They are found among plants along streams, in brush and piles of debris along river banks, in rodent burrows, and in crevices in rocks. The frogs may be found in the water from about January until April or May. At other times they live on land.

The tree frog may be used to show adaptations for swimming, jumping, climbing, and protection by adaptive coloration.

B. Salamanders or newts.

1. The waterdog

The waterdog, Triturus tortosus, is characterized by its soft moist skin that is thick and rough with many low black-tipped points. It is brown above and orange beneath. The waterdogs gather in pools, ponds, and creeks early in the spring—usually in January—to spawn. They are aquatic during the summer but, in October or November, retreat to cavities under logs on dry land to come out on warm days. They may be found under stones or boards in damp earth basements.

Waterdogs may be used to show the typical salamander with a skin adapted for protection against desiccation.

2. The Plethodon salamander

Plethodon intermedius is smaller and more slender than the waterdog. Its body is smooth and about four and a half inches long with fairly well developed legs and tail. The color is variable, generally dark gray above and grayish white beneath. Some have reddish backs with a light streak down the back. Others are mottled. Plethodon is found under rocks and rotten logs along the banks of streams, but not in the water. Females may be found brooding over eggs and young which never live in water. The salamander may be found in the spring, summer, and fall. It represents a salamander which lives and breeds on land.

COLLECTING AND REARING AMPHIBIANS.

When collecting frog eggs, it is best to go to the pond early in the morning to get the freshly laid eggs. Dip the egg clusters out with a water net and select those that have equal parts of dark and light with a single line crossing the light half. In the laboratory, put the eggs in an aquarium by themselves, as they would be eaten by the other inhabitants in a large sized tank. Tadpoles will grow and develop rapidly. They feed on vegetation and decaying organic material. They may be fed bits of earthworm, also.
two or three tadpoles should be placed in a large aquarium as too many would eat all the vegetation.

Tree frogs should be kept in a woodland or a swamp terrarium, or in one containing mosses for hiding places. There should be a stone for them to rest on. A small board or branch should slant out of the container, so that the animal can climb out. The windows of the laboratory nearest to the terrarium should be left open at night to allow the tree frogs to go out and feed. They will return before morning. Tree frogs will learn to feed during the day if food is provided. Feed them living insects, such as termites, flies, enchytrae worms, meal worms, or bits of earthworms.

Salamanders will live in an aquarium or a semi-terrarium. They may be fed by holding bits of worm before them with forceps. Several may be fed by placing them in a bowl of water containing food. If the newts refuse to eat, move the food around in the water, or use the forcep method. The newts will eat bits of earthworm, fresh liver or beef, pieces of scrambled eggs, termites, meal worms, enchytrae worms, and mosquito larvae.

IX. REPTILIA

None of the reptiles except the turtles have shells, but all of them are covered with scales. All of them except the snakes have toes armed with claws. All reptiles are cold-blooded, breathe with lungs, and reproduce by eggs, which are either hatched by the warmth of the sun or within the body of the mother.

A. Lizards.

Lizards have long bodies covered with scales. They have four legs, movable eyelids, and long tails. When their tails are broken off, lizards can regenerate new ones. The following are a few of the species which can be reared in the laboratory: the blue-bellied lizard, the Alligator lizard, and the blue-tailed skink.

1. The blue-bellied lizard: the blue-tailed swift; the fence lizard: Sceloporus occidentalis occidentalis

The blue-bellied lizard is a small lizard. It is about five inches long, and is covered with keeled scales. It is a greenish-gray, with six rows of dark blotches along its back and sides. Its chin and belly are blue. The lizard is most common about fences and on hillsides during warm weather. It may be found beneath logs, rocks, brush, or rails and, sometimes in woodpiles. During winter the lizard hibernates in these retreats where it is protected, but the first warm spring weather brings it out again.

The blue-bellied lizard represents a fence lizard which moves very rapidly, and has interesting habits. If it is tickled gently on its back it seems to become hypnotized for some time.
2. The alligator lizard

The alligator lizard, gerrhonotus, is a large lizard. It is sometimes as much as twelve inches long. It has small legs, a large diamond-shaped head, and a protractile tongue. It is dark green above and blue underneath. This lizard moves clumsily from side to side with slow movements. It is found on the ground of tree-covered hillsides, under logs, rocks, leaves, or brush. It is active during warm sunny weather, and hibernates during the winter.

The alligator lizard has interesting movements and feeding habits. Its tongue darts out, catches the food and returns to the mouth, almost faster than the human eye can follow.

