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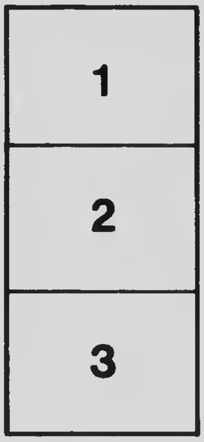

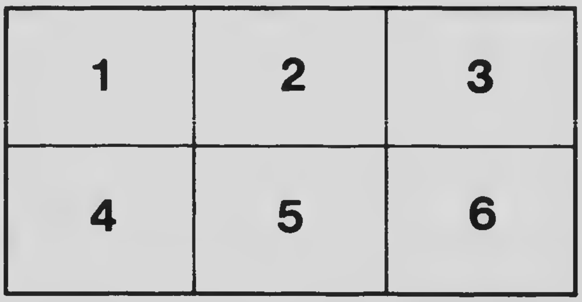

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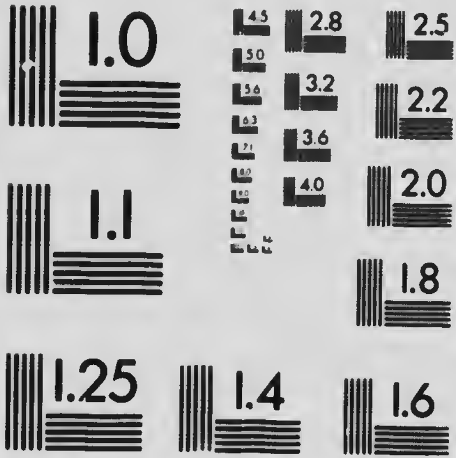

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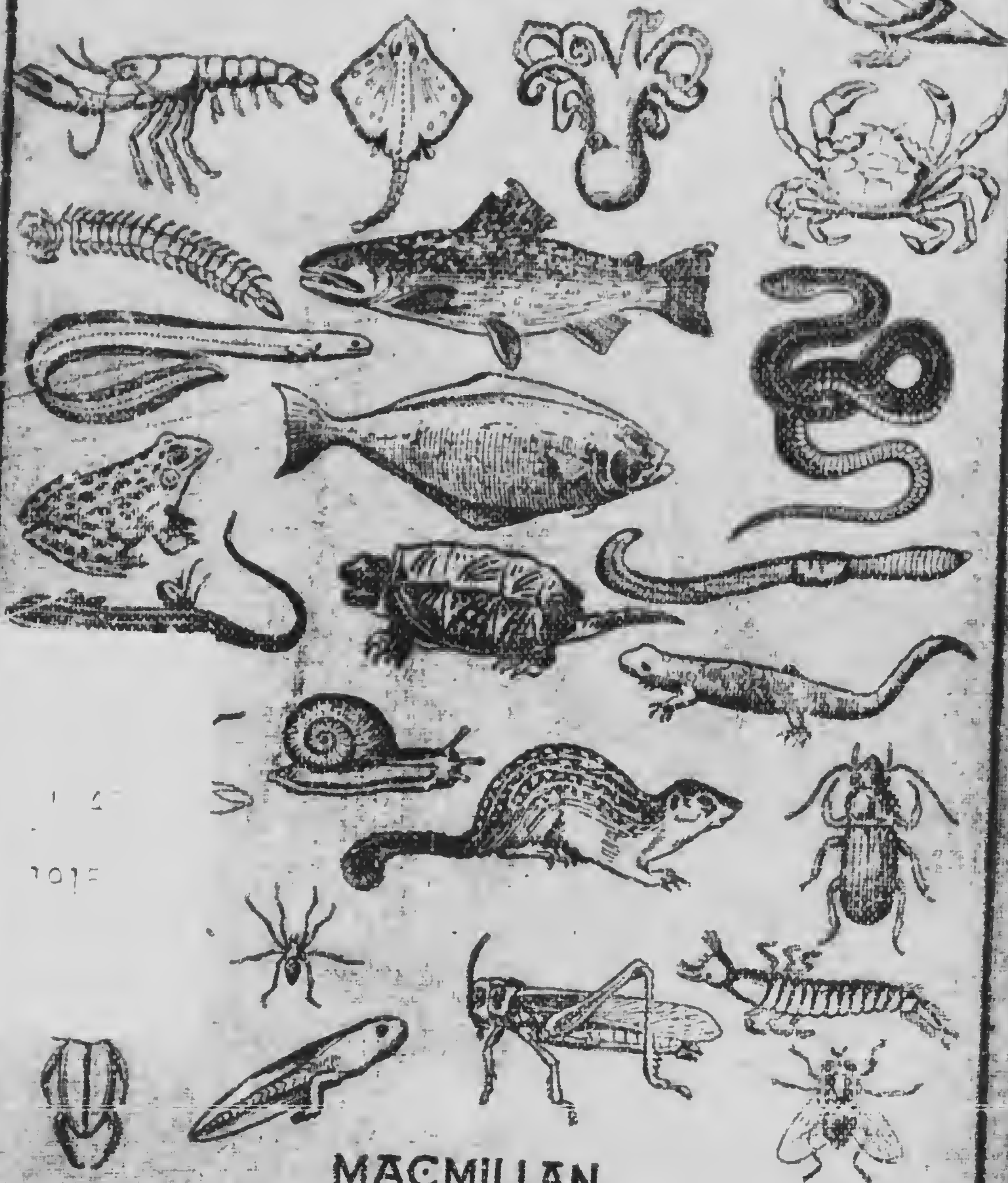

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1. The Eastern Swallowtail (*Papilio asterias*) and larva.
2. The Tiger Swallowtail (*P. turnus*) and larva.
3. The Spice-bush Swallowtail (*P. troilus*) and larva.
4. The Giant Swallowtail (*P. cresphontes*) and larva.
5. The Harvester (*Feniseca tarquinius*).
6. The Common Blue (*Lycena pseudargiolus*).

MACMILLAN'S CANADIAN SCHOOL SERIES

A FIRST BOOK OF ZOOLOGY

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TORONTO
THE MACMILLAN COMPANY OF CANADA, LTD.
1915

PREFACE

The North American edition of this book has been prepared for pupils of the lower forms of the High Schools and Collegiate Institutes who are taking a course in Zoology. It is also suitable for pupils taking Nature Study in the upper forms of the Elementary School.

Zoology has in the past consisted too largely of the memorization of technical names, combined with the study of structural features. It is now realized that what the pupil is interested in is the living animal, and that the structure is chiefly interesting, insomuch as a knowledge of it assists in understanding how the animal performs its functions successfully. In other words, adaptation to environment is the phase of animal study that appeals to the young student. An endeavour has been made to emphasize this phase of the subject in this volume.

Animal study is best begun by the examination of types. Some typical animals, widely distributed in Canada and the United States, have been selected and have been described quite fully as to their structure and function, and the relation between the two has been fully emphasized. It is intended that the animals themselves should be actually examined by the pupils, both in the field, and in the laboratory. Some of the larger should be dissected, as the structure of the internal organs is even more closely related to the life processes than is that of the external form. To assist the pupil in both field and laboratory work, very complete instructions have been given in the practical exercises at the end of each chapter.

This volume aims at more than stating the structure and adaptations of particular types. Zoology is a science and, as such, endeavours to show the relationship obtaining among the different animals. After the description of the type, its relation to those animals belonging to the same group is indicated, and then its relation to those of other groups.

A considerable number of new illustrations have had to be substituted in order to adapt the book for use in schools in Canada and the United States. These illustrations are largely taken from Parker and Haswell's **Textbook of Zoology, The Cambridge Natural History,** Silcox and Stevenson's **Nature Study,** Mabel Osgood Wright's two volumes **Birdcraft** and **Gray Lady and the Birds,** and the **Report of the New Jersey State Museum, 1906.**

CONTENTS

CHAPTER I

INTRODUCTION

From our earliest youth we are attracted by the animals which live, move, and grow around us. A child, very early

FIG. 1.—A scene in the country.

in life, is fascinated by the movements of a fly or bee, and longs to seize and examine it; or, again, the colour and form of a shell will arrest the attention of most young children.

Can we wonder therefore that these natural objects should likewise appeal to most boys and girls? Thus we are not surprised to find children who live in the country taking delight in collecting flowers or berries, and quite unconsciously learning at what season and in what places to find them. Moreover, with what pleasure do children from a busy town, when taken for a day into the country, engage in collecting and examining natural objects!

FIG. 2.—Humming-birds and nest.

Most of us, in our schooldays, have been absorbed in some such pursuit as that of collecting plants, fishing, or bird-nesting, and this to the exclusion of other kinds of recreation, so that we may well ask ourselves why Nature's attractions seem to appeal to us less in later years; yet even a grown-up person would probably derive as much pleasure as a child does, if he were visiting the sea-shore for the first time. After he had contemplated the power of

FIG. 3.—Wood-thrush and nest.

the restless waves, his attention would be turned to the animals which inhabit the sea-shore,—in the rock-pools or amongst the abounding profusion of sea-weed.

We are, in fact, naturalists, or students of Nature's handiwork, instinctively from youth. The boy who learns to tell the songs of birds and knows their mode of flight; the size, colour, number of their eggs, and where these may be found; or the youth who has learned the favourite haunts

FIG. 4.—Baltimore Oriole and its hanging nest.

of the trout in the neighbouring streams; are both unwittingly naturalists. For it is not merely the structure of the bodies of animals, but their habits and all about them, which must be included in the study of that branch of Natural History known as Zoology. Moreover, although much may be learned by examining animals, this knowledge should be extended by carefully reasoning out the why and the wherefore of the various structures which different animals possess.

We may suppose we are taking a walk in the country. Let us consider some of the problems which must be solved. The birds about us are varied in size and colouring,

FIG. 5.—Lesser Tern alighting on nest.

i.e. the blending of their colours. Some have long beaks, others short. Why should there be such variation in the shape and comparative size of birds' beaks? Do we associate these differences with their food and habits? Whether we do so or not, there is a close relation between a bird's beak and the nature of its food.

Much diversity of pattern is displayed by birds of different kinds in nest-building, and in the number, size, and marking of the eggs. Does the boy on his nesting expeditions ever wonder why the robin has a mud-lined nest, whereas the crow and the mourning-dove make a nest of sticks? Or, again, does he know why the meadow-lark and the killdeer build nests on the ground, while the

FIG. 6.—A sea-shore scene at low tide.

mourning-dove builds its nest in the lower branches of a tree? The latter bird lays only two eggs, but the robin lays four or five. Why? Yet such a boy would be astonished—and with good reason—to find a mourning-dove's nest containing five eggs, or a swallow's nest made of sticks. In order to answer correctly the above and similar questions, it is important to learn some of the facts which a proper inquiry will afford.

The student of animal life is not content with observing, for instance, the long ankle region and short fore-limbs of a frog, but seeks a correlation of these features with the power of jumping. The tongue of a frog, again, is associated by a zoologist with the way in which the frog feeds.

A visit to the sea-shore reveals the fact that many animals which live in sea-water are not found in ponds or rivers. None of the frogs, newts, water-beetles, or "water-boatmen" of our ponds are to be found inhabiting the rock-pools which are left at low tide. Why is this? The answer is that these animals are not adapted or fitted for living under such conditions. There is a strong tendency for us to grow so much accustomed to finding certain animals living in particular places under certain conditions, that we too often neglect to ask ourselves why some animals are completely limited to particular localities.

These and innumerable other questions the student of animal life can investigate if properly equipped,—by making a careful examination of animals, their structure, habits, food, movements, and so forth. Judging from the interest in animals which we display in early life, and the apparent lack of it as we grow older, it would seem that most of our youthful interest in the subject leaves us. So many and fascinating are Nature's secrets, however, that each day would bring an added zest to our inquiry into this subject if we learned to examine intelligently, and deduce correctly, the answers to many of the questions which the study of animal life affords. In the following chapters a few animals will be considered, and an attempt made to show how wonderfully they are fitted for the way in which they live, feed, and move amid their surroundings or environment.

CHAPTER II

THE EARTHWORM

Where found.—Earthworms may be found on lifting up boards or large stones which have lain on moist soil for some time; they may also be obtained by following closely behind the plough in the newly-made furrows, or by digging up garden soil, especially if this be rich and damp. Occasionally after very heavy rains worms are found on the surface of the ground in large numbers, though they usually remain in passages or burrows beneath the surface during the day, and appear above ground only at night for the purpose of getting food. In frosty weather earthworms descend much deeper into the soil, and are consequently more difficult to obtain in winter.

Work of Earthworms.—The tracks of worms are frequently discernible on the surface of a muddy road after wet weather, as grooves leading to or from the opening of a burrow. But more distinct evidence of their recent presence is furnished when a closely-mown lawn is examined on almost any morning of the year from May to September. Near the openings of burrows will be found little heaps of fine crumbling earth. This earth has been brought up to the surface of the ground by worms, and, having passed through their bodies, has been deposited in the form of castings. The little animals practically eat their way through the soil, leaving passages or burrows behind.

A good deal of nutrient material is present in the soil, and this is extracted by the worm during the passage of earth through its body. The castings, consisting of material of no further use to the earthworm, are deposited at the mouth of a burrow. The earthworm is an invaluable friend to the farmer, for it not only burrows in the soil—thus making passages for the access of air, light, and moisture—but it is also continually bringing to the surface finely-divided earth in which there is a fresh supply of nutriment for plants. In other words, the little animal ploughs, harrows, and at the same time helps to drain the land.

Appearance.—The earthworm has a round elongated body, tapering rather more abruptly at the front or **anterior** end—viz. the end which leads the way when the animal is moving along—than at the hinder or **posterior** end. The colour is reddish-brown on the upper or **dorsal** surface and grayish-white on the under or **ventral** surface—viz. the region in contact with the ground. The **mouth** is not difficult to find; it is an opening at the front end of the body overhung by a fleshy **upper lip**. At the hinder end of the body the vent, an aperture through which castings are ejected, is situated. Although the body is for the greater part of its length similar in size and appearance, the first one-third is rather thicker than the rest, while the posterior or hinder region is somewhat flattened, and appears as though pressure had been put upon this region, thus slightly altering its shape. About one-third of the way along the body from the front end there is a broad ring or girdle—the clitellum—encircling the animal; this is really a thickening of the skin, and is not found in young worms.

Segmentation.—Perhaps the most striking feature of the earthworm is the presence of a regular series of rings along the body. The animal seems to be made up of a number of similar successive pieces or **segments**, about one hundred and fifty in all; consequently we speak of the worm as a **segmented** animal.

Movement.—When an earthworm is taken up in the hands and its body gently drawn between the finger and thumb, a slight roughness is felt, and this is more noticeable if we begin at the hind end and draw the animal backwards than if we begin with the front end. The roughness is due to small bristles, or **setæ**, situated in the skin, and projecting a little above it. The setæ may be more clearly seen by the aid of a lens, especially on a freshly-killed worm: four double longitudinal rows can be made out, arranged on the sides and under surface of the

FIG. 7.—Earthworm. (The numbers refer to the segments.) (× ½.)

body. Thus, eight setæ, pointing slightly backwards, occur on every segment, except the first and last.

It is interesting to observe the movement of an earthworm. A touch of the finger will probably cause it to "contract,"—an action whereby there is no decrease in size or volume, but rather a decrease in length with a corresponding increase in thickness.

The contraction is effected by numerous muscles beneath the skin. When a worm proceeds in any direction it fixes the front end of its body and draws up the succeeding segments. It then fixes these parts and pushes forwards the front end by an expansion or elongation—and consequent decrease in thickness of this region—and thus partly pushes, partly drags, its body along. The setæ act as pivots in this progression, any region of the body being temporarily fixed by pressing the setæ of that region against the earth, or surface over which the animal is moving.

Respiration.—When we take in a deep breath, air containing oxygen is drawn into the lungs, in the walls of which our blood circulates. Gases such as oxygen and carbon dioxide can pass through a membrane like the wall of the lungs by a process known as **osmosis**. In this way an exchange of gases occurs; oxygen passes from the air in the lungs into the blood, and at the same time carbon dioxide passes out from the blood and takes the place of the oxygen. Thus i.. .e blood gets rid of its carbon dioxide and becomes .urified or aerated by acquiring oxygen. By the act of **expiration**, or breathing out, carbon dioxide in the lungs escapes from the body. An earthworm, however, has no lungs, but its skin—well supplied with minute blood-vessels—performs this impor- nt fun-tion of **respiration**.

The process of osmosis cannot continue e- ve y unless the skin be moist, so that a worm would die from suffocation if its skin dried up. The earthworm's skin is kept moist partly by the damp earth and partly by a fluid which is continually oozing out from the body through minute pores in the skin. The pores lie in the little grooves dividing the body into segments—a pore in each groove along the middle of the dorsal surface. Owing to their position they are known as **dorsal pores**. The fluid ejected from the body by these pores is fatal to the myriads of microscopic organisms in the soil which would otherwise settle and grow upon the earthworm's body.

Digestion, Circulation, and Excretion.—Of the material which is taken into the worm's body as food a large proportion is never utilized, and this is passed out by the vent as **fæces**, which takes the form of castings. The material which is utilized as food must be first dissolved or **digested**. Digestion takes place in the **alimentary canal**. On holding up to the light a light-coloured worm the alimentary canal may be seen as a thick dark part running the whole length of the body. The digested food passes through the wall of the alimentary canal, and is **circulated** to all parts. Moreover, although much of this dissolved food is utilized by the body or **assimilated**, some is got rid of or **excreted**.

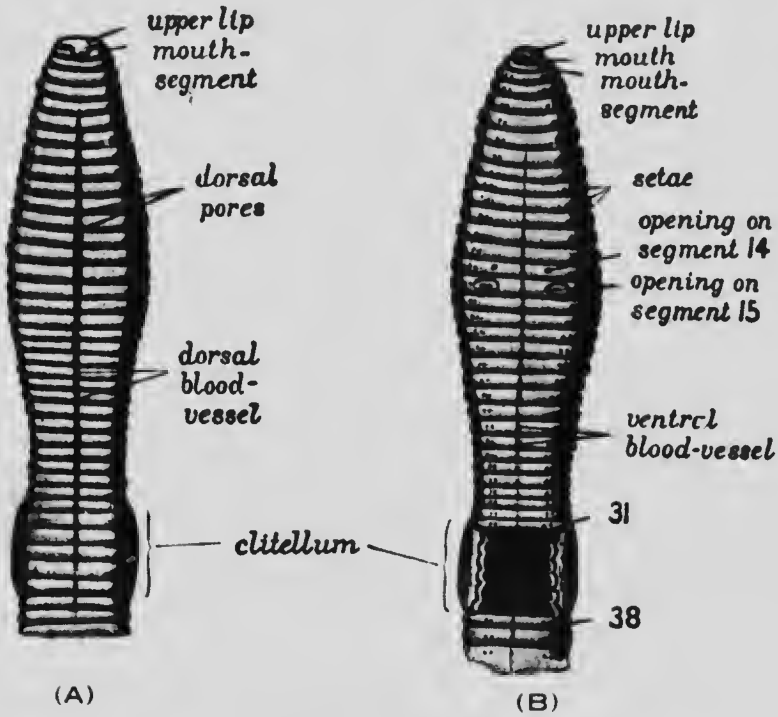

FIG. 8.—Front end of Earthworm.
(A) Dorsal view. (B) Ventral view.

In the body of an expanded worm a thin dark-red blood-vessel is visible along the dorsal middle line underneath the skin. This is the **dorsal blood-vessel**. A similar vessel

—the **ventral blood-vessel**—may be detected on turning over an earthworm and examining the ventral surface; also many smaller blood-vessels may be seen. The dorsal and ventral blood-vessels have a wavy appearance in a contracted worm.

Sense of Feeling.—The earthworm not only **breathes**, but also feels, through its skin. It is well-known that some parts of our skin are more **sensitive** than others: a tiny grain of sand is felt more keenly if it gets into the eye than if it gets under the foot, owing to the fact that the skin of the human foot is not so sensitive as the eye-lid. A similar sensitiveness exists over the whole skin of the earthworm, and hence it is easy to understand why the animal contracts when touched. Moreover, the skin is affected by the daylight; usually the worm remains within its burrow during the day and comes out only at night. So that although the worm has no eyes and no ears, yet, owing to the sensitive nature of its skin, it can distinguish between light and darkness, and can even feel such a slight movement of the earth as would be produced by a stamping of the foot on the ground near it.

Reproduction.—In a well-grown earthworm not only a pair of thick-lipped openings on the under surface of the fifteenth segment behind the mouth are visible, but also two very small openings rather nearer together on the under surface of the fourteenth segment.

The earthworm produces eggs which pass out from the openings on segment fourteen. Just as the ovum or egg of a plant requires the fertilizing element of the pollen before it can develop, so also must the eggs of an earthworm be **fertilized**: this is effected by a substance which passes from the prominent apertures on segment fifteen of an earthworm, and is stored up in the body of a second individual until the eggs of the latter are ripe.

Earthworms possess organs for producing both fertilizing substance and eggs, but just as in plants the ova are generally fertilized by means of the pollen from another plant, so also in the worm **cross-fertilization** occurs.

When the eggs are about to be laid, the skin in the clitellum region actively **secretes** or produces a fluid which exposure to the air converts into an elastic substance. Thus the clitellum region appears to be surrounded by a broad elastic ring or **cocoon.** The earthworm next begins to wriggle backwards out of the cocoon, and so the latter is pushed nearer and nearer towards the mouth. While

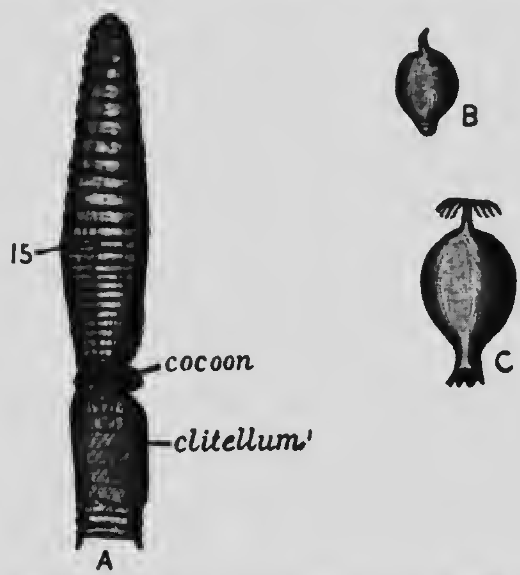

FIG. 9.—A, Earthworm, front end, showing cocoon; B, and C Cocoons of two different kinds of earthworms (× about 4).

the elastic ring is passing over segment fourteen the eggs are laid and get between the cocoon and the earthworm's body. While the eggs are being laid, a nutritive fluid and also some of the stored-up fertilizing substance are squeezed from the body and mix with the eggs. The ends of the cocoon close up as they pass beyond the mouth.

