The University of Chicago Nature-Study Series

A FIELD AND LABORATORY GUIDE IN BIOLOGICAL NATURE-STUDY

By

ELLIOT R. DOWNING

Associate Professor of Natural Science in the School of Education of the University of Chicago

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PREFACE

This field and laboratory guide in biological nature-study is the outcome of many years' experience in preparing teachers to handle nature-study in the grades and biology in the secondary schools. It is intended primarily for the use of students who are preparing to teach this work and of teachers who are already at it. It does not attempt systematically to cover the field of biology but merely to deal with those groups of plants and animals that are of most interest to pupils.

Those phases of the subject-matter have been selected that lend themselves best to project and problem teaching, that develop appreciation of the commonplace environment, and that make for social efficiency on the part of the pupil. It is hoped that the book will prove helpful to that large and increasing group of teachers, both actual and prospective, who are earnestly trying to use in the schools that scientific method and accumulated knowledge so important in modern life. Further, it is hoped that through the teachers it will serve those boys and girls who, by acquaintance with nature, will come to adjust themselves more intelligently to their environment, use the forces of the universe more effectively, and be happier in their enlarged outlook.

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INTRODUCTION

Secure a copy of the outline of the course in natural science in the Elementary School of the University of Chicago[1] (or similar outline for other schools[2]). Look it over carefully to get a clear notion of the sort of work you will be asked to do when you come to teach nature-study, for which this course in part attempts to prepare you.

Follow carefully the directions for collecting and studying the materials suggested in the outlines. It is more important that you should acquire correct methods of studying nature material and the point of view of the self-reliant investigator than that you amass information. Answer all questions asked and make all drawings and diagrams indicated in the notes on the blank pages opposite the directions. Notes and diagrams are to be in ink. Use Higgins' waterproof ink for the drawings, making them with a fine drawing-pen.

[1] Published in the *Elementary School Journal*, Vol. XVIII (February, March, and April, 1918); also reprinted under one cover and available at the School of Education bookstore.

[2] See *Nature-Study Review*, Vol. X, No. 9 (December, 1914), and Vol. XI, No. 3 (March, 1915); also *Illinois State Course of Study*, published by C. M. Parker, Taylorville, Illinois.

SOME COMMON INSECTS

Field trip.—On this trip take a couple of small boxes, a small bottle of gasoline, and an insect net. The two latter items will be furnished you; provide yourself with the boxes. Go out into a vacant lot, meadow, or border of the woods. Turn over old logs, stones, and boards; rip the bark off of stumps and capture any insects or other small animals encountered. Watch clusters of flowers for butterflies and bees, pond margins or marshy spots for dragon flies. Any of these insects except bees and wasps may be picked up without danger, and these may be captured with a net; butterflies and dragon flies will also be so taken. Spill a few drops of gasoline on the abdomen of insects, spiders, etc., to kill them; then keep them in the box. Secure the following insects: a butterfly or good-sized moth, a dragon fly, a squash bug or a stinkbug, a beetle, a locust or a grasshopper, a bumblebee, a bluebottle fly or, better still, a horsefly. Spiders, thousand legs, and sow bugs also will probably be found. Kill them with the gasoline and bring in with the insects.

Obtain a couple of crickets and put them alive into the small bottle.

Insect cage.—Make an insect cage as follows: Fill a flowerpot four inches or more in diameter with earth. Plant in it a spray of sweet clover or other available plant. Set a lamp chimney into the earth over the plant and tie a piece of cloth over the top. The earth should of course be kept moist.

The cricket.—

Feeding the cricket.—Put the crickets into the insect cage. They will be quite at home in this cage and will live for many days. Cut a thin, wedge-shaped slice of apple and put it into the cage with the edge up. The crickets will probably mount this and proceed to eat. Notice that the cricket has several pairs of mouth parts, one pair of which is very horny and serves to crush the food; the other pairs are used to hold the food as it is eaten. These jaws are provided with little finger-shaped processes—jointed palps that serve the animal as feelers. How are these jaws moved as the cricket eats?