3. The blue-tailed skink

The blue-tailed skink, pleistiodon skiltonianus, is one of the most interesting of lizards. It grows from six to eight inches long, and is characterized by a smooth skin, a tapering head and tail, a protractile tongue, and short legs. The color of this species varies with the age of the individual. When young, it is dark brown with two bright yellow stripes, pale blue under-parts, and a brilliant blue tail; when fully mature, its tail is no longer blue, but pinkish, the head has become red, and the body olive-brown above and bluish-green beneath.

The skink requires about four years to develop. Its tail is unique for, if the lizard is grasped by its tail or handled roughly, the tail will break off and remain wriggling on one's hand for a few minutes. The new tail which develops is never as large or as blue as the first one.

The skinks hide during the day, coming out in warm evenings. They may be found in the foothill regions on rocks or wood fences, on the ground between rocks, in oak and pine debris, or under stones in pastures. They are remarkable for their almost incredible swiftness and their re-generations of new tails.

B. Snakes.

Snakes are reptiles that have long, round, limber bodies which are covered with scales. Their eyes have no lids, but are covered with transparent skin. Their tongues are bifurcated and extensible. Their jaws are not united firmly at their joints. Their teeth are pointed sharply inward. Harmless snakes have many small teeth. Poisonous snakes have wedge-shaped heads, pits between their eyes and nostrils, elliptical rather than round eyes, and two or more large fangs through which poison is excreted into wounds or punctures made by the fangs themselves. Snakes shed or molt their skins at regular intervals. Viviparous snakes bear their young already hatched. Other species are oviparous and lay eggs. A few of the harmless snakes that are suitable for the laboratory are: garter, gopher, ring-neck, and coral king snakes.
1. The garter snake

The garter snake, _thamnophis sirtalis concinnus_, can be recognized by the keels on its back and its coloration. It has a coppery red head, a dark upper body surface with a light yellowish stripe down the middle of the back, and another similar stripe low on each side of the body. The snake is nonvenomous, but emits a foul-smelling odor when it is handled. Garter snakes are _viviparous_, the females producing from ten to seventy-five at a birth. The snakes haunt the grassy margins of streams and ponds, or damp places in meadows. They are often called water snakes, because of their moist habitats. They may be found during the warm weather of spring, summer, and fall. They hibernate during the winter.

The garter snake represents a harmless, _viviparous_ snake.

2. The gopher snake

The gopher snake, _pituophis catenifer catenifer_, is very common, and is often called the bull snake. It is about twenty-one inches long. Its general color is ochre, but down the middle of the back there are dark brown saddle-like blotches and along the sides are small dark spots. The females lay eggs. The gopher snake is generally quiet and if approached will lie motionless; but if it is cornered, it will "show fight" by hissing and striking. The snake is found in the grasslands and is rarely or never seen in water or up in trees or bushes.

The gopher snake represents a harmless _oviparous_ snake which emits a distinct blowing hiss, and has a curious habit of vibrating its tail rapidly when it is excited.

3. The ring-necked snake

The ring-necked snake, _diadophis amabilis_, is very small. Its body is about the size of a lead pencil in diameter, and is less than fifteen inches in length. Its body is slate-colored above, with a red collar about the neck. Its underside is orange-red, with many fine black dots. The scales are smooth. The snake is found on shaded ground, under leaf debris, logs, boulders, or brush.

The ring-neck snake is a pretty, tiny, harmless snake which has a curious habit of feigning death. When a stone under which it may have been hiding is turned over, it lies with its brilliant under surface uppermost and its tail coiled in a tight spiral.

4. The coral king snake

The coral king snake, _lampsreptes multicineta_, may be recognized by its bright black, red, and yellow rings. It is found chiefly on shaded slopes around rocks and leaf debris in southwestern Oregon. The snake is gentle and makes a good pet. It is a harmless snake with striking colors.
Turtles.

Turtles are characterized by horny shells which enclose the body. Their necks, legs, and tails are movable, and these protrude from the shell or may be drawn back into it. It has no true teeth, but does have sharp continuous ridges on its jaws. The mud turtle is a common example of this group.

1. The Pacific terrapin or pond turtle

The shell of the pond turtle, Clemmys marmorata, is arched above, flat beneath, horny, and divided into numerous plates. It is about five inches long, with olive brown smooth upper plates, and smooth, yellow under plates which have irregular brown or yellow markings. The stripes on the fleshy head, neck and legs are bright yellow. In the late spring and in the summer, the turtle may be seen floating on logs or sunning itself on the banks of streams. It is found about ponds, and in quiet, deep parts of streams and creeks.

The turtle represents a reptile which has joined bony plates and interesting habits of locomotion and feeding.

COLLECTING AND REARING REPTILES.