In this way the eggs are fertilized, protected by an elastic coat, and supplied with some nutriment to serve as food for the future young earthworms.

Development.—Some few of the eggs—probably one or two—develop more quickly than the others, and, although there is nutrient material present in the cocoon, advance their own growth by absorbing other eggs. Thus earthworms are guilty of cannibalism on this, the only occasion throughout their lives.

The brown, horny cocoons, varying from the size of rapeseed to that of a small grain of wheat, are either deposited on the surface of the ground, or buried in the soil.

Adaptation to Environment.—Having noticed the external features of an earthworm, we will consider how wonderfully Nature has fitted the animal for its surroundings and peculiar mode of life.

The cylindrical shape of the body, with its muscular body-wall and backwardly projecting setæ in the moist slimy skin, enables the animal to move freely in its burrow without serious friction: moreover, the narrower posterior part of the body can be dragged through any passage made by the thicker anterior end. A thin, filmy, iridescent covering—the **cuticle**—protects the body against injury from the sides of the burrow. An earthworm's food consists in part of the decaying vegetation present in the earth which it swallows in making burrows; the rest of its food consists of the leaves, twigs, etc., of plants obtained at the surface of the soil.

The sensitive skin keeps the little creature informed of movements of its enemies above ground, and further guides it as to the best time to come to the surface in search of vegetable food, viz. after night-fall. The earthworm has no legs, eyes, ears, or other delicate organs which would receive continual injuries in its movements underground. Further, the worm can distinguish, probably by means of the sensitive skin near the mouth, what is good for food:—in other words, it has some sense of taste or smell and chooses its food; fat or grease buried in the earth is apparently much relished.

Intelligence of Earthworms.—Although earthworms are lowly organized animals, the structure of the body being comparatively simple, Darwin has shown that they are not devoid of intelligence. He noticed that the twigs and leaves which these animals drag into their burrows to serve as food are moved in a methodical way; in order to minimize the difficulty, an earthworm usually seizes the object in a manner most suitable for the attainment of its purpose, *e.g.* a twig would be seized by the end, and a leaf by the tip.

Habits.—The largest earthworms may grow to be one foot in length, especially in soil where food is rich and plentiful. In very hot dry seasons and in frosty weather, the animals descend some distance into the ground, coil themselves up in a chamber which they excavate, and await more suitable conditions. The common habit of stopping up the mouth of their burrow with twigs and leaves only partly dragged underground subserves two or three useful purposes; the worms' supply of air is not cut off thereby, although many enemies, *e.g.* certain slugs and centipedes, are prevented from hunting and preying upon the little creatures; further, the earthworms can feed from below on the vegetation, and yet remain in safety.

When feeding at night above ground, an earthworm usually has the broad, flat hinder-end of its body fixed in the burrow, so that, when enemies approach, a rapid contraction of the rounded anterior portion into the burrow suffices to remove the animal out of danger.

The mole is perhaps one of the most formidable enemies of the earthworm.

Kinds of Earthworms.—We have already observed that the mouth is overhung by a fleshy upper lip. When the latter is examined from above it appears to be dove-tailed into the first segment behind the mouth—the **mouth-segment.** This condition is found in the earthworm distinguished by the name *Lumbricus terrestris.* There are, however, other kinds of earthworms in this country, one of the commonest perhaps, about three inches long, and found frequently in dunghills, is the "brandling" (*Allolobophora fœtida*). The reason for assigning two zoological names to each sort of animal will be explained later. In a brandling the upper lip is not dove-tailed into the mouth-segment and the clitellum is nearer the mouth.

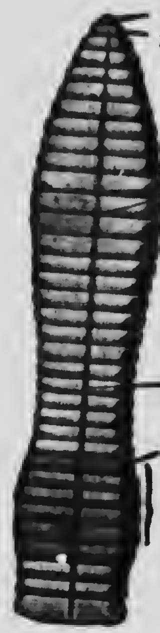

FIG. 10.—Brandling—dorsal view of anterior end (much enlarged).

PRACTICAL WORK

Dig up some earthworms from the soil of a garden or field and notice the moist skin; also the rough lower surface of the body due to the presence of setæ pointing slightly backwards in the living animal. Notice the colour, the segments, the clitellum (absent in young worms), the mouth with its upper lip, the mouth-segment, and the vent. The burrowing end of the worm is the front end. Why is this end thicker than the hinder end?

Observe the dorsal and ventral blood-vessels in a light-coloured specimen. Watch the dorsal vessel carefully and observe it contract from behind forwards, thus sending the blood towards the anterior end, thus causing a circulation. Hold the animal up to the light to see the alimentary canal.

Place some live earthworms in a box half of which is covered by a lid and half left uncovered. Place the box in the sunlight. Are the animals sensitive to light? Do they prefer the dark or the light?

Find the openings to earthworms' burrows on a lawn. These can easily be detected by the castings piled up. Put different food materials near the burrows and cover them with flower-pots so that other animals cannot eat the food, and see what foods the worms eat, and which they prefer. Try meat, both fat and lean, lettuce, celery, onions, cheese, etc. This experiment may be varied by keeping earthworms in a flower-pot of moist earth and placing the materials on the top of the soil in the pot. Place a sheet of glass over the top of the flower-pot to keep in the moisture. Find if an earthworm will live in water.

Rake the weeds and mud from the bottom of weedy pools and search the former for earthworms.

Watch the movements of a worm: its contraction and expansion. Unfortunately the other structures cannot be observed successfully on a living animal. Place a large earthworm in methylated spirits for about two minutes. Most probably some of the contents of the alimentary canal will be ejected. Observe that they consist largely of earth.

Count the segments from the mouth to the clitellum, not including the upper lip, of a dead earthworm (*Lumbricus*). See that the clitellum extends over segments 32-37. How many segments are there in the whole body? Notice that there are no setæ on the first and last segments.

Examine the reproductive openings on segments 14 and 15.

Note the complete absence of teeth or jaws.

Find the dorsal pores—they are most easily made out in front of the clitellum. By slightly squeezing the body in this region a fluid can be made to ooze out through the pores: this fluid helps to keep the skin moist.

Immerse an earthworm in methylated spirits until it is quite dead. Now seize the animal between the fingers, and with scissors cut through the dorsal wall from end to end, being careful not to cut too deeply: place the worm, dorsal side uppermost, on a board, spread out the cut edges, and pin them to the board.

Observe the following structures: (1) The alimentary canal is the most prominent; it runs from end to end. At the anterior end it swells out into a large, thick, muscular pharynx, then contracts into a thin œsophagus which passes back among the white reproductive organs; it then swells out into two large sacs closely following one another, the first the thin-walled crop, the second the very thick-walled gizzard. Cut these open to see their contrasting thickness. From the gizzard the intestine passes backwards to the vent, and is of uniform thickness throughout its course. (2) The transverse membranous partitions corresponding to the external segments and separating the body cavity into compartments. (3) The ventral nerve cord. To see this the alimentary canal is removed and it is observed directly below it.

Examine a closely-cut lawn or field where the castings of earthworms are found. Notice how leaves are frequently to be seen partly dragged into the burrows by the stalk, or by the tip of the leaf. Thus the worm wards off enemies from above, and can feed and breathe without emerging from its burrow.

Examine some castings: observe that they consist of finely-divided earth. Weigh two or three. Count the number of worm-holes in a square yard of a field or garden, and estimate the weight of soil thus brought to the surface of an acre (4840 square yards) of such land.

Ascertain whether a living worm is affected by a loud noise, a bright light, or by stamping the foot on the ground near it.

Make a drawing of an earthworm from above, from the side, and from below, naming all the structures you observe. The drawings should be diagrammatic.

Try to obtain an earthworm just wriggling out of its cocoon;—also the cocoons, which are sometimes deposited on the ground.

Peel off the filmy, iridescent cuticle from a worm which has been left for a day or two in methylated spirits.

Obtain a brandling. Note how it differs in structure from an earthworm with regard to: (1) upper lip, (2) position of clitellum. Draw from above.

Obtain earthworms from as many different conditions of soil and moisture as possible. Determine what segments the clitellum occupies on each and decide if the worms are all of one kind. The different kinds are distinguished in this way.

EXERCISES

1. Describe the external characters of the earthworm. How does a worm feel, move, and breathe?

2. Define mouth-segment, setæ, clitellum, ventral, segmented animal, posterior.

3. Give an account of the habits of earthworms. How are earthworms adapted for the kind of life they lead?

4. What enemies is the earthworm likely to meet, both above and below the ground, and how does it protect itself from them?

5. In what ways does the earthworm assist the farmer, and in what way might it be harmful?

CHAPTER III

THE FRESH WATER CLAM

Where found.—The clam always lives in water and can be observed in the shallow parts of lakes and large rivers. It is also found in most of the small streams which empty into the larger rivers. On looking down into the clear

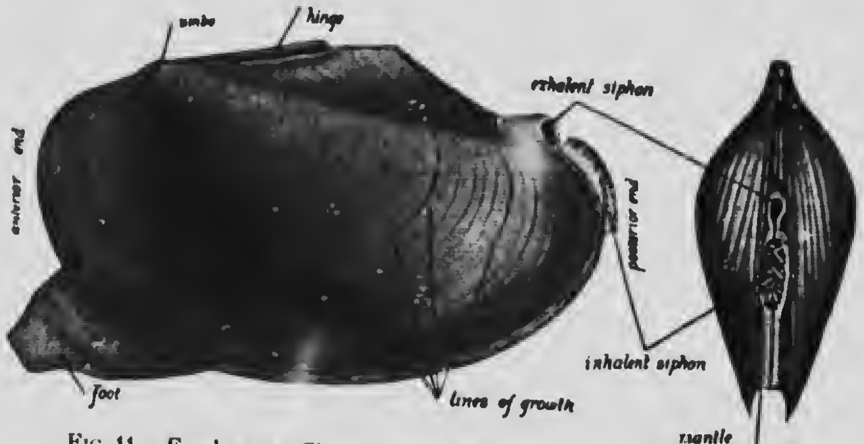

FIG. 11.—Fresh water Clam viewed from the side and from the end.

water of a lake or river one may sometimes observe on a quiet day large numbers of clams half buried in the sand or mud. Again, they may be found with the shell buried entirely in the sediment of small creeks, only a hole indicating their presence. They can easily be captured with a net or in the hand, as they appear to be quite stationary. A very much smaller kind of clam is found adhering to the weeds growing in any stagnant pond.

Shell.—The clam is provided with a **shell** composed of two pieces, which are not entirely separate, but united by an elastic ligament, called the **hinge**, on the dorsal or upper side. Each half of the shell is somewhat oval in outline and is brown in colour on the outside. One region on each side of the hinge is known as the **umbo**, and this represents the shell of the young animal. As the clam grows, additions to the margin of each half of the shell are made periodically, and, in consequence, the shell of the fully-grown animal possesses a series of lines of growth arranged concentrically around each umbo. Since the growth of the shell takes place more rapidly behind the umbo than in front of it, the latter is situated nearer to the anterior than to the posterior margin.

The inside of the shell is lined by the beautiful, iridescent "mother of pearl" with which we are all familiar. The two halves of the shell consist largely of limestone and form a strong protective covering for the animal within.

Appearance.—When the living clam is observed in an aquarium, it will be seen that the two halves of the shell gape somewhat at the ventral margin, and that at the posterior, most pointed end two tubular openings are distinguishable between the valves of the shell. The lower opening has a fringed margin and is larger than the upper. These openings are called the **siphons**. By means of them water containing food is carried into the animal's body, and from them water containing useless material is discharged. The water enters through the lower or **inhalent** siphon, the fringed margins of which strain out any grains that might irritate the soft, fleshy body inside the shell. The water is driven out through the upper **exhalent** siphon.

Movement.—The tongue-like, yellow, fleshy mass can be seen projecting into the sand from the anterior margin of the shell. This is the **foot**, which is an extremely muscular organ by means of which the animal is able to plough its way slowly over the mud or sand, leaving a trail behind it like a shallow furrow. When the exposed, fleshy parts of the clam are touched, the foot and siphons are rapidly withdrawn into the shell, and the latter is tightly closed, so that one cannot readily force it open. If the shell

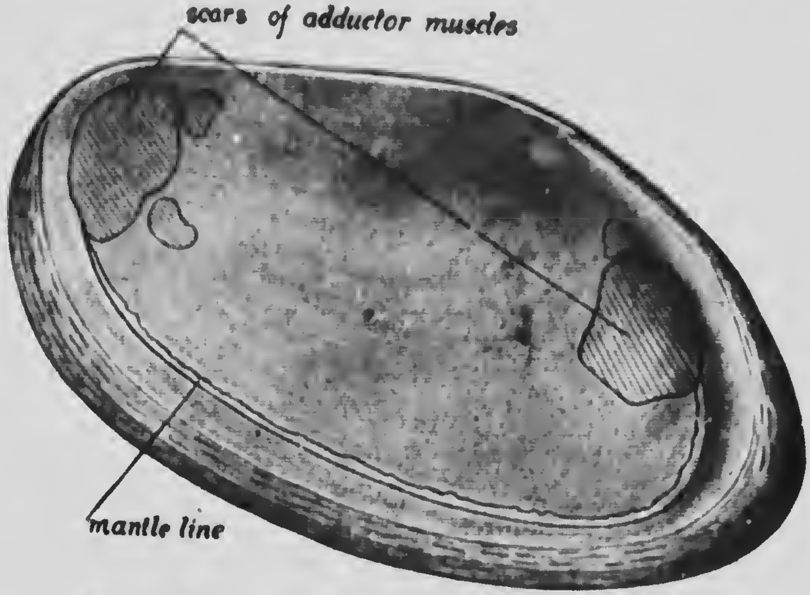

FIG. 12.—Fresh water Clam showing interior of right valve.

valves are forced apart, however, there is seen within the shells two powerful muscles which pass across from valve to valve. One is located towards the anterior and one towards the posterior end of the animal's body. These are the **adductor muscles**, and are used to draw the two valves together, and to hold them firmly in that position. When these muscles are relaxed, the elastic hinge causes the valves to gape ventrally. Other small muscles will be seen close to these adductors. The former serve to draw out the foot or to retract it again. All these muscles leave visible scars on the shell at their place of attachment.

Respiration.—When the shell valves are carefully drawn apart, the animal's body can be seen as a fleshy mass covered by a thin, yellowish membrane—the **mantle.** This covering is continuous with the rest of the body dorsally, but is free ventrally, and forms a lining to each shell valve. Only around its margin is the mantle attached to the shell; an impression of this attachment may be

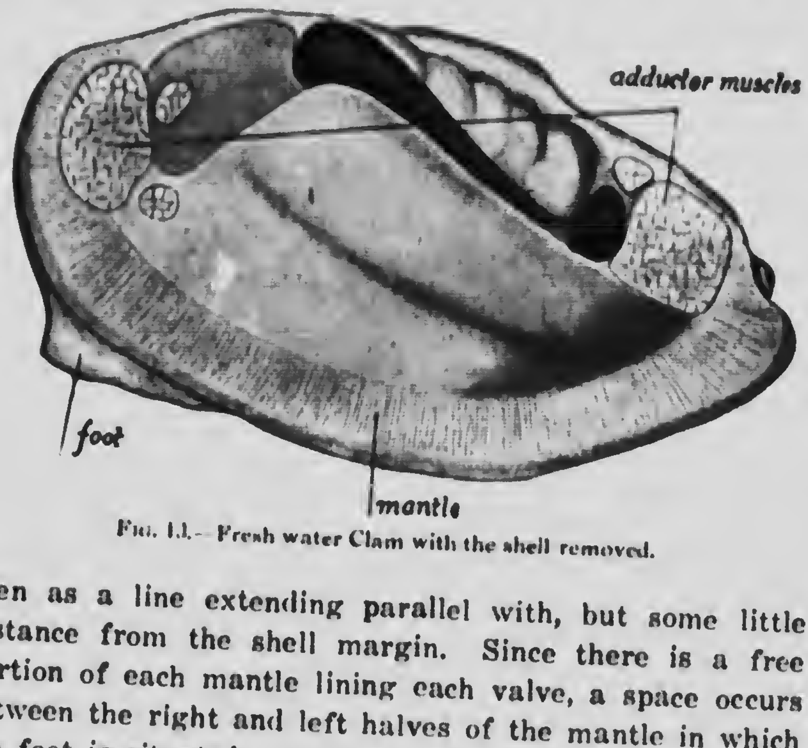

FIG. 13.—Fresh water Clam with the shell removed.

seen as a line extending parallel with, but some little distance from the shell margin. Since there is a free portion of each mantle lining each valve, a space occurs between the right and left halves of the mantle in which the foot is situated, and on each side of the foot are the respiratory organs or gills. These structures, two on each side, hang down from above into the space between the foot and the mantle. The surface of one of these gills, when examined under a microscope, exhibits numerous little hair-like structures called cilia, which are constantly moving together in one direction and then slowly returning to their original position—exactly like the blades of wheat when a series of gusts of wind pass over a wheat field. The rhythmical movement of these cilia produces a current in the surrounding water, in through the inhalent siphon, over the gills and mouth, and out through the exhalent siphon. Immediately beneath the surface of the mantle and gills there are many small vessels containing blood which in the clam is colourless. The oxygen dissolved in

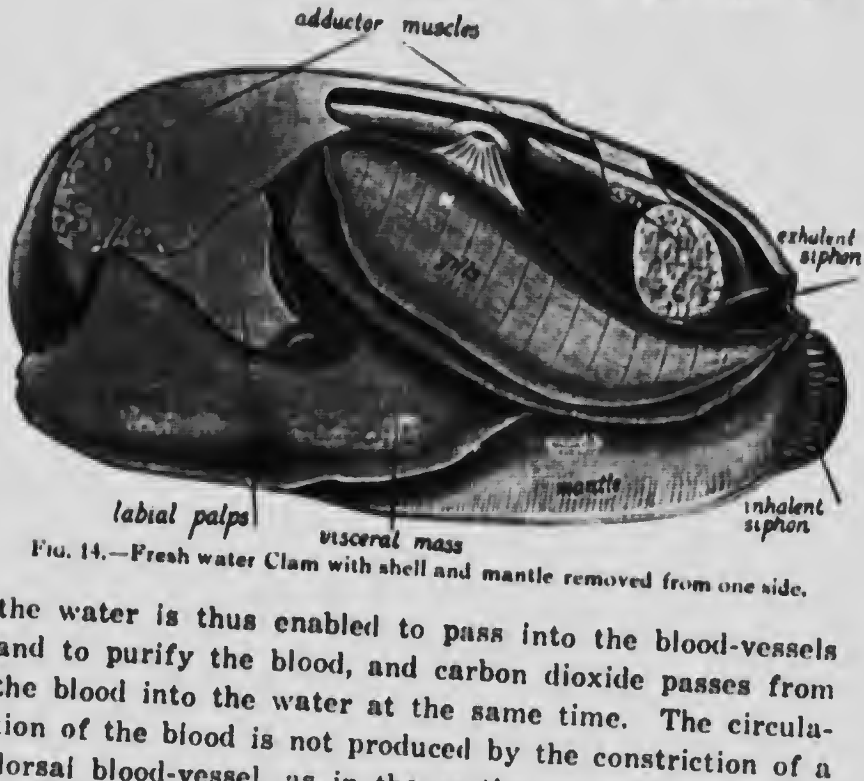

FIG. 14.—Fresh water Clam with shell and mantle removed from one side.

the water is thus enabled to pass into the blood-vessels and to purify the blood, and carbon dioxide passes from the blood into the water at the same time. The circulation of the blood is not produced by the constriction of a dorsal blood-vessel, as in the earthworm, but by a more complex struc‑ ‑re, the heart.

Feeding.—Lying between the gills at the anterior end is a soft structure, the visceral mass, which is continued below into the foot. Below the anterior adductor muscle and above the visceral mass is the mouth, an oval opening, bounded on each side by two triangular membranes called **labial palps.** The water that is brought in through the inhalent siphon contains many microscopic animals and plants: these are carried forwards by the current and with the assistance of the palps are passed into the mouth. Thus the clam has no method of seizing its food, but depends entirely upon the good material which may happen to be brought in the water which is kept moving by the cilia upon the gills and on the inside of the mantle. Within the visceral mass lie the organs of digestion, namely, the stomach, digestive gland, and a much coiled intestine. From the intestine the digested food passes into the blood and thus to all parts of the body. The intestine terminates in the vent, which is close to the exhalent siphon, and through this the fæces passes.

Smell and Feeling.—The clam does not hunt for food, nor does it flee from enemies, and so it is not altogether surprising that it possesses no eyes. Again, this creature has very little power of selecting its food, hence a sense of smell would not be of much use, and none has up to the present been detected, although, near the place where the water enters the body, there is an organ endowed with the power of testing the purity of the water. The sense of touch is well developed, particularly on those parts which are exposed when the shell is partly open, namely, the siphons, mantle, and foot. A small organ of hearing, however, is buried in the muscular mass of the foot.

Reproduction and Development.—Clams resemble flies and differ from earthworms, in being male or female. The eggs of the female leave the visceral mass by a **genital aperture,** but do not pass out from the shell. They remain in a cavity above the base of the gills. Here they are stimulated to develop by fertilizing substance from a male clam brought in through the inhalent siphon by the current of water. The fertilized eggs are passed into cavities situated in the outer pair of gills, whereby the latter become greatly distended. The eggs remain here for a considerable time, and if the gill be examined it appears in time to be packed full of a mass of sand grains. These are the little clams, provided with two shell valves, the ventral margin of each valve forming an incurved hook. The young animals pass out through the exhalent

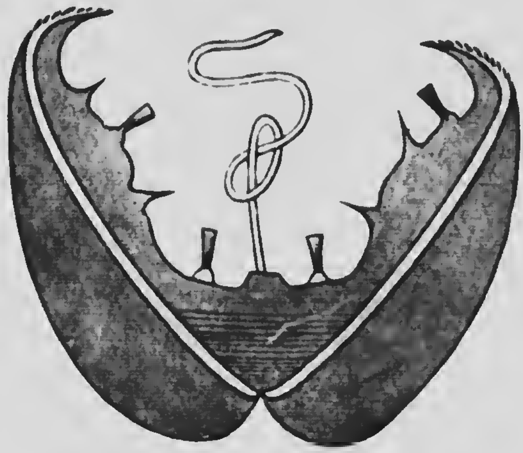

FIG. 15.—Young Fresh water Clam.

siphon, cling, by means of the two hooks on the shell, to the skin or gills of some passing fish and travel about in this position, while they pass through certain stages of their growth. Finally when ready for a free existence they become detached from the fish, and gradually assume the appearance and habits of the adult clam.