Parts of a cricket.—Notice on the head of the cricket the pair of long feelers, or antennae. Can you demonstrate how these function? Touch one of the appendages at the end of a cricket's body and see if he is aware of it. Notice next the large eyes, each occupying a good share of the side

of the head. These eyes are compound eyes; that is, they are made of a large number of simple eyes. Thrust your finger at the cricket without touching the antennae. Does he seem to see well?

Movements.—Watch the cricket as he walks. How does he move his legs? Do the legs always move in the same order? Look carefully at the cricket's foot and notice of what parts it is made. Draw the foot. How do the hind legs differ from the other legs. How far can a cricket jump? See how many times its own length a grasshopper can jump. How far could a boy jump if he could leap as far in proportion to his length? Study the hind leg of the grasshopper to see if you can discover what appliances and arrangement of parts there are that enable him to jump so well. What advantage is it to a cricket or grasshopper to be able to jump? When you pick up a grasshopper by its hind leg what often happens? Would this be of any value to the insect?

Cricket music.—The cricket is perhaps better known by his music than by his appearance. Undoubtedly the crickets will sing while they are confined in their cages. Observe how this is accomplished. Do both male and female crickets chirp? Can you think what possible end the chirp serves? How can you tell the male and female apart? See the ear, an oval disk, on the first leg of the animal.

Breathing.—Observe a cricket or grasshopper carefully and see that the abdomen is made up of a number of rings, each telescoped into the one ahead of it. These rings are held together by delicate membranes which cannot ordinarily be seen but which are evident when the abdomen of the locust is extended in the egg-laying process. Watch the abdomen carefully and observe that it is constantly expanding and contracting, bellows-like. In fact, this is the way in which air is drawn into the body. These insects do not breathe through their mouths; they do not have any noses, but the air is taken in through several little pores that can readily be found on a grasshopper's abdomen, one on each side of nearly every ring. Draw the abdomen to show these.

Egg-laying.—Watch beside the sidewalks for a grasshopper laying its eggs. In the autumn you will find the female with the abdomen thrust deep into the ground, the insect looking as if the abdomen had been cut off. Make a sketch of the position assumed by the insect, then lift the animal up so as to pull the abdomen out of the ground. Note how long the abdomen is. Dig up the soil at this spot and see if you can find the cluster of eggs. Normally they remain in the ground until the following spring, when they hatch into young locusts, or grasshoppers, as we commonly call them.

Plagues of locusts have been among the notorious insect phenomena in the history of the world. The western states have many times suffered

from invasion of the Rocky Mountain locust, and the locusts of the Old World have frequently invaded civilized communities and have played havoc with growing crops. Read the article, "Jerusalem's Locust Plague," in the *National Geographic Magazine* (Vol. 28, p. 511, December, 1915).

Insect collection.—If an insect collection is to be made each pupil should provide himself with an insect net, bicycle oil can full of gasoline, a deep cigar box, a sheet of cork, and insect pins.

Insect net.—To make the net frame use an old broomstick or a two-foot length of bamboo for a handle and a forty-inch length of stiff wire for the hoop. Bend the wire so that the ends will cross each other six inches from their tips; twist these crossed wires about each other two or three times. Now bend the ends so they will lie on opposite sides of one end of the handle and with fine wire or strong cord bind the net frame securely to the handle. If preferred, the wire frame may be soldered to a brass ferrule made to fit onto a jointed handle. The net is best made of coarse bobinet,

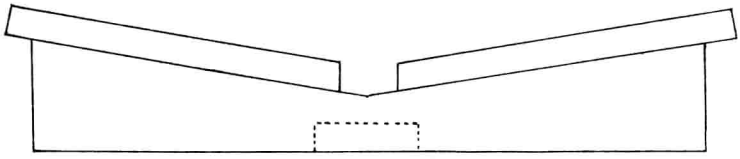

FIG. 1.—Diagram of the spreading-board

although cheesecloth or fine-meshed mosquito netting will do. It should be about eighteen inches deep and large enough around to fit the hoop. Sew it onto the wire frame and then bind a strip of cloth over the wire to prevent wear.

Box.—Glue sheet cork to the bottom of the cigar box in which the insects are to be kept, stuck on pins set into the cork. Insects, like bugs and flies, may be pinned by running an insect pin of appropriate size through the thorax; beetles, by sticking the pin through the right wing cover. Dragon flies, moths, butterflies, etc., must be spread so that the wings will remain expanded.