To catch lizards, one should use a noose on a string, a small live trap, or just his hands. In the laboratory, lizards will live in a reptilian terrarium. It is not desirable to place more than two or three lizards together because of their cannibalistic and fighting habits. One should feed them living insects, such as termites, meal worms, flies, cockroaches, enchytrae worms, and mosquito larvae. They will also eat bits of fresh meat or earthworm.

Snakes may be caught with the hands, with a noose on a stick, with forked sticks, or in snares. One should keep them in a reptilian terrarium. Small species should not be put with large ones or they might be devoured. Their cages should be kept clean from all uneaten food.

Gopher snakes should be fed one or two mice once a week although they will live for weeks without feeding. These snakes are the easiest to tame and make the best pets.

Garter snakes should be fed one frog each once a week. They are easy to look after, but are unpleasant to have around because of their offensive odor. The snakes will live for a long time in a terrarium.

Feed the ring-necked snakes termites, meal worms, or bits of fresh fish or beef. Hold the food before the snake with forceps. This snake is small and needs food every day.

The coral king snake will eat little garter snakes, skinks, or mice. Feed it about once a week.
Use a long handled dip-nert, or the hands, to catch turtles. Select the smaller specimens for the laboratory. Turtles live best in a terrarium containing water and soil, such as a semi- or a swamp terrarium. They need sufficient sand in one end of the vessel to bury themselves in, and water in the other end to eat their food in. Feed them earthworms, termites, or raw beef. Feeding turtles (29) on canned salmon or tuna fish helps to overcome "soft shell" which is a common ailment in captive specimens during the winter.

X. AVES.

Aves or birds are feathered bipeds which are warm-blooded and lay eggs. Birds show a high degree of parental care and protection of the young. The screech owl and young crows may be used to represent this group.

A. The screech owl.

The screech owl is a small nocturnal owl, eight to ten inches long, and distinguishable by its gray color, its eyes in the front of its head, and its ear tufts spread far apart. It makes a tremulous, mellow, hooting sound. The owl lives in oak regions in the open country. In the day time it hides in holes in trees, or imitates a dead limb in a mass of foliage.

The screech owl represents a beneficial owl. Its plumage is adapted for its protection. It makes a good pet.

B. The crow.

The crow is a perching bird about seventeen to twenty inches long. It is characterized by black plumage, very strong legs and bill, and a very high harsh voice. The crow is found in farming regions, in open fields, on fences, and in valleys of willow-bordered streams. Crows generally occur in large flocks, and are residents here.

The crow shows feet adapted for perching, and is a good pet when caught young.

CARING FOR BIRDS IN THE LABORATORY.

The birds may be kept in bird cages or in live cages. Feed the owl meat, a mouse once a day or an equivalent amount of meat. About once a week the owl should have a chicken head for the bone it contains. The crow will eat bread and milk several times a day. It will also eat grain and insects.

XI. MAMMALS.

Mammals are distinguished by the fact that they develop hair. They have four-chambered hearts, are warm-blooded, breathe by means of lungs, and suckle
their young. Rodents represent one group of mammals.

Rodents are characterized by having gnawing teeth. Their incisor teeth are chisel-like in form and continue to grow in length throughout life. The Douglas pine squirrel and meadow mice are common examples of rodents.

A. The Douglas pine squirrel

The Douglas pine squirrel is characterized by dark brown upper parts and bright orange under parts. Its habitat is the coniferous woods or bottom lands. The squirrel may be found in the spring, summer, and fall.

The squirrel represents one type of rodents with interesting habits of feeding and climbing.

B. Meadow mice

Meadow mice, micretus, are little gray mice, commonly found in shallow burrows, under logs, or rocks and in fields, hillsides, and woods. They may be found in the spring, summer, and fall. They are pests among the field crops, but have interesting eating habits and make good pets.

REARING RODENTS IN THE LABORATORY.

Live traps baited with oatmeal may be used to catch rodents. Set the trap along a trail, under a fallen log, in a hole, in a runway through the vegetation, or at the base of a tree.

In the laboratory, place the rodents in a live cage or terrarium. Feed them nuts, grain, pieces of apple, dried fruit, pieces of vegetables, bacon, or oatmeal, or small quantities of all of these.

One should treat the animals gently and with kindness so that they are happy. Keep the cages clean with fresh sand or sawdust on the floors. Feed the animals regularly, and remove all uneaten pieces of food. Do not overfeed the animals. Do not overcrowd them in the cages. Keep predacious forms by themselves. The temperature should be cool and even. Give the animals plenty of fresh, clean water to drink. Remove all sick animals and all dead forms immediately to prevent fouling of containers. The cage should be sterilized two or three times a year.
Chapter IV
VIVARIA AND A HERBARIUM

I. VIVARIA.

Laboratory study of living plants is made possible through the use of vivaria, such as balanced aquaria and terraria.