Habits and Intelligence.—The clam leads a passive life after it once settles down to live freely in the sand. Its most common attitude is one in which the front end of the ventrally gaping shell and the foot are completely buried in the sand or mud, while the other end of the shell points obliquely upwards so that the siphons are exposed above the sediment. The water circulates continuously in and out through the siphons. Clams living in streams usually choose that part of the bed where the current is swift, in order that the water circulating over the gills will be constantly fresh and hence more food will reach the mouth. The food consists largely of small particles of animal and vegetable material floating in the water. These animals remain for a considerable period of time in one locality, but can move slowly over the bottom of the lake or stream. During the winter they bury themselves deeply in the mud of the bottom, and thereby escape the frost. No great signs of intelligence, however, are to be expected in an animal which has no eyes, an imperfect ear, and very little interest even in the kind of food which reaches it. Its interest in the world around is very remote.

Adaptation to Environment.—The clam moves slowly, and is no doubt impeded in its movements by its shell. Fortunately for this creature the power of rapid movement is quite unnecessary. In the first place, instead of a clam having to search or hunt for food, that material is brought to it, and secondly, the animal has no need to escape from enemies, for when these approach, the siphons and foot are retracted into the shell, and the powerful adductor muscles tightly compress the two valves of the shell together.

Such a method of defence does not require that the clam shall be provided with any organ for watching the approach of an enemy: add to this the fact that the animal lives usually with the front part of the body buried in mud or sand and we can understand the absence of eyes. It is important, however, that the clam should be aware of the proximity of a foe, and this is indicated to some extent perhaps by the organ of hearing and more particularly by the well-developed sense of touch possessed by those parts of the body which are normally exposed: viz., the mantle edge, the foot, and the siphons.

The clam exercises practically no choice in the matter of food and so no keen sense of taste is developed. The most important feature of its environment is a continuous supply of fresh, clean water, to test the purity of which the organ of smell is present. The colour of the outside of the shell is unobtrusive and renders it inconspicuous.

Variation.—The collector who pays attention to the markings on and the shape of clam shells will not fail to observe that slight differences often occur. These are known as **variations**. We are all able to recognize differences in appearance, size, etc., among our friends and among strangers. Differences in human beings are often very marked in people from widely separated regions of the world. Thus, the characteristic features of a Chinaman are readily distinguishable from the peculiar type of features of the European. Similarly, variations occur among lower animals, including the clams. If a number of clam shells from different situations be selected, all belonging to the same kind, a careful set of measurements of these will show that the shape is variable and that the intensity of colour is of varying degree corresponding with the environment of the animal, namely, the bottom of the stream or lake.

Kinds of Clams.—If the streams be carefully searched it will be seen that there are several kinds of clams to be found in almost any locality. The two most common are *Unio* and *Anodonta*. The distinction between these consists of a difference in the structure of the shell. On the inside of the shell just below the hinge Unio has projections, called teeth, and corresponding indentations on the valve opposite, the teeth on one valve fitting into the indentations on the other. The teeth are absent in the shell of Anodonta, otherwise these clams have much the same appearance. A careful search among the weeds of any pond will probably be rewarded by the finding of a very small clam adhering to the weeds in considerable numbers. This kind is the "pea-shell", *Pisidium*. It is so named because of its supposed resemblance to a pea. This animal is about the size of a pea, brown in colour, and not oval like the larger clams, but almost circular. Its shell is not nearly so flat, so that it has almost a globular shape. If it be put into an aquarium, the pea-shell exhibits greater activity than its larger relatives, Unio and Anodonta.

Snails.—In addition to the bivalves like the clams there are many kinds of snails found in America. Snails have a shell composed of a single valve within which the body is protected. The shell is of a spiral shape with a wide opening at one end; it is placed obliquely on the animal's back, with the apex situated on the right side of the body. The whole body can be withdrawn into the shell, which thus acts as a protection. During movement, however, the soft, fleshy, lower part of the snail is partly extended from the large, wide opening of the shell, thereby exhibiting a head in front, bearing two or four pairs of feelers or **tentacles**, and a long, flattened foot underneath, the latter tapering away and ending bluntly a short distance behind and below the shell. No neck separates the head from the rest of the body. The mouth is a small, crescentic opening at the anterior end, bounded above and on the sides by a conspicuous lip, which covers a semi-circular jaw. Beneath the mouth there is an underlip and behind this

FIG 16.—Snail—front view.

a rasping tongue—the **odontophore**—moved by powerful muscles, for tearing up the food.

The foot of a snail is composed to a great extent of muscles, by the exertion of which the animal progresses. During movement, a slimy fluid is continually being poured at the front end of the foot, beneath the mouth. In the fully expanded snail there is a thick, soft frill to the body, visible round the mouth of the shell, known as the **collar.** Inside the shell and continuous with the collar, a thin sheet of skin—the **mantle**—acts as a cloak, covering the upper part of the body; a space, separating the mantle

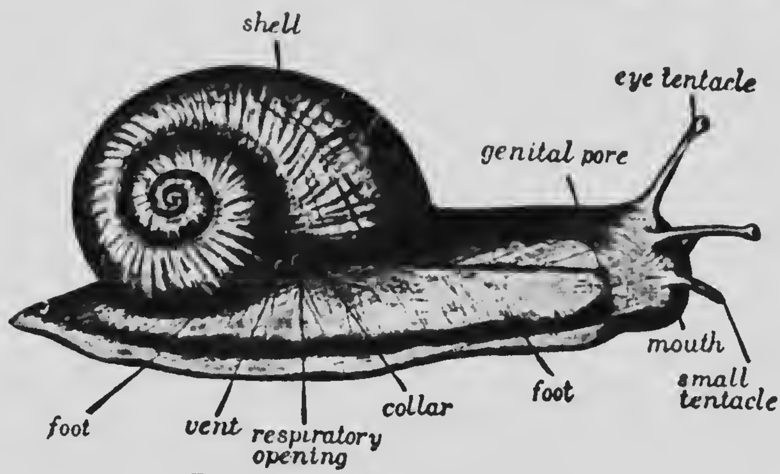

FIG. 17—Sand Snail—side view (× 1).

from the latter, is called the **respiratory chamber or lung.** Air is continually taken into, and later expelled from, this chamber through a **pulmonary** or **respiratory opening** situated on the right side of the body in the region of the collar.

There are various kinds of snails found in all parts of Canada and the United States. We may distinguish the land-snails from the water-snails: the former have two pairs of tentacles with eyes at the tip of the posterior, larger pair, whilst the latter have one pair of tentacles only, with eyes situated at the base. Behind the lung the rest of the body—comprising mainly the organs of digestion, excretion, circulation, and reproduction—fills the apex of the spiral shell and receives the name **visceral hump.** The vent, situated on the collar, is visible to the right of, but not so conspicuous as, the pulmonary aperture. Cross-fertilization occurs among snails just as among earthworms. The eggs leave the body by the **genital pore,** an opening situated on the right side. Snails make a

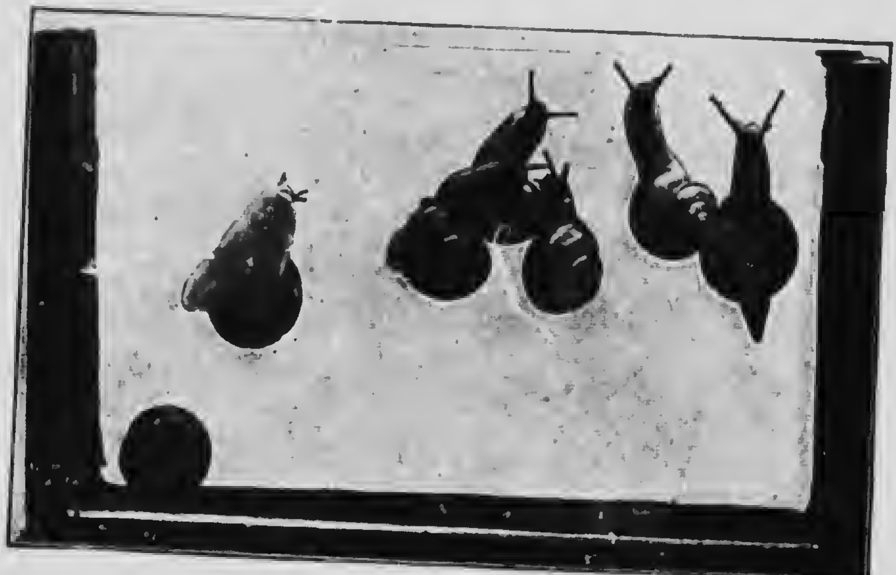

FIG. 18.—Edible Snails (× ½).

small hole in the earth, deposit their eggs, and then cover them with soil. The land-snails of North America, *Helix,* live hidden in damp places during the day and come out to feed at night. Of the water-snails there are two common forms which live in water, only coming occasionally to the surface to breathe. These are the pond-snail (*Limnæa stagnalis*), with an acute, pointed shell, and the trumpet-shell (*Planorbis corneus*), having a brown, flat, spi. al shell; both kinds may be found in ponds and fresh-water streams.

The eggs are laid in a mass of jelly, as spawn, which is attached to water-weeds and other objects. The spawn of the pond-snail has an elongated, sausage-shaped appearance, while that of the trumpet-shell is oval and of smaller size.

Slugs.—Although slugs are very similar in structure to snails, they present a different appearance, having

Fig. 19.—Shell of Field Snail. (*Helix nemoralis*) (× ½).

Fig. 20.—Trumpet Shell. (*Planorbis corneus*) (× 2).

Fig. 21.—Pond-snail (*Limnæa stagnalis*) and Spawn (× 1).

apparently no shell. In North America are several species belonging to the kind known as *Limax*. The most common is the field slug, which does much harm to vegetable crops. It rests during the day under boards and stones. As regards the tentacles, mouth, gential pore, foot, and internal structure, slugs resemble snails, but the respiratory chamber or lung is small, and bounded by skin of rather different texture from the rest. The respiration of a slug may be readily observed—the pulmonary opening continually enlarging and narrowing.

Slugs appear to prefer vegetable food—fruit especially—although they will eat the flesh of almost any animal, whether living, freshly-killed, or decaying: they will even follow earthworms into their burrows in order to prey upon them. Slugs lay a large number of eggs.

These animals emain active until late autumn; snails hibernate earlier than slugs, since cold weather affects them more readily.

PRACTICAL WORK

Examine the shell of a clam. Notice the hinge, the horny outer covering, the iridescent mother-of-pearl within, the decrease in thickness from the umbo to the margin, the lines of growth, the muscle scars on the inside of each valve, the teeth (if it be a Unio shell).

Make a drawing of the shell from the inside showing all the muscle scars you can discover.

Place a clam shell on a shovel. Put it in a fire for an hour to burn out all but the calcareous material. Notice how the shell breaks in layers, the rings of growth separating from each other.

Study a living clam in an aquarium with sand in the bottom. Notice its position, the manner of burrowing in the sand, the two siphons, the mantle. Observe its method of moving. By means of a piece of glass-tubing let some ink escape near the siphon with the fringed margin. In which direction does the water current move? Place the ink near the dorsal siphon to find the direction the water current moves here. Notice the track in the sand left by the animal as it moves. Make a drawing of a living clam in an aquarium showing its foot and siphons extended.

Place a living clam for an instant in boiling water. The shell gapes open when the animal is dead, and the body can be taken out. Examine the mantle, gills, foot, muscles, labial palps, mouth, and visceral mass. Make a drawing showing all these organs.

Collect some garden snails and slugs: place them upon large, moist leaves inside a bell-jar, and keep them under observation.

Invert another bell-jar and put into it pond-water containing water-plants and water-snails.

Observe the movement and method of feeding of both land-snails and water-snails. The movement of a garden snail can be best observed by placing the animal on a sheet of glass and looking up at the foot from beneath. Pond-snails often move on the surface of the water with shell downwards.

Note the effect of touching a fully expanded snail or slug.

Watch a slug breathing—the pulmonary opening is continually enlarging and diminishing.

Draw a garden snail expanded and contracted, naming the parts. Also draw an empty shell.

Test the power of smell of a land snail by placing fruit near it. Note the movement of its eye-tentacles.

Snails in the garden may be marked with whitewash and their whereabouts determined from day to day. Observe their homing instinct.

Examine a snail withdrawn into its shell for the winter: notice the thin membrane secreted over the mouth of the shell, with an opening left for breathing.

Draw the shells of a pond-snail and a trumpet-shell. Find specimens of the slugs mentioned above and draw them: write a description of each in your own words.

After keeping the pond-snails and trumpet-shells for some days you will most likely find the spawn of these animals. Notice the difference in shape. Watch the spawn daily until the snails hatch.

Collect the different kinds of empty snail-shells you can find when out for country walks. You will probably be able to get varieties of the shell of the garden snail.

EXERCISES

1. How is a clam adapted to its environment?

2. What are the habits of a clam? Compare a clam and an earthworm, with respect to (a) structure, (b) habits.

3. Describe the shell of the clam.

4. Compare the clam and the snail in the following respects: shell, foot, sense organs, means of respiration.

5. Which is more active the clam or the snail? What differences of structure are associated with these differences in activity?

6. What uses are made of clams and snails?

7. What enemies do you think clams and snails have to protect themselves against?

8. Describe the resemblances and differences which you have observed between a field slug and a garden snail.

9. What plants in your district are injured by the slug, and what means can be used to get rid of it?

CHAPTER IV

THE HOUSE-FLY

Where found.—The common house-fly is, during the summer months, perhaps the most troublesome pest in our dwellings, and we are often compelled to set traps for it in the form of papers smeared over with a sticky substance like treacle, which attracts and also disables the fly. It is, however, not difficult to catch a specimen—for the purpose of examination—by drawing the open hand quickly over a flat surface upon which a fly is walking, and at the same time closing the hand.

FIG. 22.—House-fly (dorsal view). The line indicates the natural length.

Appearance.—The general structure can be made out by the aid of a magnifying glass or watchmaker's lens. The house-fly is almost black in front and yellowish-brown behind. Three distinct regions,—viz. **head, thorax,** and **abdomen,**—can be observed. On the sides of the **head** are the two large, dark-red **eyes**: behind the head a constriction—the **neck**—divides the front region of the body from the middle region or thorax, on which are borne the three pairs of **legs** and a single pair of wings.

Segmentation.—The thorax consists of three portions which succeed one another like the segments of an earthworm. This region of the body is black, and so is readily distinguished from the hinder or posterior abdomen, which is lighter in colour, as mentioned above, and also appears to consist of six divisions or segments, with an opening—the **vent**—on the last. The house-fly is therefore a segmented animal, though the segments are not so distinct as they are in the earthworm.

Movement.—The two wings are broad, thin, transparent membranes, upon which are ridges running from the body to the wing-tips. The ridges—called **nervures**—appear to interlace occasionally; they separate the transparent regions of the wing from one another, just as the wood separates panes of glass in a window, although the nervures are not so regularly arranged. The wings are inserted laterally into the middle segment of the thorax and are moved up and down at a great rate by powerful muscles, and thus produce flight.

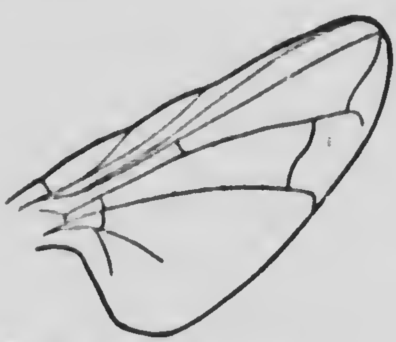

FIG. 23.—Wing of House-fly (much enlarged)—showing nervures.

Immediately behind, and partly concealed by the wings—*i.e.* projecting from the last segment of the thorax—are two small structures like drumsticks. These balancers or **halteres**, which look like small pins stuck into the body, one on each side of the thorax, are said to act as balancing organs during flight. In bees, butterflies, and other animals closely related to the house-fly, a second pair of wings is present instead of these halteres. When a fly settles upon any solid object, walking is effected by three pairs of legs.

Each leg is divided into seven regions with joints interposed. Of these regions the two **proximal**—*i.e.* the two nearer the body—are long, the **distal** five—*i.e.* the five further away from the body—are short. Each leg ends in two small claws, a **bristle**, and also two minute adhesive cushions, or **pulvilli**. The latter enable a fly to walk on the ceiling upside down.

Respiration.—The yellowish abdomen does not bear legs: it ends bluntly behind. There are certain openings—the **stigmata**—situated on the right and left sides of each segment, and through these air passes into the body and

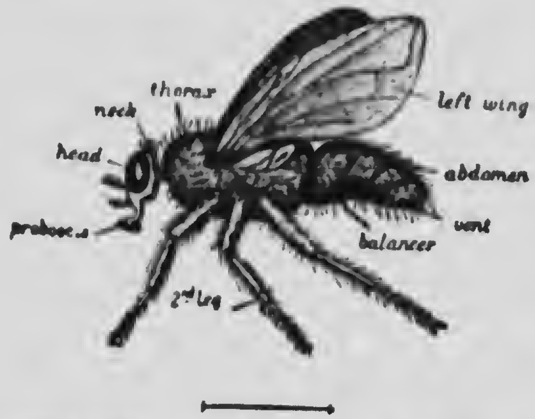

FIG. 24.—House-fly (side view). Showing the legs on the left side only.

comes into close relation with the tissues of the fly by means of minute, finely branching tubes called **tracheæ**. Thus respiration is effected by the passage of pure air into, and impure air out of the body through the stigmata.

Sight, Feeling, Feeding.—The eyes of a fly are too small for examination without a microscope. Their rounded appearance and position on the head enable the creature to see practically in every direction without moving its head. Between the eyes two whitish patches leading towards the mouth border a median dark forehead. Two feathery feelers or **antennæ** are situated in this region.

They are larger and longer than the many bristles (of varying size) which occur over all parts of the body and legs. The mouth is not distinguishable, although a long proboscis, ending in a flat, blunt cushion, can be observed hanging apparently from the mouth. This proboscis is a tube-like structure really ending in two small suckers, which appear as the cushion above mentioned. Food is sucked up into the mouth by this organ, the nature of the food of different flies having a close relation to the nature of the proboscis, as an examination of other kinds of flies will prove.

Habits.—We may be thankful that our common house-fly never bites; the horse-fly—a species common in Canada and the United States—causes much annoyance to horses, by piercing the flesh and sucking blood from the wound. For this purpose the proboscis of a horse-fly differs from that of a house-fly, and is adapted for piercing and sucking. Another fly—the stable-fly—is rather like our common house-fly in appearance, but differs in having biting mouth-parts: the existence of this insect has probably given rise to the erroneous view that house-flies are able to bite at certain seasons of the year.

A close relative of the house-fly—the tsetse-fly, found in South Africa—is even more harmful. Its custom of biting horses and cattle and sucking their blood would not be so serious, were it not for the fact that many of the animals bitten are suffering from the "Nagana" or fly-disease. Tsetse-flies, which have sucked the blood of a diseased animal,

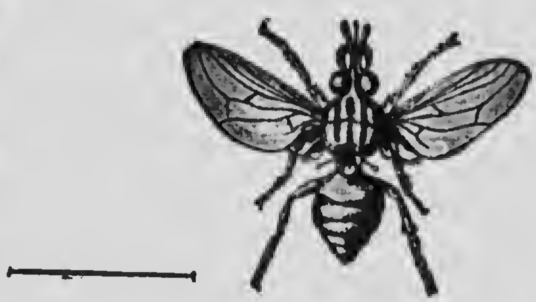

FIG. 25.—Tsetse-fly.

infect any healthy animals which thy may afterwards bite, and in this way spread a disease which causes the death of many cattle and horses.

The house-fly lives on food of all kinds: we find it settling upon our food, whether vegetable or animal. Like ourselves, it enjoys an unrestricted diet, and for this reason is called an **omnivorous** animal. It has been conclusively shown to be a carrier of typhoid and other diseases, and should be combatted unceasingly. No accumulations of stable and other refuse should be allowed to remain longer than seven or eight days in hot weather, and by a proper system of hygiene the pest can be effectually reduced in numbers.

Flies have many enemies which kill and feed upon them; we all know how the little animals which readily escape us are cunningly trapped by becoming entangled in the wily spider's web. Of course, if the fly had no enemies it would increase in numbers so rapidly as to be a serious menace to our food supply. Perhaps you have seen dead flies apparently stuck fast in the crevices of walls or in the corners of window panes, covered over with a "fluffy down" rather like the mould on very stale bread. This covering is really called "fly-mould," the fly having succumbed to the growth of this plant. The mould develops from minute particles called **spores**, which are blown about, settle on the fly's body, grow, and, at the same time, send small roots into the tissues of the creature, thereby rendering the fly too weak to get food. Such an enemy of the house-fly is called a **parasite**, since it gets food at the fly's expense. Moreover, the fly supplies the food, and is called the **host**—though the parasite is far from being a welcome guest.

Reproduction and Development.—House-flies are very numerous in warm weather; the reason will be clear when something is said about their breeding or reproduction. A fly will lay perhaps 150 very small eggs upon some dung, or other moist soft refuse. In a day or two these eggs hatch out; they are known as **grubs** or **maggots**; these minute young creatures are without limbs, and they devour the refuse upon which the eggs were laid. In five or six days the maggots have grown to their full size, and form motionless **pupæ**. The latter remain without food for a week, after which the perfect full-grown flies, provided with wings, etc., emerge. These are the **imagos**, or adult

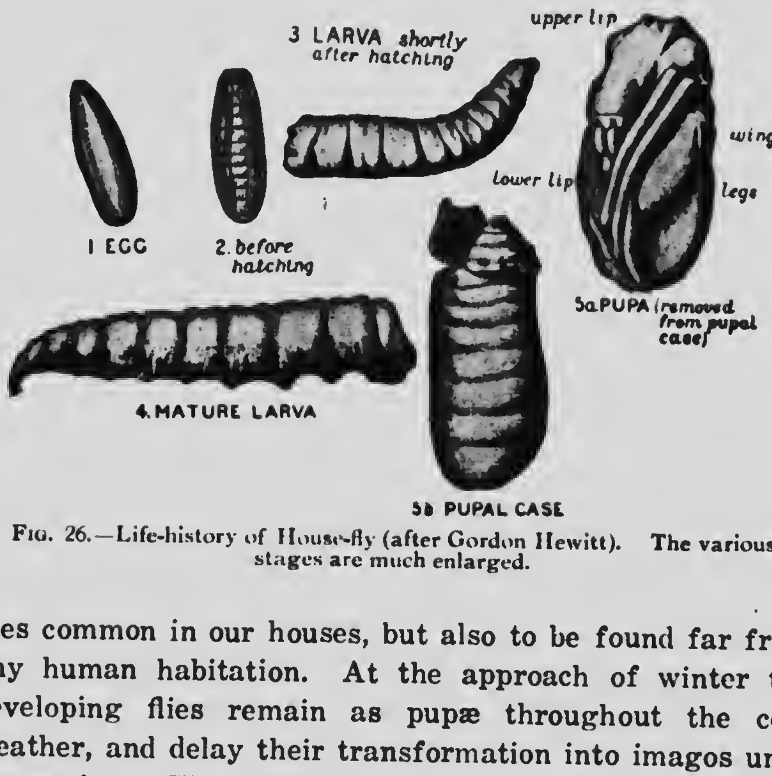

FIG. 26.—Life-history of House-fly (after Gordon Hewitt). The various stages are much enlarged.

flies common in our houses, but also to be found far from any human habitation. At the approach of winter the developing flies remain as pupæ throughout the cold weather, and delay their transformation into imagos until the spring. Flies never grow after reaching the adult condition—difference in size among flies indicates different kinds or species.