Spreading-board.—For spreading the wings a spreading-board is a necessity. Take two soft-pine boards a foot or more long and three or four inches wide. Cut two strips as shown in the diagram (Fig. 1). Then fasten the boards to these ends so they will incline toward each other and have a groove between them. Underneath this groove fasten another strip of pine or cork. Run the pin through the thorax of the animal and stick its point into this lower strip of cork or pine, the body of the insect in the groove of the spreading-board. Fasten the wings on the boards by means

of strips of paper pinned across them. Do not run pins through the wings. The rule adopted by collectors is to fasten the wings so that the hind margins of the fore wings will make a straight line which is at right angles to the long axis of the insect's body. After the insect has been on the spreading-board and dried for several days it may be put into the insect box. While the insect is on the board the board should be kept in a drawer or cupboard away from mice and insect pests.

What is an insect?—Compare the dragon fly, squash bug, beetle, locust, bumblebee, fly, and butterfly. These are all insects. What characteristics have they in common? What, then, is an insect? How many of them have a hard and slippery coat-of-mail? Would such be particularly serviceable?

Adaptation of mouth parts.—Note the sharp sucking-tube of the squash bug, the coiled sucking-tube of the butterfly. The latter may be unrolled with a pin. How do these two insects feed? Draw the head of the latter insect to show its sucking-tube. Which of the insects mentioned above have the biting mouth parts like those of the cricket?

Classification.—What characteristics have spiders and insects in common? In what ways are they different? How are the thousand-legs like spiders and insects? How different? In what ways are the sow bugs like the other forms studied?

Such differences and resemblances are the basis of the classification of animals and plants. All the animals here studied belong to one group, the subkingdom Arthropoda. What are the characteristics of the arthropod type?

The animal kingdom is divided into subkingdoms like the vertebrates, molluscs, arthropods, etc. The latter group is subdivided into four classes. What are they? Give example of each.

Classes are divided into orders. Fill in the following:

The beetles belong to the order

Butterflies and moths belong to the order

Flies belong to the order

Ants, bees, and wasps belong to the order

Bugs belong to the order

Crickets and grasshoppers belong to the order

Dragon flies belong to the order

Orders are again divided into families, those insects with family resemblances being classed together. Thus the crickets belong to the family Gryllidae. Families are split up into genera and each genus into species. The animals that are practically identical all go to make up one species. Thus all tiger swallowtail butterflies belong to the species *Turnus*, all swallowtails to the genus *Papilio*. The scientific name of an animal or plant is made up of the name of its genus and species, so *Papilio turnus* is the scientific name of the tiger swallowtail.

Butterflies.—See specimens of the following butterflies and moths in the cases of the school museum or look them up in Holland's Butterfly Book and Moth Book. Learn to know them so you can recognize them in the field: monarch, royal fritillary, great spangled fritillary, Baltimore, checker spot, question-sign anglewing, comma anglewing, mourning cloak, red admiral, painted lady, Hunter's butterfly, red-spotted purple, viceroy, little wood satyr, common wood nymph, great copper, bluet, common white cabbage butterfly, dog's-head, sulphur, pawpaw swallowtail, tiger swallowtail, spicebush swallowtail, pipevine swallowtail, eastern swallowtail, giant swallowtail, and silver-spotted skipper.

Life-history of the butterfly.—In the late spring and in the summer material for the study of the life-history of the butterfly is easily found. Look over cabbage plants for eggs, larvae, and chrysalids of the cabbage butterfly. The adults will be found flying over the cabbage patch. Look on milkweed for the eggs, larvae, and pupae of the milkweed butterfly. Draw the eggs on the leaf, the larva, and the chrysalis. Keep the larva of some butterfly in the insect cage with its food plant until it pupates. See this process if possible. A few days later the chrysalis will open and the butterfly will emerge, expand its wings, and be ready to fly. Watch this also.

Moths.—The following moths are common and should be known: Cecropia, polyphemus promethea, luna, eight-spotted forester, imperial, royal, bumblebee moth, tomato hawk moth, Isabella, Io, cutworm moth, tussock moth, silkworm moth, and clothes moth.