A. A Balanced Aquarium.

A balanced aquarium is a receptacle in which both aquatic plant and animal life will thrive, and each be benefited by the other. Such an aquarium is easily started and may be maintained for a considerable time. A rectangular glass container with a capacity of six to nine gallons is the most desirable form and size. The cylindrical battery jar with straight vertical sides is satisfactory to maintain, but the inmates are likely to appear somewhat distorted through the curved sides. Other glass vessels such as fruit jars, tumblers, or large bowls may be used, but are too small to give good results and require frequent attention. Additional equipment, such as a small net, a pair of aquarium forceps, a syphon tube, and a glass feeding ring will be useful.

The directions for making a nine gallon aquarium are as follows:

1. Clean the container thoroughly and set it where it will be exposed to strong diffused light, as in or near a north or south window, but not too near a radiator. If this is impossible cut a piece of cardboard to fit over the side of the aquarium that is exposed to the direct sunlight. It may be necessary to prepare a similar shield to fit over the top.

2. Obtain some sand or gravel and wash it clean in running water. If the sand has been used previously in an aquarium, it should be boiled for a few minutes.

3. Cover the bottom of the tank to a depth of two inches or more, depending on the depth of the container, sloping towards the center, side, or end of a small tank. Have several depressions if the tank is large enough.

4. Fill the aquarium half full of pond water, or if this cannot be secured, use tap water, which stood in open containers for several days.

5. Pour the water in without disturbing the sand, by placing a saucer, or paper on the sand, and pouring the water into it, or against the sides of the vessel.

6. Plant the aquatic plants sparingly. The following plants may be purchased from a supply house, and are recommended (31): rooting forms: valianeria, sagittaria, and ludwigia; non-rooting forms: elodea, cabomba, and myriophyllum.
It is suggested (31) that the following number of each be used for a nine gallon tank: Two each of vallianeria and sagittaria, or substitute ludwigia for one. Spread the roots out on the sand and cover them up to the crowns with sand. Fill the aquarium with more pond water and arrange the leaves of the plants so that they are floating freely. Add two stalks each of elodea and myriophyllum, weighting the lower ends of the stalks with small pieces of lead or wire.

If native plants are to be used, it would be well (46) to sterilize them by placing them in a dilute solution of potassium permanganate for an hour or more to kill the algae and other destructive plant forms which may be present. Four or five small crystals of the permanganate to one gallon of water is the best solution. Wash the plants in clear water afterward. Among the common native plants of western Oregon which are recommended for aquaria are: Arrowhead, spike rush, water butteccups, hornwort, duckweed, and watercress.

In planting, general rules of proportion should be observed. Tall plants, such as vallianeria and sagittaria should be massed at the back or in a corner for background effect; and fleshy plants, such as elodea, cabomba, ludwigia, and myriophyllum are best placed in the corners or at the sides.

7. Allow the tank to stand for several days, before adding the animals. If the aquarium becomes cloudy and the plants do not grow, reduce the number of plants.

8. In stocking the aquarium with animals, put them in sparingly, and keep predacious forms to themselves. Do not use animals which will stir up the sand at the bottom and keep the water turbid. Place only healthy specimens in the aquarium. As a routine measure, subject them to the dilute potassium permanganate solution for twenty minutes before placing them in the tank.

The following animals for a six gallon tank are suggested:

a. Six inches of fish, that is, three two-inch fish or six one-inch fish. It is best to use several small fish rather than a few large ones.

b. Six to ten snails

c. One small turtle, about an inch across the shell

d. One clam, two inches long or less

e. Two small newts or one large one

For an insect aquarium with a six gallon capacity, one might provide the following (30):
a. One tadpole and six or eight pond snails

b. Two water striders, two whirligig beetles, one water scavenger beetle, six damselfly nymphs, two dragonfly nymphs, fifty or one hundred mosquito larvae and pupae.

c. Two or three caddis worms may be added

9. The water should remain clear. If it becomes cloudy, the water should be changed by using a syphon tube to remove the water from the tank. The number of plants or animals, or both, should be decreased. Cut off the dead parts of plants, and remove any animals that die.

10. Keep the aquarium covered with a glass plate to control the humidity, and to keep the animals which jump or fly from escaping.

B. A Balanced Terrarium.

A balanced terrarium is a container in which terrestrial plants and animals may be kept in natural conditions as nearly as possible. It is a convenient way of illustrating ecological groups and of providing interesting living material for the study of structures, adaptations, and habits of the inhabitants.