Metamorphosis.—The eggs of a fly hatch out as little grubs which are totally unlike the parents. The grubs or maggots feed and move about in a different way from the adults, and a complete change of structure must take place before the adult condition is reached. An animal, in the development, or **life-history**, of which such changes take place, is said to undergo a **metamorphosis**. The immature young animals before metamorphosis are known as **larvæ**.

Hermaphrodite and Diœcious.—Both the earthworm and the snail differ from the house-fly in one important respect, since all the animals of one species are alike in possessing organs for producing both eggs and the fertilizing substance which stimulates eggs to develop. Hence the earthworm and snail are **hermaphrodite** animals. A house-fly, on the other hand, is able either to produce eggs only—in which case it is a **female**; or fertilizing substance only—in which case it is a **male**. Although belonging to the same kind or species of fly, the males are further distinguished from the females by slight differences in the appearance of the head. Since flies are divisible into sexes—male and female—they are said to be **diœcious**.

Adaptation to Environment.—The house-fly is a scavenger, feeding on all sorts of food, with many enemies to avoid, and, being unprovided with any effective weapons of offence and defence, it has to find safety in rapid movement. Hence the wings for flight, the halteres for greater precision in this method of locomotion, the powerful eyes so placed on the head as to give a wide range of vision, and the jointed legs and wonderful structure of the feet, enabling a fly to settle and walk upon or beneath almost any surface, whether rough, smooth, vertical, or inverted, in search of food. The head is readily movable, the short neck being counterbalanced by a proboscis long enough to be lowered to the food; thus, bending the head, which would result in a more limited field of vision, is obviated.

The antennæ are for feeding and probably for hearing also. Lastly, the large number of eggs laid, in dung or other food suitable for the maggots, and the rapidity with which the latter develop, are all contrivances by which nature ensures the preservation of a species in the face of numerous enemies.

Insects.—The house-fly is a segmented animal like the earthworm, but unlike both earthworm and snail it is diœcious. The animal belongs to the large class of **insects.** Insects are distinguished by the possession of a distinct neck, a single pair of antennæ, always three pairs of jointed legs on the thorax, and usually two pairs of wings, though flies have but one pair. Breathing is effected by means of tracheæ. As a rule insects undergo a metamorphosis in the development.

Kinds of Flies.—Flies, gnats, mosquitoes, crane-flies, etc., are insects with only one pair of wings,—they belong to a group called **Diptera** (two-winged). Different species are classified upon the arrangement of the nervures, the position of the eyes, the nature of the antennæ, etc. For example, we have noticed how the nervures are arranged in the house-fly: in the crane-fly they appear as indicated in the accompanying illustration.

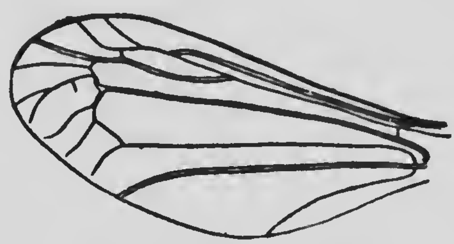

FIG. 27.—Wing of Crane-fly.

The house-fly (*Musca domestica*) and blue-bottle or blow-fly (*Musca vomitoria*) are almost alike in the nervures of the wing, but differ in size and colour; both have moderately long antennæ with feathered bristle, as shown in Fig. 24. The tsetse-fly (*Glossina morsitans*) has short antennæ, whilst the gnat has wonderfully long plume-like antennæ, especially the male (Fig. 28).

Within recent years the mosquito and its relatives have gained notoriety as the virulent enemies of mankind, since they are the medium whereby many diseases are spread

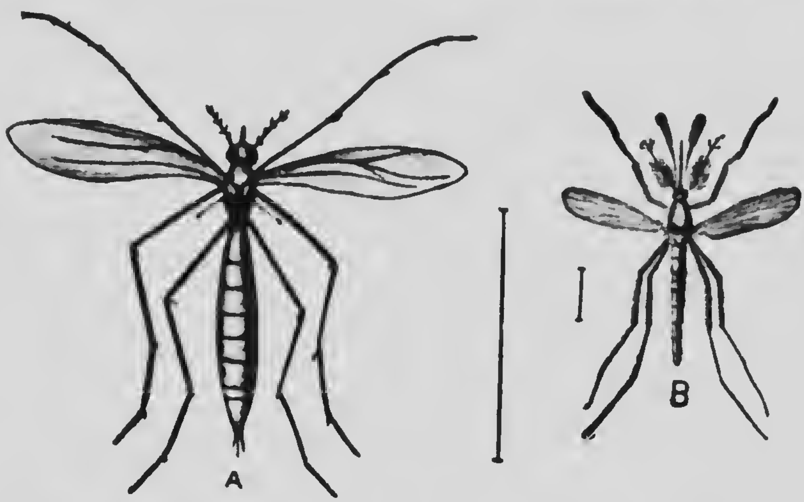

FIG. 28.—(A) Crane-fly, female; (B) Gnat, male insect (enlarged).

among human beings and domestic animals. Malarial fever, agues, yellow fever, sleeping sickness, mal-de-cadeous (South America), etc., are now known to be transmitted by insects.

PRACTICAL WORK

Put some house-flies in a bottle containing a lump of sugar; also place one or two flies on a sheet of white paper under a watch glass for examination.

Notice the colouration, the head with proboscis and eyes, the thorax consisting of three segments, with the wings and legs attached, and the abdomen with six segments visible.

Make a drawing of a fly to show these structures.

Watch a fly feeding and moving.

With the aid of a lens you will be able to examine a leg, proboscis, balancer, antennæ, and a wing with its nervures. Draw each structure separately.

Observe that as the cold weather approaches few flies are to be found, and that these are listless and inactive.

Search in the corners of windows for dead flies with a fluffy coat. These have been destroyed by a plant known as "fly-mould." Flies may be observed settling and feeding upon all kinds of food—meat, sugar, butter, jam, vegetables—they have an omnivorous diet.

Try to secure the large blue-bottle, noting difference in size and colour between it and the house-fly.

Catch some mosquitoes and some crane-flies. These latter are numerous in meadows in the summer-time.

Examine and draw the beautiful plumed antennæ of the mosquito. Note the long, slender legs of a crane-fly for rapid progression among blades of grass. Draw the wing of the latter, showing the arrangement of the nervures.

From a pond or rain-barrel collect some "wigglers" and place them in a glass jar with water and some water weeds. Study the structure of the wigglers and watch them turn into mosquitoes.

Make a collection of at least six insects belonging to the diptera. They can be recognized by having two wings instead of four.

EXERCISES

1. Give the life-history of the common house-fly.

2. How is a fly adapted to its environment and mode of life?

3. What is meant by "metamorphosis"? Give the names of any animals you know which undergo a metamorphosis.

4. Explain the terms halteres, antennæ, proboscis, parasites, diœcious, female.

5. Describe in what ways the house-fly is harmful.

6. From what you know of the method of breeding of the fly, suggest the best method of keeping down their numbers.

7. Name some diseases that are caused by the bites of mosquitoes.

8. In what ways do the fly and mosquito resemble each other, and in what ways do they differ?

9. Describe the life-history of a fly and compare it with that of a mosquito.

10. Is the fly a segmented animal? Compare it in this respect with the earthworm and the clam.

CHAPTER V

GRASSHOPPERS, BEETLES, AND SPIDERS

Having studied the house-fly, we will pass on to consider some of its near as well as its more distant relations.

The Grasshopper.—The common grasshopper, often found in pastures, meadows, and gardens, is one of the best known American insects. It is so named because it is generally found amongst the blades of grass and moves chiefly by a series of gigantic leaps. It is a good example of a typical insect, and owing to its large size is convenient for examination.

The body consists of three distinct regions, viz. a **head** bearing two antennæ and two kidney-shaped eyes, a **thorax** with two pairs of wings and three pairs of jointed legs, and an **abdomen** bearing no legs and differing in shape posteriorly according to the sex of the specimen. Three **segments** comprise the thorax and ten the abdomen, although the first and last two of the abdomen are not complete rings. The grasshopper resembles an earthworm, not only in being segmented, but also in the possession of a thin **cuticle** composed of the same horny material, **chitin**, which is greenish in the grasshopper; this investment is especially thickened on the head, certain parts of the thorax, and on the anterior pair of wings.

The anterior pair of wings, attached to the second thoracic segment, are long and narrow, thick at the base but becoming thin towards the free end; they are of little use for flying. They are called **elytra** or wing-covers, the thin, transparent, membranous posterior wings attached to the segment behind being folded up like fans beneath the elytra when the grasshopper is not flying.

If a grasshopper be placed in methylated spirits for a couple of minutes so as to kill it, the structures about the

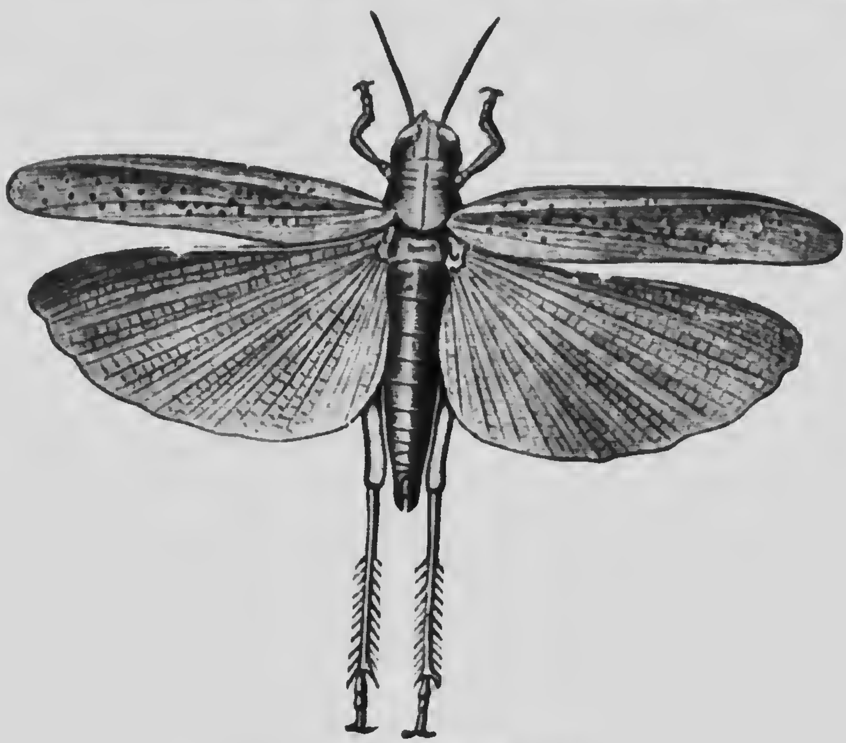

FIG. 29.—Grasshopper (dorsal view).

mouth—the **mouth-parts**—can be examined and separated with the aid of a lens and two needles. In front of and below the eyes is the upper lip or **labrum**. This covers two stout jaws or **mandibles** which work against one another and are lateral in position, not dorsal and ventral like the jaws of a dog or cat; the inner edge of each mandible bears small tooth-like projections. Behind the mandibles are two structures called the **first maxillæ**, having the jointed parts shown in the diagram (Fig. 30). Each maxilla possesses a **palp**, most likely used by the insect when feeding. The next pair of structures, or **second maxillæ**, are joined together to form a sort of lower lip called the **labium**. A three-jointed palp is present on each side. The head bears two slender **antennæ or feelers**.

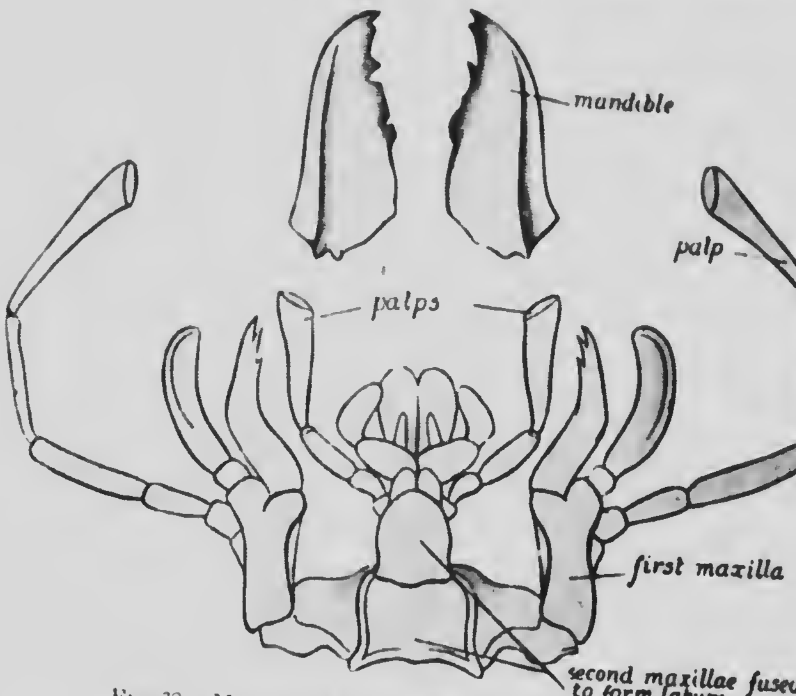

FIG. 30.—Mouth-parts of Grasshopper (much enlarged).

The legs consist of jointed pieces, the proximal parts longer and stouter than the short distal parts; each leg ends in a **pulvillus** armed with a pair of claws. The third pair of legs is very large and strongly developed.

The abdomen is alternately expanded and contracted during respiration; by these movements inhalation and exhalation of air takes place through certain openings—

the **stigmata**—two of which are visible on the thorax and eight on the abdomen on each side of the body.

The eggs, about fifteen together, are enclosed in horny capsules. The young grasshopper is smaller than the adult and has no wings, but otherwise resembles the parent. From the time of hatching to the mature condition the insect grows by casting off its outer chitinous cuticle no fewer than six times. When the old cuticle is cast off or "moulted," a new soft coat is disclosed: this

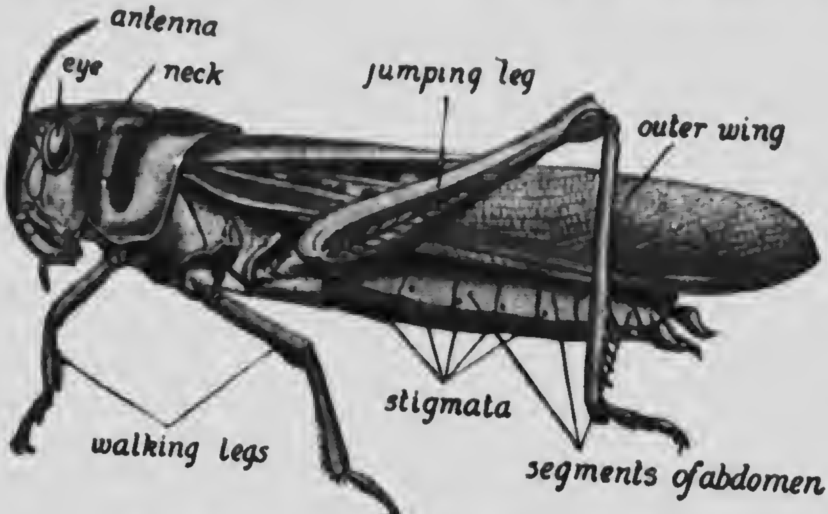

FIG. 31—Side view of Grasshopper (somewhat enlarged).

stretches as the animal grows in size, but soon sets firm and non-elastic through exposure to the air, and thus becomes the new cuticle.

We may regard the development as an example of **incomplete metamorphosis**, since there is no period in the development when the larva is a quiescent pupa.

Beetles.—The popular term "beetle" is often misapplied. Beetles are insects with the two membranous hind-wings completely folded up, when not in flight, beneath two horny fore-wings or elytra. When a beetle flies the elytra are spread out, but not apparently used. The firm cuticle gives to beetles a very definite outline and renders their identification comparatively easy.

Two eyes and a pair of antennæ are present on the moderately large head. Beetles live mainly upon other

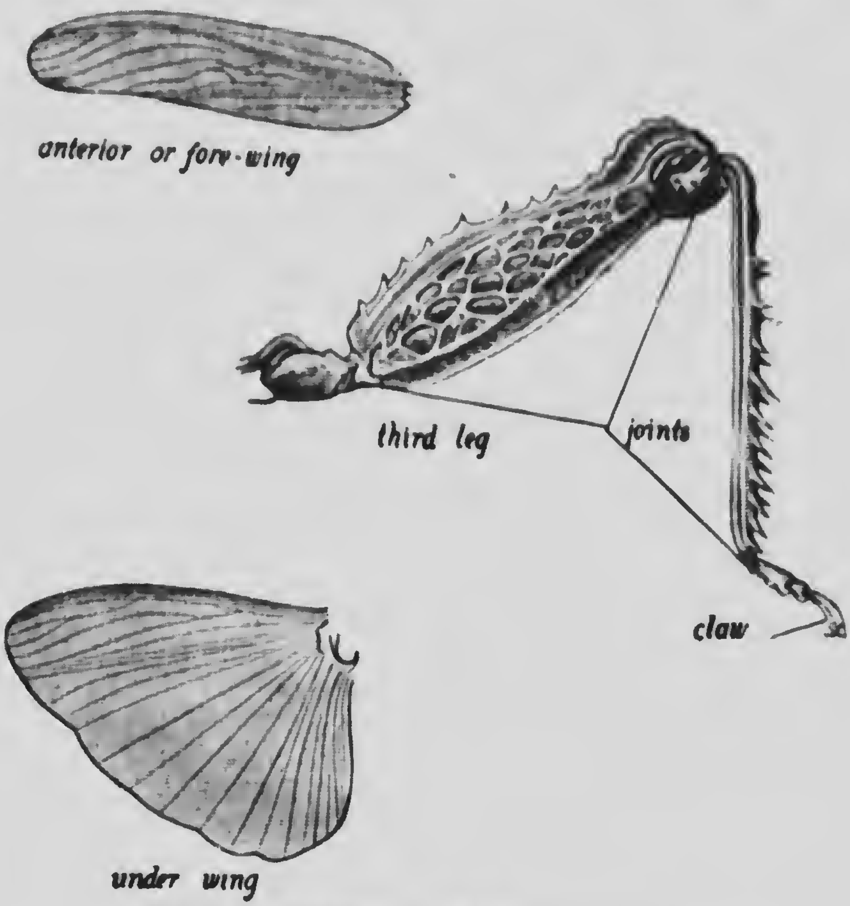

FIG. 32 —Grasshopper. The wings and third leg.

insects, and are therefore **carnivorous.** In consequence, they are provided with mouth-parts adapted for biting and chewing—very similar to those which have been described for the grasshopper.

Among the commonest beetles are:

(1) The *Colorado potato beetle*,—the common pest which does so much harm to our potato crops.

(2) *Great water-beetle*,—a voracious ... ater living in ponds and attacking worms, insects, tadpoles, newts, and even small fishes.

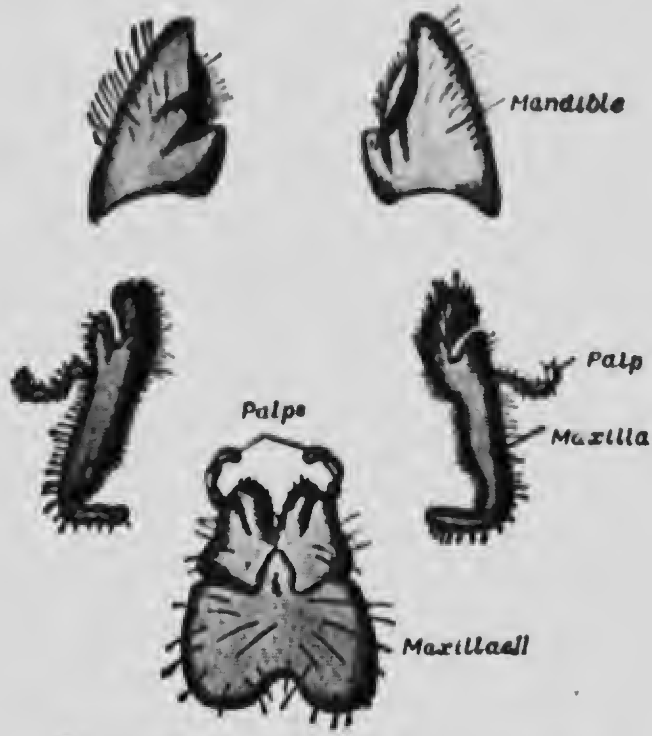

FIG. 33.—Mouth-parts of a Beetle (much enlarged)

(3) *June beetles* may be observed in May and June flying about in the evening; they are apt to fly clumsily into a lighted room and awkwardly strike against the walls. These creatures are brown and have a fan-like antennæ.

(4) *Lady-birds* are popular little beetles with black spots on a strongly-arched body. The show a remarkable

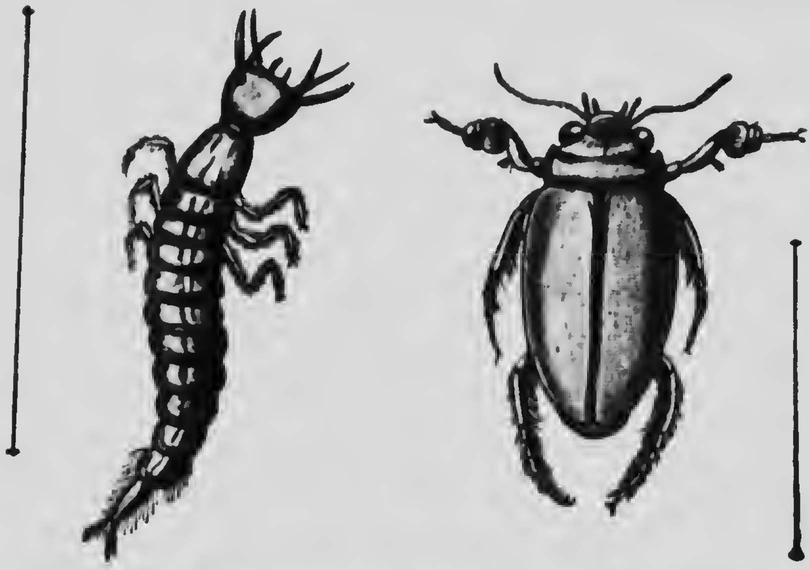

FIG 34.—Great Water-Beetle. Larva (on left). Adult male (on right)

FIG. 35.—Antenna of June Beetle (female) (× 12).

range of colour variation in the different kinds. These useful friends to farmers and horticulturists feed on plant-lice. One of the commonest species is the seven-spot lady-bird with seven black spots on the red wing-covers.