Moth larvae.—Look for the larvae of the moths. The larva of the tomato hawk moth (a big green "worm") is common on tomato plants. Cecropia larvae ornamented with blue, orange, and red knobs are easily located on willow twigs. The brown, woolly bear, a very common caterpillar, is the larva of the Isabella moth. The tussock larvae are common on elm trees. Put any of these in the insect cage together with sprays of the food plant stuck into the moist soil. Supply more of the food plant as the supply is eaten. How would you tell one of these "worms" (that are really insect larvae) from a true worm, like an earthworm? How does the animal

crawl? How does it eat? Where does it come from? The Cecropia larva, when full grown, spins a silken cocoon in which the chrysalis remains during the winter. Look for such cocoons, not only of the Cecropia but of other moths. Collect several for study (see directions, below). The tomato hawk moth larva burrows into the gound, transforms to its chrysalis, and the chrysalis remains there until the moth comes out of it the following spring. After the larva has disappeared in the soil of the pot leave it a few days before digging up the pupa.

The leaves of the following plants are the food of many larvae; look over such plants to secure specimens which can be reared. Basswood, butternut, cherry, hickory, pawpaw, poplar, sassafras, walnut, willow, grape, carrot, parsley, everlasting, thistle, and violet.

The silkworm.—One of the most interesting moths, because of its economic value, is the one that gives us our silk. Send fifty cents to the Kny-Scheerer Co., 410 W. Twenty-seventh Street, New York City, for a batch of silkworm eggs. They will come on a small piece of card which may be put in a covered tumbler with a few fresh mulberry leaves. The eggs will hatch in a few days and the tiny larvae will crawl onto the leaves to feed. Add fresh leaves as necessary and as the larvae grow transfer them to an insect cage where more sprays of leaves may be kept. Keep record of the length of a newly hatched larva and of its length on successive days as it feeds. The full-grown larvae will spin their cocoons. How do they do it? Is the silk thread continuous? How long is it before the moth hatches after the cocoon is complete? Mating and egg-laying follow, and the eggs will start the cycle again.

Study of the Cecropia cocoon.—The Cecropia is known as the American silkworm. Note and draw shape of cocoon. Cut it open carefully so as not to injure the contained pupa. Is the silken covering tough? Is there variation in the thickness of the silken covering? (Compare yours with your neighbors'.) Can you see in the pupa the eyes, legs, antennae, abdominal segments? What advantage is the cocoon to the animal? Draw the pupa. In the spring the pupa transforms to the moth and comes out of the cocoon. Watch the process either in this or some other moth. Let the moth, limp and bedraggled as it comes out, crawl up on some support like the wire sides of the large insect cage and expand its wings. Watch it to see how this is accomplished.

Parasitism.—You will be quite sure to find that some of the Cecropia cocoons are full of small silken cocoons instead of the usual pupa. These cocoons will develop into ichneumon flies that lay their eggs in the larvae of Cecropia. The young feed on the blood and later on the internal organs, killing the animal but often not until it has spun its cocoon. If opportunity

occurs, watch in the spring and early summer the great ichneumon, Thalessa, depositing its eggs in the larvae of wood-boring beetles. At least see the specimen of this insect in the museum, noting the very long ovipositor, and read "The Bewitched Cocoons" and "The Most Marvellous Drill in the World" in William Hamilton Gibson's *Sharp Eyes*.

Ants—a study of an animal community.—

Directions for making nest.—Cut a piece of glass 4 by 5 inches or any convenient size, or use for the foundation of the nest an old 4 by 5 negative. The gelatin film can be cleaned off the negative if the latter is soaked in water for a little while. Cut some glass strips one-half inch wide from any old window glass. It is best to use glass of single thickness and to use window glass rather than picture glass, since the former is softer and less difficult to cut. To cut glass secure a wheel glass-cutter from the hardware store, for five or ten cents. Lay a ruler on the glass a little to the left of the line along which the cut is to be made and, holding the glass-cutter as you would a pencil in writing, draw it along the glass beside the ruler, using just enough pressure to make the wheel cutter "bite" the glass. You can tell this best by the noise. Any school child can cut window glass, for no great strength is needed. When the scratch is made place the thumbs on top of the glass near the edge on opposite sides of the scratch and press upward with the bent first fingers held below the glass.