The usual terrarium is an aquarium case, either round or rectangular, or round with two sides flattened. It should be covered with a glass top. A terrarium may be constructed in the following way (5): Secure a shallow, wooden box about eighteen by twenty-four inches and three to four inches deep. Against each side and on the inside of the box stand pieces of glass cut in lengths to fit the box, and about twelve inches high. Put in soil to the level of the top of the wooden box. This soil will hold the glass in place at the bottom. To keep the glass from bulging at the top, run a strip of adhesive tape around the outside of the glass pieces near their tops. Make a glasscover to fit. In place of the adhesive tape, Dr. F. T. McLean suggests (15) double brass corners with adjustable diagonal screws to hold the glass firmly in position.

Large bottles, when filled with interesting arrangements of plants, make attractive terraria. Other glass containers, such as battery jars, fish bowls, large candy jars, or casseroles, may be used. A thick layer of absorbent material, such as sand, gravel, sawdust, or sphagnum moss is necessary for the base of all types of terraria. Some charcoal should be added to the soil to keep it sweet.

The following are more narrowly limited types of terraria, with directions for their construction:

1. Woodland terraria

a. Clean the container thoroughly and cover the bottom to a depth of two inches with clean coarse sand or gravel.
b. Build the gravel into a hill at one end.

c. Add a layer of loam and decaying leaves from the woods to a depth of one and a half inches, covering all of the gravel.

d. In planting, it is best to have a definite plan in mind, a bit of woodland, a fern glen, or a moss group. Then decide on the point of view so that one side of the vessel can be planted with the taller things as a background, while the front can hold the smaller plants.

Have the plants wet to start with. Use a spoon or small paddle to make a depression for each plant, spread out the roots, and cover with soil. Use mosses, liverworts, small ferns, seedlings from coniferous soil, and any other small woodland plants desired which can be moved. Small fleshy fungi such as bird's-nests, brackets, peziza, and mushrooms will grow here. Add one or two moss or lichen-covered stones or twigs. Any large leaf or frond which touches the glass or obscures the vision, or any stalk which is too tall, must be cut off at the base. If the cut is too drastic, Andrew suggests that (2) the wound may be touched with a bit of powdered charcoal. Remove the debris, such as evergreen needles and withered leaves, with the aquarium forceps. Avoid overcrowding, excessive heat, too much moisture, and meaningless ornamentation of plants. Refuse to allow mold to develop by removing the top for a few minutes each day.

e. Pour water in carefully and in a way that does not disturb the plants and soil. Use enough to saturate the sand or gravel layer completely, and make the loam moist.

f. After the plants have been established, a few animals may be put in. Such forms as land snails, newts, land insects, and a tree frog may be added.

g. Cover the terrarium with a glass top to control the humidity. Keep it in a light place, such as a north or south window, and in a steady temperature of about seventy-five degrees, Fahrenheit.

h. For a bottle terrarium, use bottles ranging from one-gallon capacity to fifteen or more gallons. Depending (15) on the size, have two or three half-inch holes bored in the lowest part of the bottom, to provide for drainage. Over the bottom place pieces of broken pottery, convex side down, and cover with a layer of sand. Next add the soil mixture of equal parts of sand, humus, and top-soil. Keep the planting low in front and higher towards the back. Put the smallest plants in first, then the middle-sized plants, and finally the largest.

Make holes in the soil with a blunt stick, and put the plants in with a lifter or tweezers. Then draw the soil around the roots with a flattened stick or paddle. Be sure the roots are in firm contact with the soil.
2. Bog terrarium

The bog terrarium requires a very acid soil and more water than the other terraria. To make a bog terrarium, one should follow these directions:

a. Obtain a water tight container of satisfactory size.

b. Obtain soil from a peat or swamp bog. Test it with litmus paper for its acid content. This may be done by placing a blue litmus paper in the damp bog soil. The paper will turn red if the soil is acid.

c. Put in a gravel base two inches deep and place three or four inches of the bog soil over this base. Build a hill at one end of the tank.

d. Fill the tank with pond water so that the soil opposite the hill is about one-third under water and the hill is moist.

e. Add plants, such as sphagnum moss, pitcher plants, sundew, marsh marigold, bunchberry, and marsh violet.

f. Bog, or semi-aquatic, insects and animals may be placed in the container. Snails, tadpoles, newts, salamanders, mosquito larvae, dragonfly larvae, and others will thrive here. Use these very sparingly as to numbers.