Spiders.—These animals have four pairs of legs and no neck, antennæ, or wings: hence they are not insects. The common garden-spider spins a wheel-shaped **web** between the smaller branches of trees, or in the crevices of walls. This familiar creature has the head and thorax fused into one region and separated from the bulging unsegmented abdomen by a narrow waist. There is a white, cross-shaped marking on the upper or dorsal side of the abdomen: otherwise the body is of a grayish or brownish colour.

FIG. 36.—**A** and **B** two Lady-birds June Beetle below

The jointed legs are long and well able to support the body: they bear bristles and two or three grasping claws at the end. In front of the legs are two **pedipalpi**: these are shorter than, but otherwise resemble in appearance, the first pair of walking legs. Anterior to the pedipalpi there is a pair of two-jointed **chelicerae**, which are used for seizing the prey. They consist of two jointed pieces of which the proximal portion represents the handle of a knife, and against this the distal portion, at the tip of which a **poison-gland** opens, can be received like the blade of a knife into the handle.

The mouth of a spider is very small; the animal feeds

FIG. 37.—Garden-spider and Web.

by sucking the juices of its prey. There are eight small eyes present on the head. Perhaps the spider's most interesting structures are its **spinnerets**: in the garden-spider these appear as four large and two small elevations at the hinder end of the body. At the summits of these little knobs are borne a great many minute openings, through which the silken threads used in making the web, etc., are spun out. House-spiders make webs—familiarly known as "cob-webs"—and at one end attach a horizontal, tubular den in which they hide.

The young spiders hatched from the eggs undergo no metamorphosis, the young resembling the adult except in size.

Adaptation to Environment.—Grasshoppers and beetles have many of the structures which flies possess, and which enable them to escape from enemies, *e.g.* wings and legs. The powerful mandibles, too, provide them with a means of defence and attack against any enemies which they are likely to encounter during their nocturnal wanderings. Spiders can move quickly by means of their long legs. The poison glands enable them to kill or wound seriously many other animals. Some spiders construct a den which has a protective value. The familiar custom of descending a rapidly-spun thread is often resorted to when other escape is impossible.

PRACTICAL WORK

Draw a living grasshopper (or one killed by immersion for a short time in methylated spirits) from above, below, and from the side, showing clearly the head with its antennæ and eyes, the three regions of the thorax with the jointed legs and the two pairs of wings. Also the segmented abdomen with the terminal segments in a male and in a female.

Remove a leg from a dead grasshopper and make an enlarged drawing with the aid of a lens.

Carefully remove from beneath the labrum the mouth-parts (viz. the two brown, toothed mandibles, the first maxillæ with palps and the fused second maxillæ or labium with palps).

Note the ten pairs of stigmata on the sides of the body. In a living grasshopper observe the alternate dilatation and contraction of these apertures.

Watch a grasshopper in the field: notice how it uses its jaws to bite off the blades of grass; how it uses its claws for hanging on to the blades; how it uses its legs for jumping.

Make a collection of the different kinds of grasshoppers to be found in the field.

About June collect some grasshoppers and endeavour to preserve specimens of different sizes and different wing development, and thus trace the stages of the partial metamorphosis.

Detach a fore-wing and a hind-wing. Observe and draw the arrangement of the nervures. The latter run in lines and do not form a network.

Examine and draw a lady-bird, a June beetle, and a water-beetle.

Examine the vegetable garden for lady-birds. See how many kinds can be found.

Keep a water-beetle in an aquarium and watch how it swims, breathes, and what food it eats.

Observe the web of a spider, the appearance of this carnivorous animal, and its jointed limbs. Note the main points of difference between an insect and a spider.

EXERCISES

1. Describe the mouth-parts of a grasshopper. Compare with those of a fly.

2. Give a short account of three kinds of beetles.

3. How does a grasshopper differ in structure from a June beetle?

4. Name three methods of locomotion of the grasshopper and describe the organs used in each case.

5. How is the lady-bird beneficial to man?

6. How is the grasshopper harmful to man? What means can be taken to keep it in check?

CHAPTER VI

BEES AND WASPS

Hive- or Honey-Bee.—Doubtless there are few people who have not seen a bee-hive—the home of that industrious insect the hive-bee, or, as it is more frequently called, the honey-bee (*Apis mellifica*). These little creatures are spoken of as **social insects**, since they live together in communities, each individual taking a share in the work of the commonwealth, or fulfilling its allotted function inside the hive with such orderliness and sagacity as is perhaps rarely equalled even in human societies.

Honey.—This display of industry among bees has one main object,—the storing of a winter food-supply of **honey**. This substance is not the nectar of flowers, but is formed by the admixture of nectar with the bee's saliva.

Hive.—The nest or hive may consist of varying material, including woolly fibres, pieces cut from leaves of plants, etc. Holes in trees, walls, or banks may be utilized as a hiding place for the hive. The crevices of a hive are stopped up with **propolis**—a resinous material which bees collect from the bark and buds of certain trees—especially the horse-chestnut. The hives in an apiary are, of course, artificial. A populous hive may contain a queen, several hundred drones, and from thirty thousand to fifty thousand workers.

Queen, Drones, and Workers.—In the hive of a honey-bee there are three kinds of individuals: the **queen,** a female, with a larger and more slender body than the others, and having short wings and a curved sting; the **drones** or males, possessing no sting, and being stouter though smaller than the queen; and the **workers,** which

FIG. 38.—(A) Queen, (B) Drone, and (C) Worker bee.

are present in great numbers, and are smaller than either the queen or the drones.

Honey-comb.—Inside the hive there is a structure—the **honey-comb**—formed by the bees from wax; this consists of little six-sided compartments or **cells,** of which there are two sizes: ordinary small cells used either for storing honey or for the development of workers, and somewhat larger cells in which the drones develop. At the edge of the comb a few large acorn-shaped **royal cells** are reserved as nurseries for future queens.

Queen.—The queen develops from a fertilized egg, hatching in three days as a limbless grub, which is carefully fed and tended by workers who prepare a food called **royal jelly**—the future queen's sole diet. The larva or grub is sealed in a "royal cell" when full-grown, and after spinning a cocoon which is open at the hind end, becomes a motionless pupa, emerging in fifteen days from the time the egg was laid as an **imago**—or insect in its perfect state,—by biting its way out of the cell into the hive. During the whole life of a queen bee—a period varying from three to five years—she is engaged in laying eggs, only leaving the hive if there is a migration to fresh quarters, or on the single occasion when impregnation with the fertilizing substance of a drone occurs. Thus a queen bee is exempt from the cares of providing food and of protecting the hive. Since, however, only one queen can exist peaceably in a hive, there is a commotion if another queen is developed, and a fight occurs, resulting either in the death of one queen, or in her removal by some loyal workers to a new hive. Should a queen come as an interloper the workers ignore her, and she is allowed to starve to death.

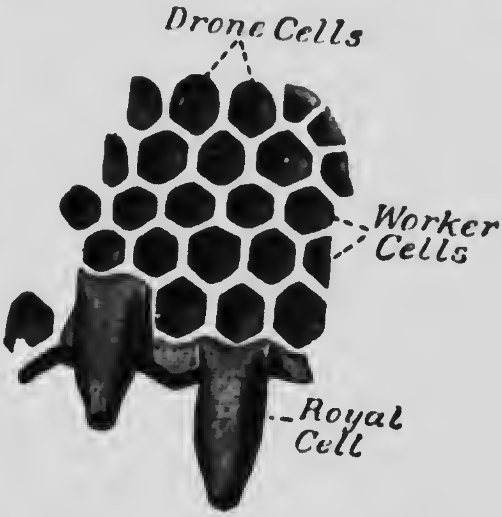

Fig. 39.—Piece of honey-comb.

Drones.—A queen may lay as many as 3000 eggs daily, which, if fertilized, become workers, unless the larvæ be fed entirely upon royal jelly, when the fortunate grubs develop into queens. Many eggs remain unfertilized and give rise to **drones** or males. These individuals have large eyes, and produce the substance with which a queen fertilizes her eggs. When the food of the hive is becoming scarce, viz, at the end of the summer, the workers economize by getting rid of the drones—since the latter are lazy and do no work. The hapless males are, in fact, ejected from the hive and left to die. An unfertilized egg develops into a drone in twenty-four days.

FIG. 40.—Hind-leg of Worker Bee

Workers. — As in other communities, the workers form the mainstay of the hive. These little creatures hatch from fertilized eggs, being fed for the first five days on royal jelly, and later upon a mixture of pollen, honey, and water. Adult workers seal up in cells the full-grown **larvæ**, the latter spin a cocoon and "pupate," *i.e.* become motionless pupæ, emerging after 21 days from the time of hatching as perfect insects, or **imagos**, by biting their way out into the hive. These individuals are really females which do not lay eggs, because they are sterile; they are specially adapted for collecting food and for constructing the hive.

The hind-leg of a worker bee has a broad first joint, the **pollen-basket**, not found in queens or drones: below this the second region carries a number of transverse rows of hairs which constitute the **pollen-brush**. Pollen is removed from a flower by the "brush" organ and then transferred to the "basket." The mouth-parts of a worker are most efficient, the proboscis being longer than in a queen or drone. Although so industrious, the workers appear to live only six or eight weeks, unless born at the end of a season, in which case they may survive through the winter.

In special cases workers may become fertile and lay eggs, producing drones.

Food.—The food of a bee "colony" consists of the pollen of flowers and the nectar which occurs in the spur of many flowers, such as the pansy. The honey, which is manufactured and stored up most carefully by the workers during the summer, is intended as a supply of food for the winter.

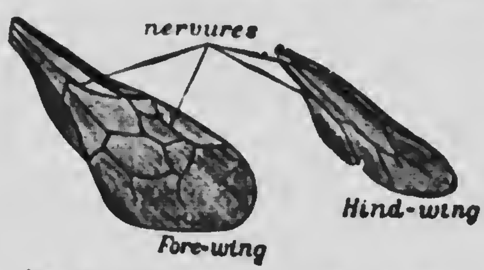

FIG 41 —Fore and Hind-wing of a Bee.

Sting.—This organ is situated near the hind end of the body, and is a pointed structure with little hooks, or **barbs**, at the end. In consequence of the presence of these barbs, the withdrawal of the sting from a wound is usually impossible. Hence a bee can sting only once, the loss of this defensive organ and consequent mutilation of the body often proving fatal to the insect.

Movement.—Like the fly, the bee has legs modified at the end for movement on different surfaces; but whereas a fly has two little pads—the **pulvilli**—on each foot, a bee has only one. Both pairs of wings are used in flight.

Since the hive- or honey-bee and the large humble-bee form communities, they are called "social" bees. Some species—*e.g.* the carpenter-bee—do not form these communities, but live in pairs, male and female, and are distinguished as "solitary" bees.

Wasps.—These insects are generally "social," and live together in a commonwealth, although some kinds prefer to live like hermits—the so-called "solitary wasps."

A community of social wasps comprises drones, queen, and workers, the latter differing but little from queens, and in some cases being able to lay eggs. The nest and comb are constructed not of wax, but of woody matter chewed up: this dwelling is located in a bank, wall, tree, and sometimes underground. The queen wasp feeds the grubs as they hatch out, first with honey and the juice of fruits, later on with the bodies of insects. Bees differ from wasps in having a strictly vegetarian diet. The wasp grubs grow, spin a cocoon and pupate. In about a month's time the pupæ become perfected as "imagos," and upon them devolves the task of completing the nest and nursing the next batch of young.

FIG. 42.—Nest of Wood Wasp (× ½).

The comb in a wasp's nest consists of many roughly six-sided chambers, or cells, arranged in tiers connected by pillars. In the late summer larger cells are formed for the future queens, and often for the drones. Such a community thus constituted breaks up after existing for one season, most of the workers and drones dying, since wasps suffer severely in cold weather, though some, at least, of the queens survive the winter, and found new "colonies" in the following spring.

Wasps resemble bees in bodily structure, having two pairs of rather narrow wings (each with a network of nervures), three pairs of legs on the thorax, sharply marked off from which is the elongated abdomen with alternating yellow and black bands. Hence the colouration of a wasp is more noticeable than that of a honey-bee.

The head bears long antennæ, while the mouth-parts resemble those of a bee.

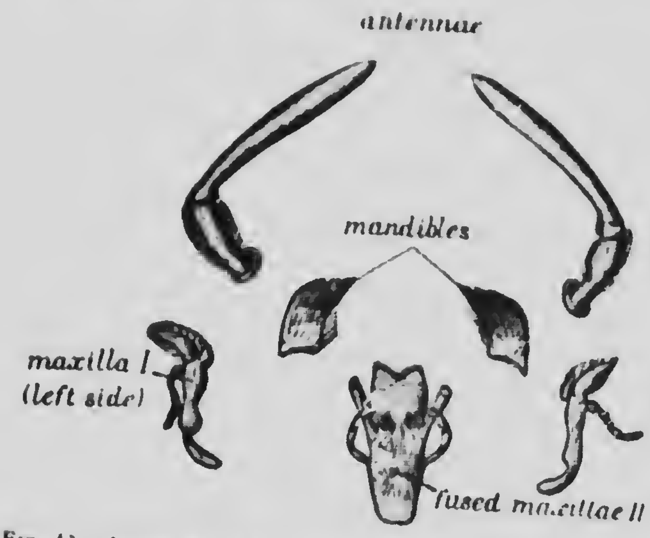

FIG. 43.—Antennæ and Mouth parts of Wasp (much enlarged)

Wasps live on nectar, insects, and sometimes on the honey stolen from bees; they are also fond of the flesh of sweet fruits, *e.g.* the pear. The sting has no barbs at its end, and so the insect, unlike the bee, is able to withdraw its sting from a wound without fatal results to itself.

The most common kind of social wasp is *Vespa maculata*, whose comb containing grubs is used as bait by anglers, and called **wasp-cake.**

The smaller yellow-jackets (*Vespa germanica*) build their nests above ground, in or beneath stumps or stones. The yellow-jacket can inflict a severe wound with its sting.

Adaptation to Environment.—From the foregoing account it will be understood how bees and wasps—whether workers, drones, or queens—are fitted for the life they lead. The mouth-parts, etc., of workers are modified for gathering food, the legs and wings for movement, and the sting for defence. We shall refer later to the colouration.

PRACTICAL WORK

Inspect a bee-hive in summer time—worker bees are continually leaving and returning to the hive; their duty is to gather food and honey for the community. In winter activity ceases, and those bees which have not succumbed to the cold weather remain inside the hive until the spring.

Look out for "swarming" on a fine, sunny summer morning when a queen and a number of loyal subjects leave a hive to found a new "colony."

Buy some honey in the comb,—taste the sweet, sticky, yellowish fluid. A thin coat of wax closes the open end of each cell. Allow the honey to drain from a comb, and, when the latter is dry, draw some of the cells. Note the regularity in shape; also the larger royal cells if present.

Examine a worker bee. Draw, naming the structures observed.

A bee may be killed by immersion in methylated spirits —probably the sting, at the hind end of the body, will be everted.

Notice the eyes, and the antennæ with 13 joints.

Make drawings of a hind-leg (with pollen basket and brush); the mouth-parts (separate these with two needles); a wing (noting the nervures).

Observe the flight of a bee among flowers; notice the direction of its path; the humming sound and the cause of it; what flowers it enters and how it uses its claws for hanging on, and its mouth for extracting the nectar. Does it prefer any particular colour? Does it ignore flowers of any particular shade?

Make a collection of as many kinds of "bumble" bees as visit the flower garden.

Similarly examine a wasp. In your drawing show how a wasp differs from a bee in shape, colouration, etc.

Look out during your country walks for nests of the wood wasp (built in trees), and for the nest of *Vespa germanica* in stumps and under stones. Drenching with water will incapacitate the wasps, when some of the wasp-cake may be examined and permanently preserved in spirits.

Draw stages showing [illegible] metamorphosis.

EXERCISES

1 Give an account of any "social" insect.

2. How would you distinguish a bee from a beetle?

3. What do you understand by propolis, cell (of honey-comb), royal jelly, pollen-basket, worker bee?

4. In what ways are bees helpful to the flowers they visit?

5. Name some of the enemies of bees in your neighbourhood.

CHAPTER VII

BUTTERFLIES AND MOTHS

Butterflies.—We have all seen these familiar insects flitting from flower to flower in the summer time. Some are beautifully coloured, although they are neither so large nor so gorgeous in our dull climate as those of tropical countries. Minute scales, of different shapes and colours, cover the wings as a fine dust, which is readily rubbed off by the finger: the colouration of butterflies is due to the presence of these scales.

As an example of this group of insects we will consider the "large white" or well-known "cabbage white" butterfly of our vegetable gardens.

Cabbage White Butterfly.—The dark hairy body is divided into **head, thorax,** and **abdomen.** The head bears two large eyes, a pair of long, thin antennæ with club-like ends, and mouth-parts taking the form of a long proboscis used as a sucking tube. When not in use, the proboscis is coiled up like a watch-spring.

Three pairs of long, weak **legs,** as well as two pairs of large, broad, nearly white **wings,** are borne on the thorax. The male has dark markings at the anterior edge and tip of each fore-wing, whereas the more beautiful female has in addition three black spots on the dorsal side of each anterior wing. (Fig. 44.) The abdomen, bearing no appendages, is enveloped by the basal parts of each hind-wing.

1. Milbert's Tortoise Shell (*Vanessa Milberti*).
2. An Argynnis Butterfly.
3. The Question Sign (*Grapta interragationis*), larva and chrysalis.
4. The Mourning Cloak (*Vanessa antiopa*), larva and chrysalis.
5. The Pearl Crescent (*Phyciodes tharos*).
6. Silver-bordered Fritillary (*Brenthis myrina*).

Life-history of Cabbage White.—The bright-yellow eggs are laid in clusters conveniently near the future food of the larvæ, viz. on the back of cabbage, turnip, or cauli-

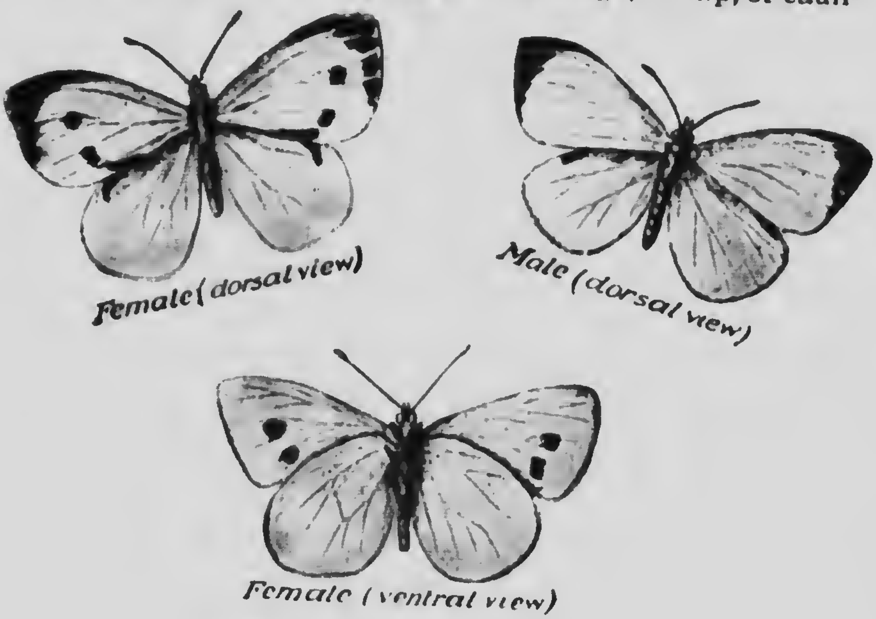

FIG. 44.—Cabbage White Butterfly. (× [illegible])

FIG. 45.—Caterpillar and Chrysalis

flower leaves. Several batches of eggs may be laid during the summer. When hatched, the larvæ, or **caterpillars**, have a greenish back with yellowish under-surface, small black dots on the body, a yellow streak along the dorsal surface, and large black spots on the sides. The social caterpillars may frequently be found in numbers, feeding voraciously. When full-grown they hang by the tail to some firm object with which their colour harmonizes, and spin a silken girdle round the freely-hanging anterior end. The outer skin is now dispensed with, and after another has been acquired, the quiescent **chrysalis** condition is reached.

From the angular chrysalis (Fig. 45) finally emerges the **imago**, or perfect insect, unless the time of year happens to be late autumn, in which case the chrysalis persists through the winter, and the imago emerges in the spring following.

Habits of Butterflies.—It is unusual to find butterflies active in cold weather. They are generally in evidence only during the daytime in sunny weather. One striking characteristic of most butterflies is the attitude assumed when resting on a flower or other object; at such times the upper surface of each wing, often brightly coloured, becomes closely opposed to the other—*i.e.* the wings are placed back to back,—and only the under surface of each wing is visible.

Caterpillars.—These larvæ may be naked or hairy. They are provided with a pair of small eyes, one pair of short antennæ, jaws for biting, and a trunk consisting of eleven segments, of which the first three bear two, jointed legs each—the walking legs of the future butterfly: moreover, from one to five of the other trunk segments may bear stumpy unjointed **pro-legs**, or "cushion-feet," ending in little suckers. The pro-legs are useful in the larval stage only, and are not represented in the adult butterfly; the mandibles or biting jaws are also lost, and a proboscis is developed for sucking up the nectar of flowers, and for feeding occasionally on other substances.

Chrysalis.—The pupa stage of a butterfly—the chrysalis—is confined in a closely-investing, horny covering, under which the appendages of the body—the future wings and legs—are glued together. In all butterflies the chrysalis has an angular outline. Some butterflies and moths, *e.g.* the silk-worm moth, spin a silken **cocoon** which shelters them so long as they remain inactive pupæ.

Kinds of Butterflies.—Butterflies may be conveniently divided into five families:

(1) *Fritillaries and browns*—having the first pair of legs so small as to be useless for walking, *e.g.* tortoiseshells, red admiral, monarch, painted lady, viceroy, great spangled fritillary, and checkerspot.

(2) *Blues, coppers, and hairstreaks*—*e.g.* spring azure, American copper, banded hairstreak.

(3) *Whites, yellows, brimstones, and orange tips*—having a conspicuous colour, with the abdomen partly covered by the basal parts of the hind-wings—*e.g.* cabbage white, clouded yellow, orange tip, brimstone.

(4) *Swallow-tails*—including many tropical forms of great splendour; hind-wings produced into a "tail": several species are found both in Canada and in the United States.