The walls.—Fasten the half-inch strips along the edges of the foundation glass with ordinary glue, laying the strips flat, i.e., with the broad side down. Leave a half-inch opening at one corner for a door. Cement a second strip on top of each first strip, so as to make this glass wall two thicknesses of glass high, in order to allow enough space for the ants to move around freely inside the nest. With strips of glass divide the nest into two rooms, leaving a space between this partition wall and the outer wall to serve as a door. Cut some black cambric or calico into strips an inch wide and glue it to the edge of the nest all the way around, letting it lap over on the top of the wall and on the under side of the foundation glass. This makes an opaque covering for the wall of the nest, like a passe-partout binding.

Ventilation.—Cut some strips of Turkish toweling an inch wide. Turn in the edges of this toweling so that they meet, thus making a half-inch strip that is double. Now cement these turned-in edges to the top of the half-inch strips that form the walls of the nest. Cut pieces of glass of proper size to cover each room of the nest and lay them on the Turkish toweling for a roof. The toweling admits enough air to ventilate the rooms. Since ants are accustomed to live in the dark, pieces of cardboard should be cut the same size as the glass covers for each room and laid over the nest.

When the nest is in use, keep the parts in place by drawing a rubber band around them. When the nest is lying on the table, light is excluded from the under side by the table, from the edges by the black binding, and from above by the pieces of cardboard. Cut a thin slice of sponge and place in the inner room. The nests should stand a few days to dry out, as the odor of glue is not an agreeable one even to ants.

Directions for stocking and caring for the ants' nest.—Take a pint fruit jar with its cover and go out to where ants are abundant. Dig up an ants' nest or break to pieces an old log or stump in which are found the galleries of the large black carpenter ant. Look for the eggs, larvae, or pupae. The eggs are tiny white grains, the larvae look much like rice grains, while the pupae look like puffed rice grains. Scoop these up with the ants and dump them into the pint jar; more or less dirt and débris will be taken up at the same time. Cover and bring the material back to the schoolroom. Set the completed ants' nest on the bottom of a large shallow tin pan; see that the sponge in it is moist. Set this pan in a still larger one partly filled with water. The inner pan must at no point touch the rim of the outer. Dump the material brought in from the field down beside the nest. As the débris dries out the ants will take their eggs, larvae, and pupae into the nest. When this is accomplished plug the front door of the nest with a wad of absorbent cotton. The nest may now be taken out and kept on the table for observation.

Feeding the ants and cleaning the nest.—A bit of peanut the size of the head of a pin or a bit of sponge cake dipped in honey may be put into the nest once a week. A shred of raw meat may occasionally be given the ants. Uneaten remnants of the food should be removed within twenty-four hours. To clean the nest remove the cardboard cover from one room. The ants will take their material all into the dark room. Then plug the door between the two rooms and wipe out the vacant room with a cloth moistened in alcohol. Let the room stand open for five or ten minutes, until the alcohol fumes have disappeared. Remove the plug from the door, cover this room, and uncover the other. Then the process may be repeated in the second room.

Habits.—Watch the ants you have to see how they busy themselves. Can you distinguish queen, drones, and workers? Are there soldier ants present? Which members of the community feed the larvae or young ants? Do the ants of the community seem to communicate with each other? If so, how? Do they feed each other? How does the ant clean itself? Watch the nests of ants out of doors to see what the animals are doing. Among other things you will find that the ants whose nests are in the sand will be busy bringing grains of sand out of the nests and carrying

sand grains in again. Can you explain this apparently foolish process? In the late summer and early fall you will find a great many winged ants coming out of the nests. These are mostly males getting ready for the nuptial flight. Find out what the nuptial flight is and the events that happen at this time.