3. Swamp terrarium

This terrarium is similar to the bog terrarium, but one end is built up with rocks and bog soil to form an island, and the other end is from six to ten inches under water. Obtain bog soil for the terrarium when collecting bog plants. The plants and animals of the bog terrarium may be raised here, but aquatic plants and animals may be added.

4. Field terrarium

A field terrarium requires sunlight and field soil. Place the soil over the gravel base, and use a moderate amount of moisture so that the soil is moist. The glass cover is not necessary, unless jumping animals or insects are added. In this case, cheesecloth covering may be used. Field glasses make a good sod layer in which to plant the field plants. Among the plants suitable for a field terrarium are small cudweed plants, shepherd's purse, wild strawberry, violets, pussy's ears, and stone-crop. Several others may be included. Add one or two lichen-covered stones and twigs to provide hiding places for the insects. Include a few terrestrial animals or insects, such as snails, slugs, sowbugs, spiders, or small lizards.

C. Moist Chamber

A moist chamber is made most easily by placing a moist paper towel on
a plate and covering it with a bell jar or similar glass container. The towel should be kept moist but not wet. Such plants as mushrooms, liver worts, mosses, lichens, and other fleshy fungi will live here for a short time.

D. **Insect ages.**

A covered Petri dish or a finger bowl is an excellent cage for very small forms, such as the larvae of dermestids, grain-weevils, wire-worms, and earwigs.

A lamp chimney cage is a simple and inexpensive cage to make. Fill a small four-inch flower pot three-fourths full of damp soil or sand. Plant the food upon which the insect feeds, or put a branch of it, in the soil. Another method is to bury a small bottle in the soil, fill it partly with water, and insert the food plant in the water. Cotton should be packed around the stems at the top of the bottle so that the insects will not fall into the stems and drown. Put the insects on the plant, and place a lamp chimney or a farm lantern globe over the top of the plant and press it down into the soil. Tie a piece of cheese cloth or netting over the top of the chimney. This kind of cage is easily kept clean, and food is readily put in and removed. All kinds of climbing and jumping insects, such as caterpillars, aphids, crickets, and grasshoppers, may be kept in such a cage.

A wide-mouthed jar or bottle with an inch of damp soil in the bottom and cheese cloth cover makes a good cage for earth-burrowing insects. Insects such as beetles, wire-worms, fly maggots, cockroaches, tomato-worms, and meal-worms will live in this type of cage.

The cereal box cage is made of an empty, paste-board cereal box or ice cream carton. Cut two oblong holes on opposite sides of the box. Cut two pieces of wire screening an inch larger than the holes in the box, and place them inside the box over the holes. Sew them to the carton with a coarse needle and a piece of twine. Place insects that do not jump or fly, such as caterpillars, cockroaches, or large beetles, inside and cover with a lid.

To make a showbox cage for parasites and gall-making insects, one should cut a small hole in one end of a shoebox large enough to make possible the insertion of the open end of a small glass vial or bottle. Insert the vial so that the closed end projects out from the box. Place parasitised caterpillars, that is brown, sick acting, puck-marked, egg or cocoon covered caterpillars inside the box and cover with a lid. Galls that are found on various plants should also be placed in this type of cage. When the parasites or gall insects emerge in the dark interior of the container, they will be attracted by the light coming from the vial, and will fly or crawl into it and may be observed.

An artificial ant nest is easily constructed. Duncan (42) suggests...
that the foundation for the nest should be a large block of soft wood. A
piece eighteen inches long, twelve inches wide, and two inches thick is
preferable, although smaller pieces can be used. Two cleats, one inch by
four by eleven inches, should be nailed crosswise on the bottom of the
piece to prevent it from warping. A mort or groove an inch wide and at
least a half an inch deep should then be gouged out of the upper side
of the block. This should run all the way around the block, and should
be at least a half inch in from the edge. This is to hold the water which
will prevent the ants from escaping. Before being used, however, the groove
should be coated inside with wax. To do this, melt some paraffin and pour
it, while very hot, into the groove. The groove will then be nicely water
proofed and the block will not absorb water from the moist.

When the foundation for the moat is completed, find a tin or wooden
box about seven inches square and a half-inch deep inside. No lid will
be needed. Cut two holes in one end of the box. Make one of these a
quarter inch across. This will serve as the entrance to the nest. Make
the other hole about a half-inch across. Next tack the box, open side
up, to the foundation block. The box should not at any place project
over the moat.

Next, one should place an oblong piece of sponge or a roll of absorb-
ent cloth through the larger hole, so that part of the sponge will project
into the box, and part will remain outside. Water, poured on the sponge
or cloth periodically, supplies moisture for the inside of the box. Finally,
get a piece of window glass, cut so that it will just fit inside the box. Support this on small blocks or pieces of cork so it will be held
about three-eighths of an inch above the floor of the box. The nest is
now complete.