(5) *Skippers*—with thick bodies, antennæ slightly hooked at the tip; usually with dingy colour and fitful movement, *e.g.* northern cloudywing.

Moths.—Like butterflies, moths are scaly-winged insects, but the majority perhaps may be spoken of as **nocturnal**, *i.e.* they are most active at night. Moreover, whereas nearly all butterflies are harmless, the larvæ of many moths are very destructive pests. It is not difficult to distinguish a moth from a butterfly, since the antennæ are pointed and without knob-like endings (cf. Butterflies); on alighting, too, moths generally keep the wings expanded. The thorax is not clearly marked off from the abdomen, the whole body being shorter and thicker than a butterfly's. The caterpillars are naked or hairy, usually with less than five pro-legs; the pupæ are generally covered by a cocoon, which is frequently concealed underground.

The chrysalis has a rounded, not an angular, outline.

At least five thousand kinds of moths are found in Canada and the United States. The better known kinds are:

Large moths—e.g. sphinx, silk-moths, polyphemus, and underwing.

Small moths—e.g. clothes moth and the owlet moths, of which there are many species.

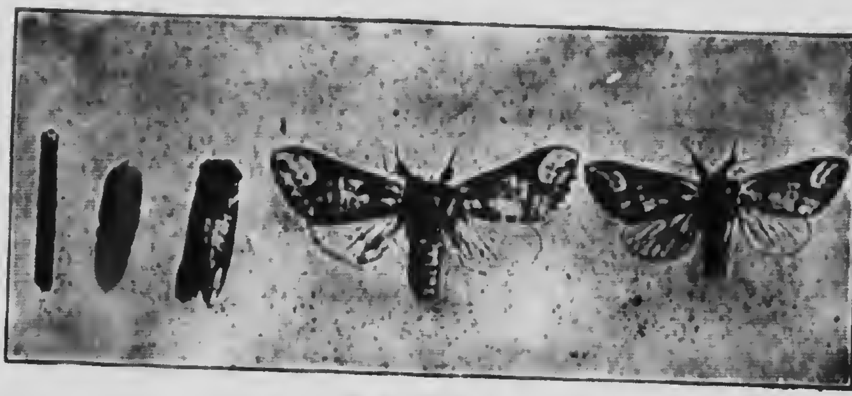

FIG. 46.—Life history of Buff Tip Moth

Protective Devices of Animals.—We may now take a brief survey of the animals already dealt with, in order to perceive how varied are Nature's methods of protecting animals. An earthworm's safety is its burrow; even when feeding on fallen leaves or twigs above ground the hind end of the body is usually retained in the mouth of a burrow, so that the whole animal can be quickly withdrawn at the approach of an enemy. Since the worm moves in its burrows with surprising rapidity it has a fair chance of escape from slugs (which follow it underground), moles, and other burrowing animals. As the snail is able to withdraw into its shell, its means of

PROTECTIVE COLOURATION. 1. Hornet. 2. Hornet Clear-wing Moth. 3. Lappet Moth resting on faded beech leaves. 4. Caterpillar on twigs. ($\frac{2}{3}$ nat. size.)

defence is of a passive nature—a fortuitous device for such a slow-moving creature. Flies have wings, and their keen eyesight enables them to escape from most enemies with consummate ease. The shape and colour of some insects perhaps afford us the most wonderful examples of protective devices among animals, and these means of self-preservation will be described under the headings of Protective Resemblance, Mimicry, and Warning Colouration.

Protective Resemblance.—Many caterpillars, beetles, butterflies, etc., are coloured, marked, and shaped in such a manner that they are most difficult to detect amidst their customary surroundings. The more we learn about colouration of animals, the more we are convinced that this rule is general. We need, however, to ascertain carefully the characteristic environment in each case, otherwise difficulties present themselves. We must, for example, compare the colouring of a tiger with the blades of yellow, jungle grass, upon which the sun is shining, the plumage of a bird of paradise with the upper foliage in a tropical forest, and so forth. The opposite page-plate shows how a stick caterpillar and a lappet moth harmonize with their respective environments, and so only their most persistent or practised enemies would detect them while at rest. When most butterflies alight upon a flower the wings are apposed and their dorsal surfaces are thus contiguous, so that only the dull-coloured under surfaces of the wings are visible. Hence the gaily-painted wings are hidden, and the under surfaces—being harmoniously coloured to match the surroundings—form a protective colouration. Since moths come to rest with the wings expanded, in their case the upper surfaces of the wings exhibit the protective colouring.

Warning Colouration.—Wasps and hornets have brightly spangled bodies, and possess the sting as a means of defence. The easily recognized and vivid colour may serve a double purpose—both as a warning to other animals not to risk being stung, and also as a means of terrifying foes. Hence, only their inveterate enemies, fully acquainted with their methods, will venture to attack. Since all animals have natural enemies, it would be erroneous to suppose that the colouration invariably results in an animal being saved, though it undoubtedly tends to prolong its life and increase its chances of avoiding enemies.

Mimicry.—Children quickly learn to avoid a wasp or hornet, but are not intimidated by a defenceless butterfly or moth. The sting and buzzing noise of the former inspire fear. A moth closely resembling in colouration the dangerous hornet will often be mistaken for the latter, and so will escape attack. Thus the clear-wing moth simulates or mimics the hornet, and by so doing increases its chances of preservation. The phenomenon is known as **mimicry.**

PRACTICAL WORK

Notice in a cabbage white butterfly the head, thorax, abdomen, proboscis, knobbed antennæ, eyes, two pairs of wings with scales easily rubbed off, colouration (especially the differences between the markings of male and female), and the six weak legs on the thorax. The cabbage white is a member of the group of butterflies known as "whites,"—for it has the first pair of legs shorter than the others, and the basal parts of each hind-wing partly envelop the abdomen.

Draw a male and a female specimen.

Collect some caterpillars of the cabbage white—they are usually to be found creeping on cabbage or cauliflower leaves. Make out the colouration, jaws, eyes, antennæ, and the trunk with eleven segments; also the position and number of the walking legs and pro-legs. Keep some of these caterpillars, feeding them from time to time with fresh cabbage leaf, and watch them feed, grow, and metamorphose into pupæ, later becoming imagos.

Examine the chrysalis of a butterfly; make a drawing and name the parts. Visit this quiescent animal each day until the imago appears. Keep data of your observations as to the time of year and locality of the butterflies you collect.

Observe a butterfly's attitude in repose upon a plant.

Collect a pair (male and female) of the common butterflies and moths in your locality. Try to classify and name them.

Moths must be sought for during the daytime on the bark of trees, in crevices, holes, and dark places. They become active after dusk. A powerful light has a strange attraction for butterflies and moths, intimidating them to self-destruction. Moths differ from butterflies in their antennæ, which are often feathery and without knobbed ends. Moths also have more stumpy bodies.

Distinguish and draw the chrysalis of a moth.

Place an underwing on the rough bark of an ash tree and note the harmony of colouration.

Similarly examine a sulphur yellow lit on a sandy road, a skipper on grass or leaves and note the protective colouration. Note other cases of this phenomenon. Collect specimens of the monarch and viceroy, a wasp and a clear-wing moth, a honey-bee and a bee-fly, and note the mimicry.

EXERCISES

1. Give the life-history of the cabbage white butterfly.
2. Write an essay upon the protective colouration devices of animals.
3. How would you distinguish a moth from a butterfly?
4. Name four moths in your district which are harmful to the farmer. Describe how they can be combatted.

MICROCOPY RESOLUTION TEST CHART

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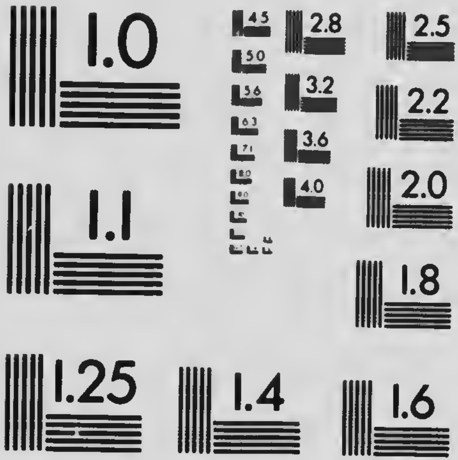

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CHAPTER VIII.

ANIMALS, THEIR CLASSIFICATION AND NOMENCLATURE

Animate and Inanimate Objects.—The popular notion that a cat or horse is an "animal," whereas a fly or fish is not, is erroneous; it is important to gain a clear conception of what is meant by an animal. Earthworms, snails, horses, flowers, trees, mushrooms, etc., have component parts known as "organs," by which they are enabled to feed, breathe, grow, and reproduce new structures like themselves. Hence we speak of all such things as being organic, or as "organisms," and since they have the above mentioned powers they are known as "living" or animate objects. In the domain of Nature there are stalactites, icicles, crystals, etc., which "grow" without being animate or possessing life. Yet the nature of the growth in organisms is quite different from the increase in size of an inorganic object. In the latter case there are no organs, and growth means an addition of material to the surface of the inanimate object: when organisms grow, material is added to the individual parts or organs of the body.

Biology.—The comprehensive study of Biology involves an enquiry into the structure, history, habits, occurrence, reproduction, and development of all living objects, *i.e.* the study of organisms.

Plants and Animals.—There is a wide difference between two objects such as a horse and a cherry tree. Both are organisms endowed with life, for they are each capable of growth, respiration, feeding, and reproducing new individuals. The horse, however, can move from place to place in search of food, whereas the tree is fixed in the ground in a spot which it cannot leave. This fact is reflected both in the manner of feeding and in the nature of the food. A horse has a mouth, by which solid food—such as grass and oats—may be taken into the body. A tree has no mouth, and can feed only on liquid food which passes in by the roots, and on gaseous food absorbed through the leaves.

Hence we distinguish animals—*i.e.* organisms which as a rule can both move and take in solid food—from plants, —*i.e.* organisms which possess no mouth, and therefore are unable to take in solid material as food; moreover, plants have not usually the power of movement.

Zoology and Botany.—The subject of Biology is conveniently sub-divided into Zoology—the study of animals; and Botany—the study of plants. Owing to the structure and habits of some very simply constructed organisms, it is uncertain whether we should range them with animals or with plants.

Classification.—We have devoted some attention in the preceding chapters to the examination of an earthworm, a garden snail, and a house-fly. The object of taking these "types" will be apparent when it is understood that a great many animals are, as it were, "related" to such types. This similarity of groups of animals to one another is most interesting, and leads us to the subject of the "classification" of animals. In the first place there is no vertebral column (popularly termed "backbone") in any of the animals already studied. All such animals are called invertebrate, and belong to the collection of animals known as **Invertebrata.**

The animals to be considered in the succeeding chapters possess a vertebral column, and belong to the **Vertebrata.** Whereas Vertebrates are so closely related that they can be included in one large sub-division or **phylum,** the Invertebrates differ among themselves so widely, that it is necessary to sub-divide them into several groups or **phyla.**

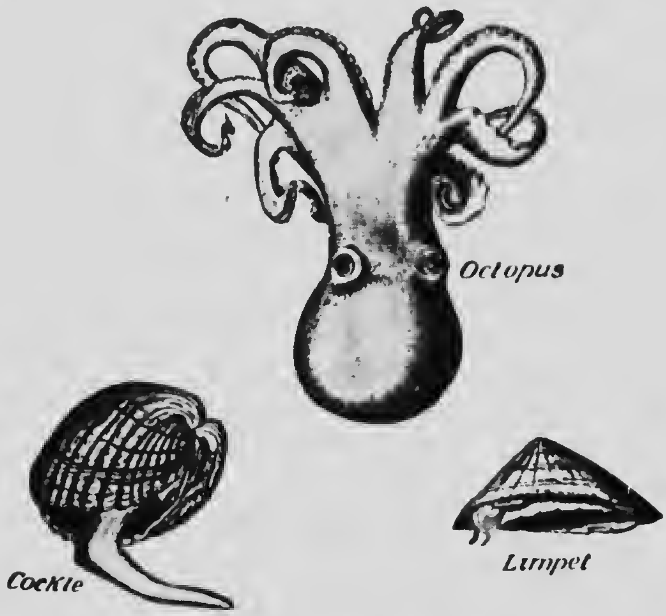


FIG. 47.—Examples of Mollusca.

Thus the earthworm is a member of the phylum **Annulata.** The animals in this group have the body divided into rings or "annuli." The elongated muscular bodies are not protected by a shell or other hard covering; the mouth is placed at the front end and the vent at the hind or posterior end of the body. Many other "worms" live in the sea and have appendages for swimming as well as setæ. Leeches, too, are among the Annulata.

The garden snail more nearly resembles a slug or an oyster than an earthworm does, because a snail possesses a large, muscular foot for locomotion; moreover, it possesses a shell. This shell is hidden in the body in the case of many kinds of slugs. Snails, slugs, and oysters belong to the phylum **Mollusca**—animals possessing a foot for movement, no legs or wings, and usually protected by a shell which may consist of one piece (snail) or two (oyster). Many Molluscs live in the sea and breathe by means of gills—*e.g.* oysters, cockles, mussels, cuttlefishes, squids, and octopuses. They are always covered by a mantle.

The phylum to which the house-fly belong—the **Arthropoda**—includes a vast number of animals. The name "Arthropoda" means "jointed limbs"—a feature of all the animals in the group. They agree with Annulates in having segmented bodies. The **Arthropoda** includes flies, bees, wasps, beetles, crayfishes, woodlice, crabs, spiders, ticks, mites, and many other animals. These numerous forms, which are readily distinguishable, can obviously be sub-divided; hence we find the Arthropoda consisting of smaller or sub-groups calles **classes.** Thus spiders, harvestmen, ticks, mites, and scorpions have four pairs of legs and no wings. They compose the class **Arachnida.** The class **Crustacea** includes crabs, crayfishes, prawns, lobsters, shrimps, and all animals with more than four pairs of legs, with a hard covering, or **carapace,** protecting the body, etc. The class **Myriapoda** includes millipedes and centipedes—all with numerous jointed legs. Centipedes have one pair of legs on each segment of the body, whereas millipedes have two pairs. Lastly, the class **Insecta** or insects includes all invertebrate, jointed-limbed animals with only three pairs of legs and usually two pairs of wings. Beetles, wasps, bugs, flies, bees, dragonflies, grasshoppers, butterflies are insects.

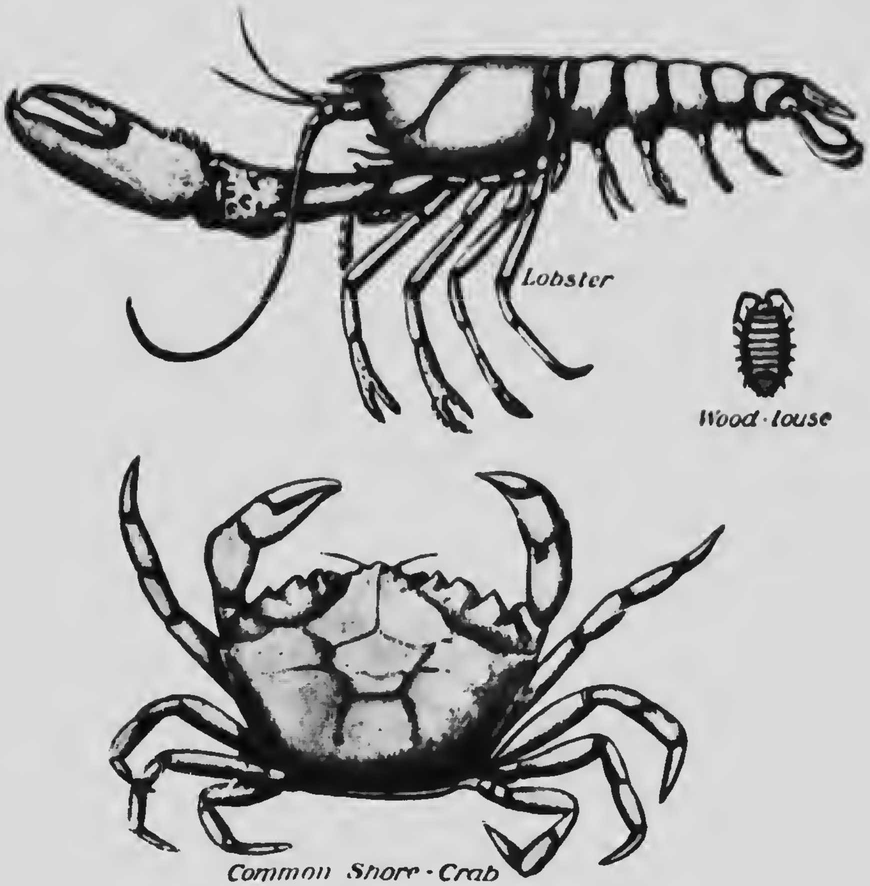


Fig. 48.—Examples of Crustacea.

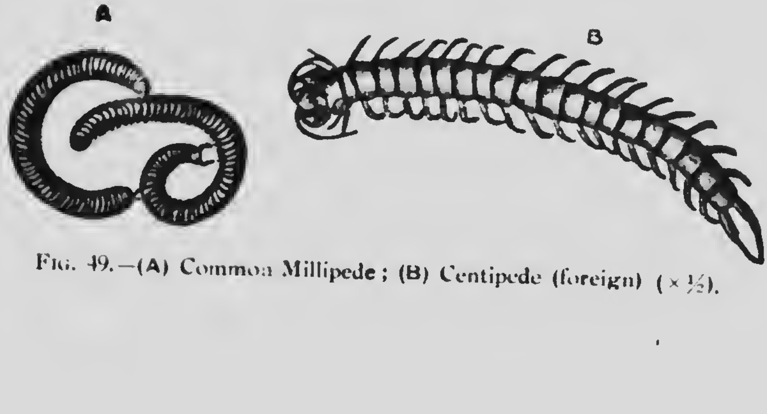


Fig. 49.—(A) Common Millipede; (B) Centipede (foreign) (× ½).

The classes in turn consist of still smaller groups or **orders**. Taking the insects as an example, we have the order *Coleoptera* ("sheathed wings"), including beetles; mosquitoes and flies are included in the order *Diptera* ("two wings"), bees, wasps, and hornets belong to the orders *Hymenoptera* ("membranous wings"); crickets and grasshoppers to the order *Orthoptera* ("straight wings"); while moths and butterflies compose the order *Lepidoptera*, which includes the "fritillary" family, the "scaly wings".

In sub-dividing orders we come to the **families.** The family of "blues," and so on.

In the chapter on butterflies and moths we found the "tortoiseshell" included in the fritillary family. Such a collection of animals forming part of a family is spoken of as a **genus.** The question-sign butterfly is also a fritillary, but since it differs from the tortoiseshells in some structural features in which all tortoiseshell butterflies resemble one another, it is put in a different genus. Animals included in the same genus receive a name (usually Latin) called the **generic** name, and also a second or **specific** name, indicating to what particular **species** or "kind" they belong. A species is, therefore, a collection of similar animals which reproduce new animals of their own kind.

The individuals of a species, while they are similar are not exactly alike, in fact if any two individuals are compared many small points of difference can be detected. These differences are called variations. Sometimes the same variations occur in many individuals and are reproduced in the offspring. Under such conditions the individuals possessing these characters are called a variety of the species. The terms race, breed, and strain are frequently used as almost similar to variety, though the last two terms are more frequently applied to the common domestic animals.

Thus, in the genus of "tortoiseshell butterflies" we find the red admiral, *Vanessa atlanta*; the Compton's tortoiseshell, *Vanessa j-album*; Milbert's tortoiseshell, *Vanessa milberti*; the mourning-cloak, *Vanessa antiopa*, and the painted lady, *Vanessa cardui*.

Hence, in classifying a red admiral, we should write:

Phylum—Arthropoda.
↘ **Class—Insecta.**
↘ **Order—Lepidoptera.**
↘ **Family—Fritillidæ.**
↘ **Genus—Vanessa.**
↘ **Species—atlanta.**

In this way naturalists of all nations have the same zoological name for any particular species of animal, and much unnecessary confusion is avoided.

Thus animals are classified by taking into consideration their **anatomy** or body-structure.

Arguing in the reverse direction, we shall expect Arthropods—*e.g.* a fly and a spider—to resemble each other more closely than they resemble either a worm or snail; on the other hand, a fly, being an insect, will resemble a bee more closely than a spider does.

EXERCISES

1. Distinguish between a plant and an animal, and between animate and inanimate objects. Give examples.
2. How are animals classified and named? In what "order" would you place a fly, grasshopper, moth, mosquito, lady-bird, June beetle, hornet? Give reasons.
3. Write out in full the classification of the painted lady (*Vanessa cardui*).

1. The Clouded Sulphur (*Colias philodice*), larva and chrysalis.
2. Hunter's Butterfly (*Pyrameis huntera*), larva and chrysalis.
3. The American Copper (*Chrysophanus hypophlaeas*).
4. The Canadian Skipper (*Erynnis Manitoba*).
5. The Painted Lady (*Pyrameis cardui*), larva and chrysalis.
6. The Red Admiral (*P. atalanta*), larva and chrysalis.

CHAPTER IX

THE BROOK TROUT

We will take as an example of fishes the familiar brook trout (*Salvelinus fontinalis*) of our rivers and brooks.

Appearance.—The skin on the back is more or less mottled or barred with dark olive or black, but is without spots. On the side it has large, bright-red spots, the lower fins are dusky and the belly of the male is often reddish. If the sides be examined carefully they are seen to be

Fig. 50.—Brook Trout (× ⅓).

covered with minute scales. These scales are usually much larger in other species of fish and grow by concentric additions consisting of calcium carbonate. The head is devoid of scales, although bones protecting the brain may be felt beneath the skin.

The body tapers bluntly towards the **snout**, and more gradually towards the **tail** posteriorly: it may be described as torpedo-shaped, widest from side to side about midway between the dorsal and ventral regions, and rather thicker above than below. This shape is best adapted for movement in water, the body offering little resistance to progress. Engineers and shipbuilders have copied the fish's shape in constructing vessels and torpedoes for cutting through the water.

The cresentic **gill-openings** may be regarded as defining the **head** in front from the **trunk** region behind, since a neck is absent. On the ventral side, at the hinder end of the trunk, the **vent** is situated, the **tail** comprising all the body behind this opening. A streak—the **lateral line**—found only in fishes and in some other aquatic animals like the tadpole—runs along each side of the body from head to tail.

Movement.—The tail of a trout is undoubtedly its most important locomotive organ. Around the posterior end of the tail a fringe of bony rods—**fin-rays**—strengthens the **caudal fin.** This flexible, vertical structure can be moved from side to side in such a way that the fish is forced forwards.

A similarly acting, but much less efficient, mechanism is the propeller of a screw steamer—an example of our imperfections in mechanics as compared with the devices of Nature. Boatmen imitate the movement of a fish's tail when propelling a boat by means of a stern oar.