Aphids.—Look for plant lice on the succulent fall weeds, or on the plants in the garden. You will find most of them with their sucking-tubes imbedded in the tissue of the plant from which they are drawing their food. Some of them may be the winged males and females. You will often find ants visiting these colonies of aphids. Watch the ants to see what they do to the aphids. Read *Bulletin 131* of the University of Illinois Agriculture Experiment Station on the "Behaviour and Habits of the Cornfield Ants." Read also W. M. Wheeler's *Ants* (pp. 267–93 and 318–36). Look up the facts in regard to the rate of reproduction in the plant lice.

Wasps.—If possible find in the woods or around the barn nests of the paper wasps, or under the eaves of the house, barn, or outbuildings the clay nests of the mud-dauber wasps. Watch the wasps to learn as much as possible of their habits. Procure some old nests of either the paper wasps or the mud dauber and examine their method of construction. Can you make out the life-history of the animal?

Dragon fly.—Watch a dragon fly in its flight. Time it in seconds as it flies from one point to another. Measure the distance and see how many miles an hour it is going. Listen to the hum of a bee and devise a way to tell how many times it flaps its wings in a second. Observe on what the dragon fly feeds. Watch to see how many it eats in the course of a few minutes. What other names has a dragon fly? Are they justified by facts? Watch the dragon fly as it flies over stream or pond. Can you observe it in the act of depositing eggs? The young which hatch from these we shall study later. Draw the wing of the dragon fly. Weigh the wings and the rest of the animal separately. What is the relative weight of wings and body in a modern aëroplane? In what direction do most supporting veins run in the wing of the dragon fly? In what part of the wing are they? What is the advantage of this? Compare the bracing of the veins in this wing with the system of ribs and braces in an aëroplane wing.

Insect color.—Examine the wing of a butterfly under the low power of the microscope. Rub the wing with the finger and examine the rubbed spot again. What have you on your finger? With what are the wings covered? How are these arranged on the wings? Examine a spot of color. To what is it due? What is the color of the real grasshopper? the katydid? the locust? Where do the two former live? the latter?

Was the cabbage-butterfly larva at all hard to find? What other larvae are green and what advantage does this color give them?

Are bees and wasps easy to find? What other animals that are abundantly able to care for themselves are also conspicuously colored? Is the tussock-moth larva brightly colored? Do birds eat it? Feed the brightly colored larvae of a milkweed butterfly to chickens. Will they eat it? Would you judge the milkweed butterfly to be palatable? What other larvae besides that of the tussock moth do you know to be hairy? Is there any evidence that these hairs are irritating to the skin?

Look at specimens of the walking-stick beetle in the school museum; of the anglewing butterfly on the dead leaves; and specimens of several moths on pieces of bark in cases to show protective colors. The red-spotted purple and viceroy butterflies are closely related, both belonging to the same genus. The viceroy butterfly looks much like another common butterfly to which it is only distantly related. Which is this? Might this resemblance possibly profit the viceroy? Why is the bumblebee moth so named? Which animal profits by the resemblance? Of these several examples given which would you classify under protective coloration? warning coloration? mimicry?

House fly.—Obtain some manure or some refuse from the kitchen and put an inch of this material in the bottom of a jelly tumbler. Capture several house flies and put them in the tumbler, covering the latter with a piece of cheesecloth held on by a string or rubber band. See if you can observe the flies laying their eggs. How many are laid? In a short time, probably, larvae will appear. Likely some of these will crawl down next to the glass when they pupate. How long is it before young flies appear? Fruit flies found in and about baskets of grapes or peaches may readily be bred if several are put in a test tube with a piece of fully ripe banana, plugging the top of the tube with a piece of absorbent cotton. The flies are small, but the stages in the life-history show plainly and they occupy little room. Locate in the block in which you live places where fly larvae or maggots are found. Any collection of decomposing matter is likely to contain them. Manure piles, garbage cans, lawn clippings, and garden refuse are likely places, and they may be found in heaps of rags, under bits of paper or oilcloth, or almost anywhere where the larvae can keep moist. On the opposite page draw a map of the block in which you live and show on it by red dots where you find the house fly breeding.

Rate of reproduction.—Look up data in regard to the rate of propagation of the fly. How many generations may there be in a single summer? How many eggs does the female lay? How long does it ordinarily take from the time the eggs are laid until the adult flies are grown? Starting