To establish a colony of ants, liberate them on the part of the founda-
tion block which is not covered by the box. Food should be supplied to
them here. If one desires, he may fill a part of the space beneath the
glass with damp earth. The ants like to have their nests dark inside, so
it will be well to cover the nest box with a square of black cloth laid on
top of the glass, except when the colony is being observed.

E. Live Animal Trap and Cage.

Secure a five-cent mouse trap, and an old tomato or fruit can,
a piece of small mesh wire-screening which is an inch larger than the hole
of the can, and a piece of copper or other soft wire. Place the open edge
of the can under the pan of the mouse trap, and wire the trap to the can.
Fasten the wire-screening to the lever of the trap, so that when the spring
snaps the lever, the wire-screening closes the mouth of the can. The cap-
tured prey can not escape. Place the bait, such as oatmeal, in the back
part of the can to lure the animals in. The trap is set using the methods
employed in setting an ordinary mouse trap. When the animal steps upon
the screening in quest of the bait, the trap goes off, the lever, to which
the screening is fastened, snaps up and the screening closes the mouth of
the can and shoves the animal in.
Animal cages suitable for rodents and birds may be purchased from biological supply houses, or they may be built in a simple shop.

To make a cage, cover a box frame or a packing box from which one or more sides has been removed with quarter or half-inch mesh galvanized wire netting. Glass can be used on one side. A hinged door in the wire netting, or a sliding glass door, should be placed at one end near the bottom to facilitate the cleaning of the cage or the placing and the removing of birds or small animals.

The cage should be provided with a feeding dish, such as a small finger bowl or Petri dish, and a small container for water. A good clean method for supplying water is as follows: Secure a three-ounce bottle with a wide mouth, a cork to fit, and a piece of glass tube about six inches long. Bend the glass tube slightly near the center. Hold one end of the tube over the flame long enough to smooth the glass at the end of the tube from which the animals are to drink. Insert the other end of the tube so that it just passes through the cork. Fill the bottle with water, stopper it well with the cork with the tube in it and invert the bottle. Fasten the bottle to the side of the cage with wire so that the free rounded end of the tube protrudes into the cage about two inches from the floor. The water will not drip, but will remain at the end of the tube where the animal can lick it.

Spread a layer of sawdust or sand over the bottom of the cage. Provide a nesting box, closed on five sides, but with one end open. Place nesting material, such as old quilt wadding, cotton, or bits of dry grass, in the cage but do not put any in the nesting box.

F. A Reptilian Cage.

In a terrarium, or similar deep glass container, place a layer of sawdust, sand, or gravel, and a few stones and branches or large pieces of bark fastened firmly to broad bases for the reptiles to climb on. Supply a watch glass or shallow dish with water in it, also. This cage will serve for very small snakes and lizards. Larger snakes will require larger cages than most schools will care to provide.

II. HERBARIUM.

The equipment for collecting and drying botanical specimens and for pressing and mounting them should include the following:

1. A collecting can (vasculum), or a portfolio type plant press
2. A heavy laboratory plant press
3. Plant driers, such as newspapers, paper towels, or regular blotting paper
4. Corrugated boards, binder's boards, or strawboards
5. A trowel, or pick
6. Mounting sheets
7. Manila folders
8. A notebook

A container of some sort in which the specimens may be placed as they are gathered in the field should be used. This may be a collecting can, or a portfolio press. Plants will remain fresh or only slightly wilted in a vasculum for two or three days, if necessary.

The light field press or portfolio is recommended for bringing a large number of specimens to the laboratory. A simple plant press is made by placing together two pieces of heavy binder's board or strawboard, twelve by seventeen inches, and fastening with two straps of heavy cords.

The trowel should be a good heavy one. The ordinary garden trowel is not durable enough for this work, hence a botanical trowel is recommended.

Collecting sheets are folders of un glazed paper, sixteen and a half by twenty-three, or eleven and a half by sixteen inches when folded. Old newspaper out to these sizes make good, inexpensive collecting sheets. They are used in the field to keep the specimens until they have been mounted and pressed. A collector should get enough of the roots, stems, leaves, flowers and fruit of each specimen, and arrange them on the sheet in such a way that their natural relationships are shown. Large plants may be bent in a V or N shape, to get them on the paper. Sections of roots; stems bearing leaves, flowers, or fruit; and portions of the bark should be represented on the sheet. If two kinds of leaves are found on the plant, both should be placed on the collecting sheet. Both staminate and pistillate flowers should be included even though both may be present in different parts of the same plant or on separate plants.