Fins.—A trout has no need of legs, since it does not move on land, but there are two pairs of limbs present, and these correspond to the legs of a frog or horse, although they subserve a different function and have a different structure. We speak of the limbs of a fish as its **paired fins.** The anterior pair—corresponding to our own arms—projects from each side of the body in the breast or

pectoral region. Hence they are styled **pectoral fins.** A number of fin-rays—fourteen—support a membrane which is broader at the distal than at the proximal end. Two **pelvic fins**—corresponding to our legs—are inserted about mid-way along the body in the ventral region of the trunk. The pelvic fins are smaller than the pectorals, and only ten fin-rays are present in each.

Both anterior and posterior paired fins project like shelves from the body and thus help to balance the trout. The broader, upper portion of the body is heavier than the lower part, and a dead trout floats with its ventral side uppermost. The natural position is maintained by the balancing movement of the pectoral and pelvic fins. Other fins are present, called **unpaired fins.** These are vertical in position and lie along the middle line of both dorsal and ventral surfaces.

A trout has two **dorsal fins,** of which the front or anterior dorsal is situated about half-way along the back, ten fin-rays supporting its triangular membrane. A much smaller posterior dorsal fin lies on the back nearer the caudal fin. This second dorsal fin contains no fin-rays. Immediately beneath it on the under side of the body an **anal fin,** with nine supporting fin-rays projects vertically downwards. Both the dorsal and anal unpaired fins act like keels and steady a fish during its progress through the water.

Eyes, Nose, and Ears.—The large eyes are not protected by eyelids, but are covered by a transparent skin; hence a trout is unable to close its eyes and go to sleep; moreover, it usually seeks a shady nook in order to avoid strong sunlight, coming out to feed when the sun's rays are not so powerful. A strong continuous light would seriously injure the fish's eye, because there are no eyelids which may be closed periodically in order to rest the eye. Careful observation of a living trout or gold-fish will disclose the fact that the eyeball can be moved a little and thus enable the fish to see in front as well as sideways.

The two **nostrils** are double structures which lead into cup-like **nasal sacs**; the latter do not communicate with the **mouth cavity.** A fish uses its nasal sacs for testing the purity of the water, but not for respiration. Although **ears** are present within the head, there is no part of these organs visible on the sides of the head. The trout is none the less kept informed of sounds—water transmitting vibrations more effectively than air.

Mouth, Teeth.—The **mouth** is terminal, passing round the snout as a wide slit. No fleshy lips are present, but the bones bordering the upper jaw are movable and bear small **teeth** in a simple row; the lower jaw is similarly toothed. Running parallel with those of the upper jaw a set of teeth is present in the roof of the mouth cavity—the **palatine** teeth—whilst yet another group—the **vomerine**—is found in the dorsal middle line between the palatines. The **tongue** also bears teeth.

Breathing.—The head is continued on the sides into two flaps which conceal the **gills.** Each stiff flap or **operculum** is fringed by a flexible margin—the **branchiostegal membrane.** The crescentic slit-like **gill-opening** on either side leads into a **gill-chamber** containing four pink, comb-like structures,—the gills,—borne on bony, semi-circular **gill-arches** separated from one another by **gi .-slits** which put mouth-cavity and gill-chamber into communication. Fig. 51 gives the appearance of a gill-arch and its gill cut across. Each respiratory organ or gill is a double structure composed of a number of triangular **filaments,** pink in colour, on account of the numerous blood-vessels immediately beneath their surface.

A thin membrane covering each gill separates the blood from the surrounding water. By a process of osmosis, oxygen dissolved in the water passes through the membrane into the blood, and replaces carbon dioxide which passes out from the blood. Hence the process of breathing in a fish is effected by keeping the gills continually bathed in water containing oxygen. During **inspiration** the mouth is opened, the branchiostegal membranes close the gill-openings, the operculum on each side moves outwards, and so water rushes into the enlarged mouth-cavity. During **expiration** the mouth is closed, each operculum moves inwards, and, as the throat is also closed, the

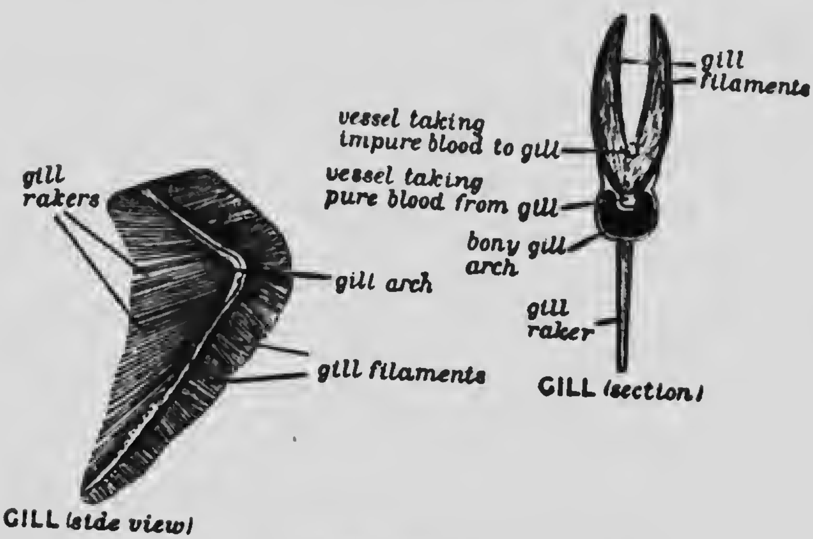


Fig. 51.—Side view and section of a Trout's gill.

water passes out by the gill-openings. If we were to put a trout into water which has been boiled (so as to get rid of the dissolved oxygen) the poor animal would be unable to breathe, and would quickly die; in other words, a fish continually requires oxygenated water, otherwise suffocation ensues. When fishes are seen to respire very quickly, it is a sign that they require fresh water; those who keep goldfish in little aquaria should be most careful either to have green plants living in the water or else to change the water regularly and often. In breathing normally a trout opens and shuts its mouth many times a minute.

Feeding.—The trout feeds upon worms and insects. It has no lips, but the food is seized by means of the palatine, vomerine teeth, and those on the jaws. A white non-muscular **tongue** is present at the back of the mouth-cavity, and, as above mentioned, this also bears teeth in a double row; the tongue, however, moves only with the throat, not independently. From the sides of each gill-arch project little rods known as **gill-rakers**; these act as strainers—allowing water to pass out by the gill-slits, whereas food passes on down the throat.

Internal Structure.—The "flesh" of a fish—consisting almost entirely of muscles—is not difficult to remove, and since a herring or trout can easily be obtained at a fish store, a good opportunity is provided for learning something about the internal structure. Beneath the skin the white muscles are arranged in **segments** (as in the earthworm), presenting, however, a zig-zag appearance. Among the muscles are small inter-muscular bones—particularly noticeable in a herring. When all the muscles of one side have been removed, the **back-bone** or vertebral column—consisting of a number of bony pieces or vertebræ arranged in a continuous series—is visible. In some kinds of fishes the vertebræ consist of "gristle," or cartilage, instead of bone.

FIG. 52.—Gill-arches, etc., of Herring, as seen on opening wide the mouth.

Beneath the vertebral column a large space—the body-

cavity—contains the **viscera.** Of these organs one can readily recognize the partly coiled tubular **alimentary canal** extending from the mouth to the vent. The wider anterior portion is the **stomach**, on each side of which is the reddish-brown **liver**, with a green **gall-bladder** closely associated. Following on the stomach is the **intestine**—much narrower and bent upon itself—from which pass off a number of tubular outgrowths clustered together. Probably in these outgrowths, as well as in the stomach and liver, fluids are manufactured; the substance produced in the liver—called

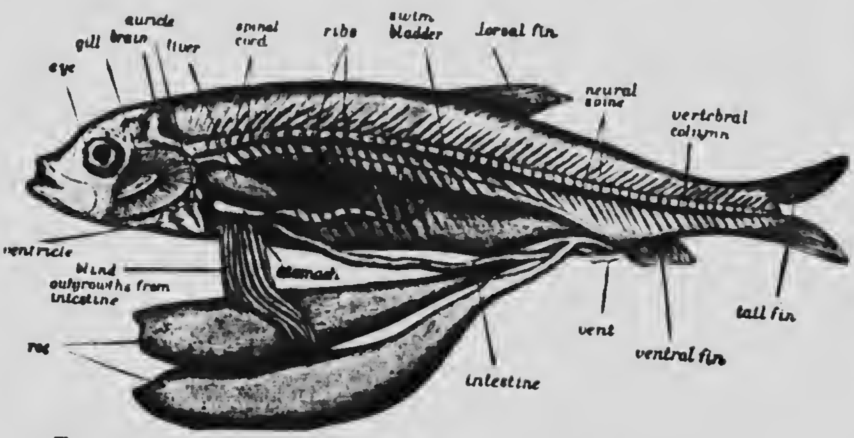


FIG. 53.—Herring dissected so as to show internal structure. ($\times \frac{1}{3}$).

bile—is stored up in the gall-bladder. When poured into the alimentary canal the fluids dissolve, or **digest**, the food.

Another prominent organ in the body-cavity is the **reproductive organ**, consisting either of two spermaries—the "soft roe"—of a male fish, or of two ovaries—the "hard roe"—of a female, containing a great many little eggs.

Still nearer the back-bone, and having a rather thick, black wall, there is a long sac-like structure containing a mixture of gases; this—the so-called **swim-bladder**—increases the buoyancy of a fish, exactly in the same way as a person, although unable to swim, would be kept from sinking if some inflated bladders were tied beneath his arms.

Between the vertebral column and the swim-bladder the kidney is situated. This organ, well supplied with blood and reddish in colour, extracts certain waste matter from the blood.

Enclosed in a special cavity beneath the throat lies the heart, in which one may easily recognize a single dark-red dorsal chamber—the **auricle**—receiving impure blood from the body and passing it into a ventral muscular, pinkish, conical chamber—the **ventricle**. From the latter impure blood is driven forwards along a blood-vessel to the gills.

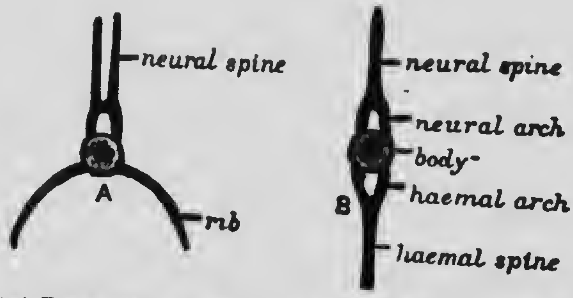


FIG. 54.—(A) Precaudal, and (B) Caudal, vertebra of Trout, as seen from in front.

By carefully removing the bones of the head the **brain** may be exposed; with it is continuous a long, whitish **spinal cord** traversing the vertebral column.

If the backbone be now separated from the flesh, and its component parts, the vertebræ, isolated, two kinds of vertebræ—precaudal and caudal—are distinguishable. In all there is a circular, disc-like portion, concave on each aspect, and called the **body**. Two ascending pieces, one on each side of the spinal cord, join up above and form the **neural arch**. A neural spine projects vertically above the arch (Fig. 54). The precaudal vertebræ have laterally-projecting slender ribs; hence they differ from the caudal vertebræ, in which there are no ribs, although a ventral arch, closely resembling the neural arch above, projects downwards and encloses blood-vessels.

Habits.—The brook trout prefers a clear-running stream, especially one in which the bottom is sandy or gravelly. Being a great feeder and a rapid swimmer, it may often be seen greedily devouring the May-flies as they rise from the water for their short aerial life. The head of a trout is generally turned up-stream, in order that food may be the more readily procured, and also that water may pass in at the mouth and out through the gill-openings. The size varies greatly: a trout weighing one pound or measuring twelve inches is, however, a fair specimen of an adult; yet much larger brook trout are frequently caught. Some have been known to live for more than thirty years. This fish, like the salmon, enters the sea and such specimens are frequently almost plain, bright and silvery.

Adaptation to Environment.—We need consider only a few organs of the body in order to understand how well adapted a fish is for an aquatic life. The shape of the body, with the muscles along each side, rendering possible the movements of the powerful tail; the paired fins for balancing; the unpaired fins acting as vertical keels; the operculum and branchiostegal membrane for aiding in respiratory movements; the gills for breathing in water; the gill-rakers for straining water from the food; all illustrate a fish's adaptation to environment. Again, the dull colouring of the trout's back and the light under-surface render the animal less conspicuous to birds and other enemies, since the effect produced when the back is lighted up and the under side is in partial shade, is such as to render the outline of the trout indistinct.

Reproduction and Development.—We have already observed that a trout is **diœcious**, male and female animals differing only in the nature of the **roe**. The female lays her eggs in masses, deposits them in holes in gravel, and covers them up. The male sheds some **milt**—viz. fertilizing substance from the soft roe—over the eggs, and thus impregnates them. The eggs contain much pink yolk. Fig. 55 shows some stages in the development of a fertilized egg.

Fig. 55.—Stages in development of Trout (× about 2).

First an opaque region in the upper pole of the egg appears, then two black spots—the future eyes; later the partial separation of the opaque region from the rest of the yolk, and the little embryo is called an alevin. At this period the young trout has eyes, but a mouth is not fully formed; hence all the nutriment is derived from a ventral, elongated sac filled with yolk. The alevin has a strange appearance, seemingly attached to the upper side of a distorted egg. The continual drain upon the food in the yolk-sac causes the latter to shrivel up, the embryo growing at the same time, until the sac becomes smaller and later unnoticeable. When twelve months old the alevin is called a **yearling**, and weighs about two ounces, and is in every way a miniature of its parents. For a time growth proceeds rapidly, the rate gradually decreasing until the adult condition is attained.

Characters of Fishes.—The two chief distinguishing features of a fish are the paired fins and the scales. The

FIG. 56.—Common Eel (× ½).

observer, who has seen the many different kinds of fishes in our markets or the specimens in a museum, must have marvelled at the diversity of colour, shape, size, and structure of the head, body, tail, scales, teeth, etc., which exists.

We will explain two familiar cases and leave the reader to search for other examples. The *common eel* and *halibut* are well-known fishes. The former has an elongated body, and can readily bore in sand and mud. Only the pectoral, paired fins are present, and these are small, since balancing or steadying such a body by these organs would not be feasible. In movement the body is thrown into many curves (thus functioning as one long tail), while the gills are well closed in and protected from any irritation caused by sand or grit. The halibut feeds for the most part at the bottom of the sea, and thus rests habitually on the sea floor. An observer would probably assume that the light region of the elongated oval body is the ventral surface and the darker region the dorsal, but this is not the case. The halibut begins life with much the same shape as a trout, but in further development there is a remarkable series of changes—the left eye travelling round so as to be near its fellow on the right side. The

FIG. 57.—Halibut (X about 8).

body becomes very much flattened from side to side, the halibut resting on the left side, which becomes white; the right side, however, becomes dark, thus harmonizing with the surroundings on the sea-bottom. Notwithstanding the fact that one eye has shifted and the mouth has become distorted, the dorsal and ventral fins, the lateral line, the gill-openings, and the paired fins have retained their original position. A halibut moves by curious undulating movements of the body, which, of course, are really movements from side to side. Halibuts live on crabs, shell-fish, and fish that frequent the sea floor.

Kinds of Fishes.—Fishes differ in the number, shape, and position of their fins. The *sunfish*, for example, has its pelvic fins in front of its pectorals. In some fishes the

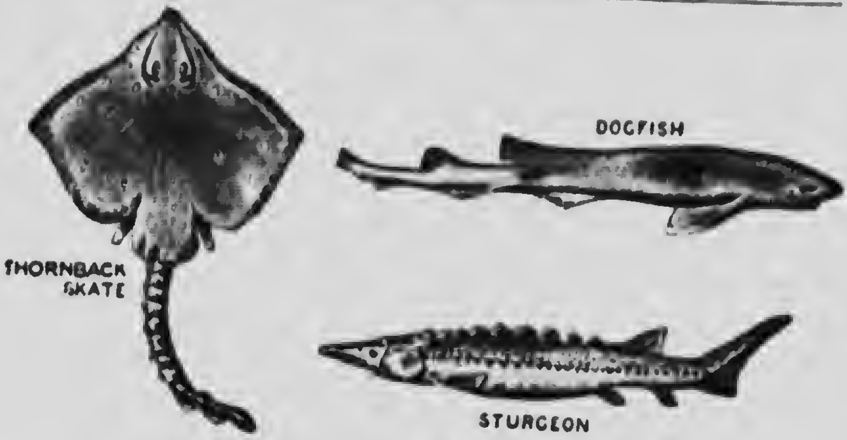


FIG. 58.—Thornback, Dogfish, and Sturgeon.

scales are thick and form large **scutes**, in others they are filmy and circular; some again have scales with a serrated margin; in the eel and halibut the scales are very small. Another useful feature aiding in the classification of fishes is the number of fin-rays in the fins; also whether these are stiff **hard spines** or flexible **soft rays**.

PRACTICAL WORK

Examine some living gold-fish or trout in an aquarium. Notice the colouration, head, trunk, tail, paired and unpaired fins, mouth, nostrils, operculum, gill-openings, etc.

Observe a fish moving, breathing, feeding.

Buy at a fish store a fresh herring for a more careful study of the body. Notice the colour, viz. steely-blue above and silvery-white below. On handling the fish many round, filmy scales are dislodged. Examine the slightly movable eyes protected by a transparent covering; the teeth, present on the tongue and vomers, but not on the jaws or palatines; the nostrils; the vent in front of the anal fin; the lateral line (not prominent); the operculum; the branchiostegal membrane; the symmetrical vertical tail fin; the pectoral fins, each with 16 rays; pelvic fins, each with 9 rays; single dorsal fins with 17 rays; and the ventral with 18 rays—none of the fins bear spines.

Open the jaws and observe the wide gape; also the gill clefts, gill-rakers, and throat.

Raise an operculum and count the pink gills in the gill-chamber, borne on the gill-arches. Cut out with scissors a gill-arch and see that the gill has the form of a double comb, the filaments representing the "teeth." Cut across a gill-arch.

Draw the herring from the side; front view with mouth wide open; gill-chamber with operculum raised; a single gill-arch and gill; a gill-arch cut across.

With a pair of scissors cut along the mid-ventral line of the body from the pectoral fins to the vent. Notice the body-cavity containing hard or soft roe; alimentary canal comprising liver, stomach with curious blind sac behind, and intestine, into which open a number of tubular outgrowths anteriorly. More dorsally placed is the silvery swim-bladder, with a fine tube leading to the alimentary canal. Note the red kidney above the swim-bladder.

Cut along the middle ventral line in front of the pectoral fins and expose the heart, of which two chambers—a pink ventricle below and a red auricle above—are readily distinguished.

Now gradually remove the flesh, consisting of zig-zag muscles, from one half the body so as to see the ribs, inter-muscular bones, and vertebral column.

Remove the bones of the head so as to expose the white brain; trace this backwards, and note that it passes into a narrower, white spinal cord penetrating the vertebral column.

Draw the fish with the above-mentioned structures showing.

Remove the vertebral column: examine and compare a vertebra (*a*) in the tail, (*b*) in the trunk region. Draw.

When a suitable opportunity arises for examining many different kinds of fish, make a careful examination looking out especially for differences in the shape, colouration, scales, teeth, tail, position of paired fins, dorsal fin (whether one or two), presence and number of spines or rays, or both.

A halibut and an eel may well be examined to illustrate adaptation to environment.

Search in any streams or rivers of the neighbourhood and find how many different species of fish you can procure. Keep each kind in an aquarium and study its habits.

EXERCISES

1. Give an account, with drawings, of any fish, describing both the external and internal structure.

2. Describe what structures fishes usually possess and how they are thereby fitted for an aquatic existence.

3. Give the life-history of a brook trout.

4. Name the chief fish of commercial importance procurable at the stores, and find from what locality each is brought.

5. Describe the method of breathing of the fish: compare it in this respect with the earthworm and the grasshopper.

CHAPTER X

FROGS, TOADS, AND NEWTS

The Frog.—We pass from fishes to some vertebrate animals which, in their earlier stages, resemble fishes in possessing gills and other structures adapting them for an aquatic life, yet differ from fishes since these particular organs do not persist throughout life, but give place

FIG. 59.—Leopard Frog (×½).

sooner or later to lungs and other characteristics of air-breathing vertebrates. The name **Amphibia** (*amphi*, double; *bios*, life) is given to these animals: the common leopard frog (*Rana pipiens*) will serve as an example for description.

Appearance.—The head, somewhat flattened from above downwards, and triangular in shape, is not separated from the rest of the body, or trunk, by any constriction which we could call a neck. A tail is not present. Like a fish, the frog possesses limbs,—two **fore-limbs** at the front end of the trunk, and two at the hinder end—the **hind-limbs**; but the legs of a frog differ entirely from the fins of a fish.

The soft, slimy skin is green, gray, or brown, and rapidly changes from one colour to the other. Two irregular rows of dark spots run along the back, two other irregular rows along the sides. The legs have brown bands on them. The skin is white to yellowish below.

There are no scales or hairs in the skin, the latter being kept moist by the secretion of moisture from certain **cutaneous** or **skin glands**. If two or three frogs be compared, the spots on the skin will be found to vary in size, number, and position, but a lateral fold along each side of the body will be found to occur in every case. Close behind each eye there is a circular area covered by a tightly-stretched membrane—the **ear-drum**, or **tympanic membrane**. A frog has no external ear-flap, the drum being flush with the surface of the body and not at the bottom [illegible] pit on each side of the head,—the condition found [illegible] vertebrates, including man.

The [illegible] prominent eyes cause two bulgings on the head. An **upper eyelid** is present and moderately well developed, but the **lower eyelid** is a mere fold of skin, continued into a thin, transparent film—the **nictitating membrane**. The latter can be drawn upwards over the eye.

Posteriorly the trunk is elevated into a hump which forms the **sacral prominence**. The vent is an aperture at the hind end of the trunk, between the junction of the hind-limbs.

Mouth and Mouth-cavity.—A crescentic slit—the **mouth**—passes round the margin of the blunt snout. The mouth is bounded above by an upper jaw bearing teeth, and below by a lower jaw devoid of teeth. On opening a frog's mouth a wide cavity—the **mouth-cavity**—is exposed.

containing a large, muscular, slimy tongue. Frogs feed upon small worms, slugs, and insects, catching the latter by rapidly darting out the sticky tongue and withdrawing it with the prey adhering.