The specimens should not be crowded or piled up on each other. Unruly twigs should be flattened and the leaves spread neatly out, with the minimum amount of folding and overlapping. Bulky forms must be reduced as much as possible by hollowing out the back, or cutting them in such a way as to detract from the surface appearance. Some of the composite heads may be sectioned or blocked up by discs of drying paper that fit closely about the bracts, to permit the rays to lie nearly flat. Bell-shaped corollas, as in the blue-bell, may be kept from being mashed by placing a pad of cotton, the appropriate size, inside the corollas.

To keep delicate flowers from collapsing, place bits of moist paper near to the fresh flower, spreading the petals as the plant is placed in the portfolio. Fine-leaved water plants should be rolled up in wet paper to bring to the laboratory. In the laboratory, the water plants should be placed in water and floated out on sheets of white paper before they are removed carefully from the water so that the fine leaves do not cohere.
To place the specimens in the portfolio, put a sheet of blotting paper, paper towels or plant driers in the portfolio, then add the collecting sheets with the specimens. Cover this with another plant drier, and so on. When the portfolio is full, cover, and strap together tightly.

Notes should be made regarding the date, localities, habitats, heights, methods of branching, colors of the flower parts, common names, etc., at the time of collection. These should be kept with the specimens on the collecting sheets, or recorded in the notebook for permanent record, using a number system to correspond with the specimens collected.

To press the specimens, remove them from the portfolio as soon as possible, and put them in the press. Arrange the plant neatly in its proper position within the space which is allowed for the herbarium sheet after it has been dried.

To arrange plants in the press, place a corrugated cardboard with a sheet of drying paper on the bottom. Upon the dryer, place the folder containing the specimen and cover with a dryer sheet, and then a corrugated board. If many specimens are to be pressed, some of the corrugated ventilators may be omitted to conserve space in the press. When all of the specimens are in the press, the clamps or straps should be tightened, and the press placed in a warm, airy place to dry. To prevent mold and discoloration, examine twenty-four hours later, and replace the damp driers with new ones. The moist driers may be dried and used again.

Two or three changes of driers in one or two weeks is sufficient for the average specimen, if plenty of boards and driers have been used. Thin plants such as ferns and grasses will dry in two or three days, while very fleshy forms will require longer. The following method for using artificial heat is suggested (27): The specimens are pressed in the usual way for a few hours until wilted. Sheets of corrugated cardboard, smooth on both sides are used. The press is strapped together again with only a moderate tightness, and set edgewise over a source of heat with a skirt of canvas to direct the rising hot air through the vertical corrugations. The best source of heat is an electric toaster or hot plate, but an oil heater gives good satisfaction.

After the specimens are dried and identified, they are ready to be mounted. The regular size for mounting paper is eleven and a half by sixteen and a half inches. Only one plant should be mounted on a sheet, no matter how small it is or how many, presumably, of the same species are to be mounted. Three methods for mounting specimens are suggested (35:2):

1. The glue is spread on a glass plate, the specimen laid on the glue and lifted as soon as all parts have come in contact with it. Then it is transferred to the paper. 2. The specimen is inverted on the paper where it has been stored, painted with glue by means of a brush and then transferred to the mounting sheet. 3. The specimen is laid on the mounting sheet and fastened there by means of small strips of gummed tape which are used in large enough quantity to affix securely the stems, petioles, flower stocks.
leaf tips, and other parts. If either of the first two methods is used, it is also well to use some of the small strips of gummed tape to fasten the specimens more securely to the sheet.

The label for the specimen is preferably attached in the lower right-hand corner. The label should include information regarding the specimen, such as the name, date, collector, collector's number, locality, etc.

The specimens are usually handled quite frequently, and often are soiled or pieces broken off. Cellophane covers for the mounted specimens are recommended (35:2-3). Cellophane is perfectly transparent, flexible, and does not interfere with detailed study. Cellophane sheets, twelve and a half by seventeen and a half inches, are placed over the specimen and the upper edge folded under the edge of the herbarium sheet. This upper edge, about an inch, is glued to the back side of the herbarium sheet. The lower corners of the cellophane are then fastened to the corners of the herbarium sheet by means of paper clips. This makes it possible for the cellophane to be rolled back should it become necessary.

One should arrange and store the mounted specimens according to their classifications in order to facilitate ready access to them. He should group the specimens according to species, genus, or family, and place them in large manila folders. Label them in one of the lower corners. Arrange the folders in a case or file in their proper taxonomic order.

To guard against museum pests, which attack the specimens, fumigate with carbon bisulphide three or four times a year. Sticks, flakes, or balls of napthaline may be kept in the cases, also.
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