The tongue ends in two lobes. Its attachment to the front end of the lower jaw subserves the process of feeding far more efficiently than if it were attached at the back of the mouth-cavity—the usual condition among vertebrates. The muscular tongue, the slit-like mouth, and the exceptionally wide gape are important: a frog is able to dart out its tongue with great rapidity and over a wide

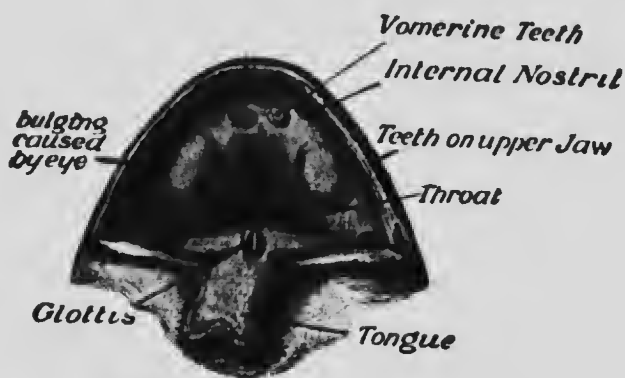


FIG. 60.—Mouth-cavity of Frog (×2).

range. Teeth are present upon two bones called **vomers** situated in the roof of the mouth-cavity. At the outer side of each vomer there is an opening—the **internal nostril**. A bristle passed into either aperture would pass out through one of the two openings on the snout—the **external nostrils**. The mouth-cavity passes into the throat behind, and this in turn leads down into the stomach. By opening a frog's mouth and drawing forward the tongue, a slit-like opening—the **glottis**—can be seen in the floor of the mouth.

Breathing.—The aëration of a frog's blood is effected partly in the skin, partly in the lungs. Hence a frog dies if its skin be allowed to dry, as the skin cannot then perform its functions properly; for this reason we find these animals can live only in damp, moist places. The respiratory movements of a frog may be seen by keeping a living animal under observation.

In the first place the frog cannot breathe, as we can, with open mouth. The external nostrils alternately open and close, and the floor of the throat moves up and down. The first action resembles that of a suction pump, since the depression of the floor of the mouth, by muscular contraction, causes the mouth-cavity to increase in size, and results in a flow of air through the open nostrils into the enlarged mouth-cavity. The nostrils are next closed and a force-pump action ensues: the floor of the mouth rises, and since the throat is practically closed, the air in the mouth-cavity is compelled to escape by the only course open—viz. down the glottis into the lungs.

Thus, during the "breathing-in" process, or **inspiration**, there is first a suction-pump and then a force-pump action. The reverse process—**expiration**—is effected by contraction of the elastic lungs and the opening of the nostrils at the same time.

Cold-blooded Animals.—The frog, like all fishes, amphibians, and reptiles, is said to be "cold-blooded." Our own blood, and that of birds, is warm—*i.e.* considerably warmer than the surrounding air. It would be better to speak of the temperature of our blood as *constant, i.e.* always the same so long as we are in a normal condition and not unwell, since a self-acting mechanism depending upon the nerves maintains this uniform temperature of the blood. Cold-blooded animals do not possess such a mechanism, and so the temperature of their blood is not constant, but is dependent upon the temperature of their surroundings.

Jumping and Swimming.—A frog seldom crawls, but progresses on land by a series of short leaps. The short fore-limb consists of three portions—a proximal **upper-arm** nearest the body, a **fore-arm**, with a **hand** distally. The hand is provided with four fingers, or **digits**, the thumb being practically absent. There are no nails on the slender digits. The fore-limbs are used as props in the squatting position, and for holding down any food—*e.g.* a large, wriggling worm—which cannot be swallowed at one gulp. Since the arms of a frog are short, they do not impede jumping movements. When not moving, a frog usually squats with the knees of the long hind-limbs directed forwards. A thicker proximal **thigh** is above the knee, and a more slender **shank** with well-marked "calf" muscle below.

The foot is curious: there is a long ankle region without a proper "heel"; also five toes, or **digits**, of which the first or innermost—corresponding to our own "big toe"—is short, the second is longer, the third still longer, the fourth the longest, while the fifth is of about the same length as the third. The toes, which have no nails, are united together by a thin, transparent web of skin, thus rendering the hind-legs more effective in swimming.

The "calf" muscle is especially important in jumping. From it a tendon passes under the ankle and along the ventral surface of each toe. When the calf muscle contracts, the bent leg is straightened and the foot exerts upon the ground an oblique, backwardly-directed force. The body is raised by the straightening of the leg, and at the same time the reaction of the pressure produced by the foot is such as to throw the frog forwards and upwards.

Vertebral Column.—The "back-bone," or vertebral column can be felt beneath the skin along the middle of the back. It is made of a row of separate pieces, and these differ in shape.

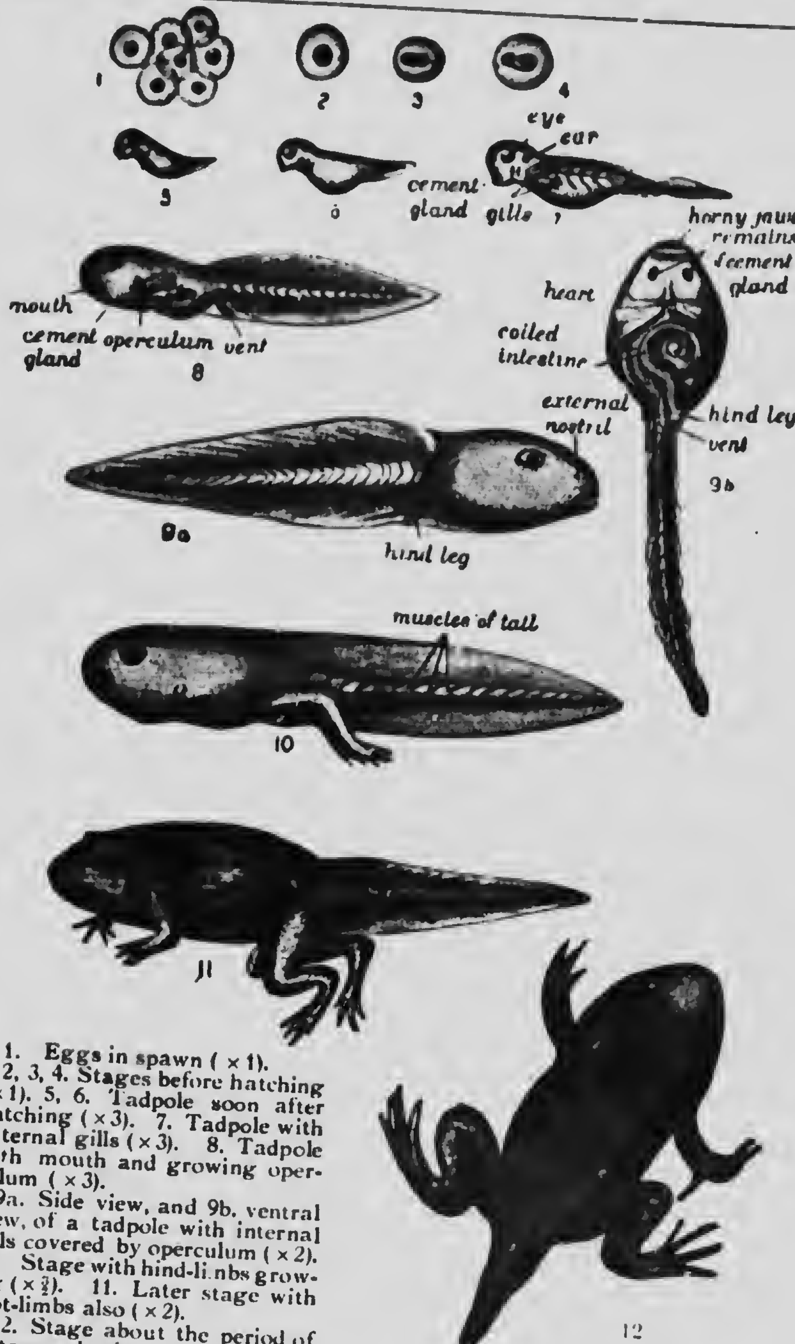
Habits.—The leopard frog inhabits marshy places or the neighbourhood of ponds and streams, taking to the water at the breeding season in early spring. Unlike the toad, frogs never travel far from water. The eggs are deposited in water usually inland, but sometimes they occur in brackish pools near the sea. Frogs have many enemies, including various birds, the fox, and the grass snake. During winter they may be found in a sluggish condition at the bottom of frozen pools where they have buried themselves in the mud. At this period of "winter sleep," or **hibernation**, the animal probably breathes entirely through its skin, the presence of life being hardly apparent. By hibernating, frogs survive the cold weather and frosts of winter, which they cannot endure. In the spring they emerge to renewed activity, and breeding occurs. During t pairing season frogs produce a curious "croaking" sound by means of two membranous structures —the "vocal cords"—situated in a chamber between the glottis and the lungs.

Reproduction and Development.—Frogs are diœcious —male and female—distinguishable by the somewhat larger size oⅰ the latter, and by the presence, in the male only, of a cushion, or pad, on the under surface of the hand in the position of the ball of the thumb in ourselves. Towards the end of March or the beginning of April the animals take to the water, the female laying a great many—1000 to 2000—eggs, over which the male sheds a milky substance, thus fertilizing or impregnating them. The spherical eggs—black above and white below, and measuring about one-twelfth inch in diameter—are surrounded by a transparent jelly which swells up enormously in the water, thereby forming a padding between the eggs; the jelly also makes the eggs adhere in a large, irregular mass called "frog spawn," which may be recognized by every country boy in ponds and creeks. It is only necessary to attempt to pick an egg out of the mass to appreciate the protective value of the jelly.

The changes undergone during development may be readily observed if some frog spawn be kept in an aquarium containing pond-water and fresh-water weeds. The eggs, if fertilized, increase in size, and, having become almost entirely black, elongate, and assume the form of little creatures with large heads, short tails, but no limbs.

Fig. 61.—Frog Spawn.

These wriggle out of the jelly and become attached to water weeds by means of a cement organ on the ventral side of the head. For a time these larvæ remain sluggish, and do not eat, since the mouth has not yet formed. When the mouth is developed, they swim about actively by lashing the tail, and feed almost entirely upon vegetation, *e.g.* water weed, although they will also eat finely-cut meat, such as liver, which is easily torn away by their horny jaws, and they are even not averse to devouring their dead or sickly companions.



1. Eggs in spawn (× 1).
2, 3, 4. Stages before hatching (×1). 5, 6. Tadpole soon after hatching (×3). 7. Tadpole with external gills (×3). 8. Tadpole with mouth and growing operculum (×3).
9a. Side view, and 9b. ventral view, of a tadpole with internal gills covered by operculum (×2). 10 Stage with hind-limbs growing (×$\frac{3}{2}$). 11. Later stage with foot-limbs also (×2).
12. Stage about the period of metamorphosis (×2).

FIG. 62.—Stages in development of Frog.

External Gills.—These appear as three little branching tufts on each side of the head, and between the gills are gill-clefts opening into the mouth-cavity. These dorsally-placed gills, containing numerous blood-vessels, act as respiratory organs for some time; at a slightly later period in the development, the tadpole breathes by means of some ventrally-placed structures frequently called **internal gills.** The internal gills, unlike the external gills, are hidden from view by a flap of skin—the **operculum**—which grows back from the head over them, and encloses a "gill-chamber" opening to the exterior by a **spiracle** on the left side of the body. When lungs have formed inside the body, the gills begin to shrivel up, and the animal comes periodically to the surface of the water to breathe air. While these changes are taking place, the body has elongated considerably—head, trunk, and large, flat tail with vertical fins being distinguishable. Soon a pair of hind-limbs begin to grow out at the base of the tail, and rather later a pair of fore-limbs bursts through the operculum on each side of the body behind the head.

As the limbs increase in size and their joints become distinct, the tail dwindles in size, but has not entirely disappeared by the time the characteristic frog-like shape of the body is assumed, so that the animal hops out on land as a frog with a little tail.

From the time of hatching until this stage, the animal is called a **tadpole**, and resembles a fish in possessing gills and a median fin; at first it has no limbs. The tadpole feeds mainly on vegetables, and, like most vegetable feeders, has a long intestine, which can be seen coiled up like a watch-spring beneath the skin. When the young frog leaves the water and becomes carnivorous, the intestine gets comparatively much shorter; the horny jaws are replaced by bony jaws and teeth, the cement organ disappears, and other important structural changes occur.

The term "metamorphosis" is applied to this series of changes in the development. As in the case of a fly, the body structure is altered in a marked manner in order to fit the creature for an entirely new mode of life. In this particular case a water-living animal—the tadpole—becomes perfectly adapted as a frog for life upon land.

Adaptation to Environment.—Frogs lay eggs unprotected by a shell, so that the habit of depositing in water masses of these eggs as spawn considerably reduces the chance of the eggs drying up and thus being destroyed. It is well known that dark clothes absorb the sun's heat much more than light clothes: similarly the black eggs, which need not only moisture and air, but also heat, have more chance of hatching out than if they were white. Again, the fact that the tadpoles remain in the water while requiring a herbivorous diet is easily explicable, since movement in water is possible with less effort than on land (owing to the buoyant effect of the water), and furthermore, since vegetable food is more plentiful in the springtime in water than on land. The tadpole is thus adapted to its mode of life and diet by the presence of horny jaws, long intestine, powerful tail, lateral line (cf. a trout), and gills.

When the tadpole becomes a frog and takes to living on land, its diet changes and the animal becomes modified in many respects. Thus the tongue becomes adapted for catching insects; the moist skin, lungs, and internal and external nostrils are fitted for respiration in air; the long, webbed hind-legs for swimming and jumping (the tail, which would be a hindrance in jumping, disappears); the bony teeth and jaws aid in the carnivorous habits assumed, whilst the colouration is obviously a device for rendering the animal less conspicuous among the grass of its swampy home.

Kinds of Frogs.—The common leopard frog (*Rana pipiens*) has a dark patch of skin on each side of the head behind the eye. Another, the bullfrog, (*Rana catesbiana*) is common in the ponds of Canada and the United States. It is by far the largest frog we have, and is often seven or eight inches in length.

Toads.—These harmless amphibians have always been maligned by superstitious people. They resemble the common leopard frog in most respects, differing only in

FIG. 63.—Bullfrog (× ½).

minor details. The skin has a sombre colouring, and numerous warty elevations occur over the whole body, one particularly large swelling behind each ear. The skin secretes a poisonous substance, which, no doubt, keeps off many enemies. A toad has no teeth; its hind-legs, too, are not so long nor are the feet so webbed as those of the frog. The toad crawls more, jumping and swimming less than its relative, and hibernates far from water—a fact

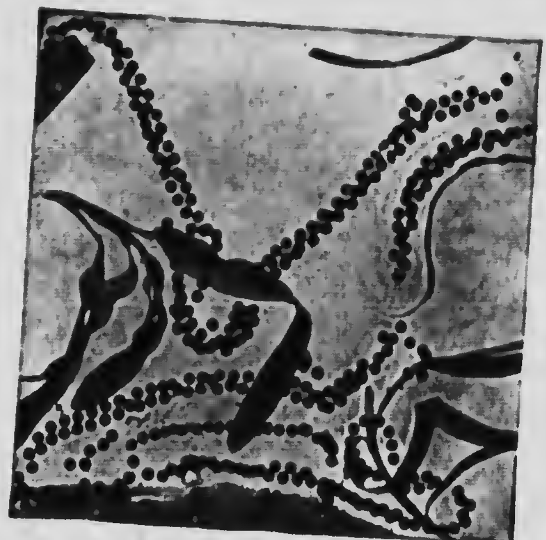


FIG. 64.—Toad spawn.

FIG. 65.—American Toad

which implies that the skin is not so important for respiration during this period of inactivity.

Essentially nocturnal in habits, this valuable garden friend eats slugs and many insects which are harmful to orchards. That toads are venomous is an erroneous view, which probably had its origin in the rapid movement of the tongue when the animal is feeding.

Toad spawn is laid in two long strings, not in an irregular mass: the elastic, gelatinous strings, containing rows of black eggs, are tangled among water weed.

The kind common in Canada and the United States is *Bufo lentiginosus*. It assumes varying colours in different localities. Several tree-frogs are common in the same localities. The common tree frog (*Hyla versicolour*) is the largest and most frequently seen. It has discs on its toes, by which it can adhere to vertical surfaces, and can even cling to a window-pane with the utmost ease. If it is seen less frequently, the pickeral tree-frog (*Hyla pickeringi*) is certainly heard more often. This diminutive little creature, less than an inch long, takes to the water as soon as the ice disappears, and its peeping trill makes the water vibrant with shrill sounds.

Newts and Salamanders.—These amphibians are quite common inhabitants of our ponds and streams, where they usually lie hidden amongst the grass at the margin of the water. Some are found under stones and logs or even in dark cellars. Fine sunny weather attracts them into the open, when they swim actively about, aided in this movement by a long, vertical, oar-like tail. Though the four short limbs are not adapted for rapid movement on land, yet much of their existence is terrestrial and devoted to seeking for food, *e.g.* earthworms, centipedes, insects, and slugs. Some enter the water during the breeding season only. The dorsal surface of newts is always darker than the lower, often brilliantly yellow-coloured, surface. The white eggs are laid by the female and wrapped carefully

FIG. 66.—Jefferson's Salamander.

FIG. 67.—Spotted Salamander.

by means of her hind-legs in the leaf of some plant growing in the water.

Numerous species are found in Canada and the United States. The aquatic species are called newts and the terrestrial forms are called salamanders. Jefferson's salamander (*Amblystoma jeffersonianum*), a large species 5 to 8 inches long, is found frequently on the great plains; its body is brown or blackish with pale or bluish spots. The spotted salamander (*Amblystoma punctatum*) is very common in the east; it is frequently found in cellars. The water newts are not common in Western America, but several species are quite numerous in the East.

PRACTICAL WORK

There is no difficulty in obtaining frogs during the summer upon marshy land or near a brook. The frogs, if they are to be kept for a day or two, should be placed in a moist place where insects and worms are to be found, *e.g.* under a tomato or cucumber frame. Do not leave a frog in a dry atmosphere where the skin may become dry, as the animal will die.

Watch a frog swimming, jumping, feeding, breathing. Notice the colouration of the body, the head with large bulging eyes, nostrils, ear-drums on a dark patch of skin, wide mouth, tongue, etc. There are no scales in the soft slimy skin. Observe the sacral prominence, short fore-limbs, long hind-limbs, absence of tail.

Count the digits on the hand and foot. See the webbed feet.

To observe the frog's development, collect some frog spawn, which may be found near the margin of ponds during April or early May. Place the spawn in a large bell-jar or other clear vessel along with some rain- or pond-water. Gather a few, fresh, green water-weeds from a pond and allow these to float upon and almost cover the surface of the water.

Place the bell-jar near some window where the light is not very powerful—otherwise the development will proceed too rapidly. Examine the spawn from day to day, and note the changes described above by which tadpoles are hatched and grow by degrees to be about 1½ inches in length. Feed them from time to time on small pieces of raw liver.

A piece of bark or cork should be placed on the surface of the water when the tadpoles show signs of metamorphosing, *viz.* when the limbs are formed and the animals keep coming to the surface to breathe air.

In about four months or less from the time of hatching, some of the tadpoles (with tails decreasing in size) may be expected to climb on to the cork as little tailed frogs.

Toads are readily distinguished by the warty skin, which usually presents a dirty appearance.

Compare a toad and a frog. The spawn of a toad consists of long strings of jelly containing black eggs. If you are fortunate enough to find some toad spawn, allow it to develop along with the frog spawn, and note that the toad larvæ are blacker than tadpoles and do not possess the same yellow freckled skin.

Newts may also be found, in April or May, hidden in the floating grass round the margin of a pond, or the white eggs (wrapped singly in leaves of water plants) may be easily hatched in gently running water in a sunny spot.

The little larvæ have prominent gills and, later, legs also; they are extremely interesting.

Study the skeleton of a large frog or toad. After killing the animal by putting it under a bell-jar with some cotton wool soaked in chloroform, clean off the flesh from the bones and note the following points:

(1) The head skeleton composed of a central box, the cranium, enclosing the brain, and a facial part which surrounds the mouth, consisting of the upper and lower jaw· in the skull there is a good deal of cartilage as well as bone.

(2) The backbone, composed of vertebræ and a narrow, elongated posterior piece—the urostyle. Processes project laterally from each vertebra except the first, which has no transverse processes. Notice that the vertebræ are tubular, and when fitted together they form a tunnel in which the soft, white, spinal cord lies.

(3) The leg bones with their girdles. The girdles are the parts connecting the leg bones to the rest of

the skeleton. The girdle of the front legs is a circle which is incomplete. The skeleton of each leg consists of a series of bones.

Place a dead frog on its back; cut it open along the middle line; pin back the cut regions and notice the following organs:

(*a*) The digestive canal beginning with the short œsophagus which leads into the large stomach. This is followed by the long coiled intestine ending in the vent.

(*b*) The liver composed of large red lobes on each side, partially covering the heart and stomach.

(*c*) The lungs, two membranous bags hidden by the liver; they unite just before they open into the throat.

(*d*) The heart, lying between the lobes of the liver. Blood-vessels pass to, or leave this organ. Those which bring blood to the heart are dark-red and are known as veins. Those which carry blood from the heart are pink; they are called arteries.

(*e*) The reproductive organs lie on each side beneath the digestive canal. In a female the ovaries are most conspicuous and appear as bags with little black eggs. In the male two white bodies, the testes or spermaries, may be observed.

(*f*) The kidneys are two deep-red organs, which will be seen only when the digestive tube is removed or displaced to one side.

EXERCISES

1. How does a tadpole differ in structure from a frog?
2. Compare together a fish and an amphibian, giving the distinguishing characters of each.
3. Describe the metamorphosis of the frog.
4. State the chief differences between a frog and a toad.
5. What structures of a frog fit it for life on land?
6. In what ways is a toad beneficial?
7. Describe the structure of the skeleton of the frog.

CHAPTER XI

TURTLES, LIZARDS, AND SNAKES

The Snapping Turtle.—This animal is one of the most widely distributed turtles of North America. It is found from the Atlantic coast to the Rocky Mountains and usually inhabits shallow ponds or lakes.

FIG. 68.—Snapping Turtle (×¼).

Carapace and Plastron.—A turtle appears at first sight to have a shell into which the body can be entirely withdrawn through openings in front and behind. This idea is wrong. The body is really covered with **scales** which originate in the skin, and can be seen on the head, neck, or legs.

Beneath the scales on the back and sides the vertebral column and the much flattened ribs have all joined up to form a dish-shaped **carapace.** On the under side of the body a fusion of bones has resulted in a flat structure called the **plastron.** In most turtles the edges of this fit all round against the margin of the carapace, leaving only an opening in front through which the head and fore-limbs may be protruded, and an opening behind, through which the tail and hind-limbs are pushed out, but in the snapping turtle the plastron is considerably reduced in size.

Tortoise-shell. — The incompletely-closed, dome-like structure framed by the carapace and plastron is covered

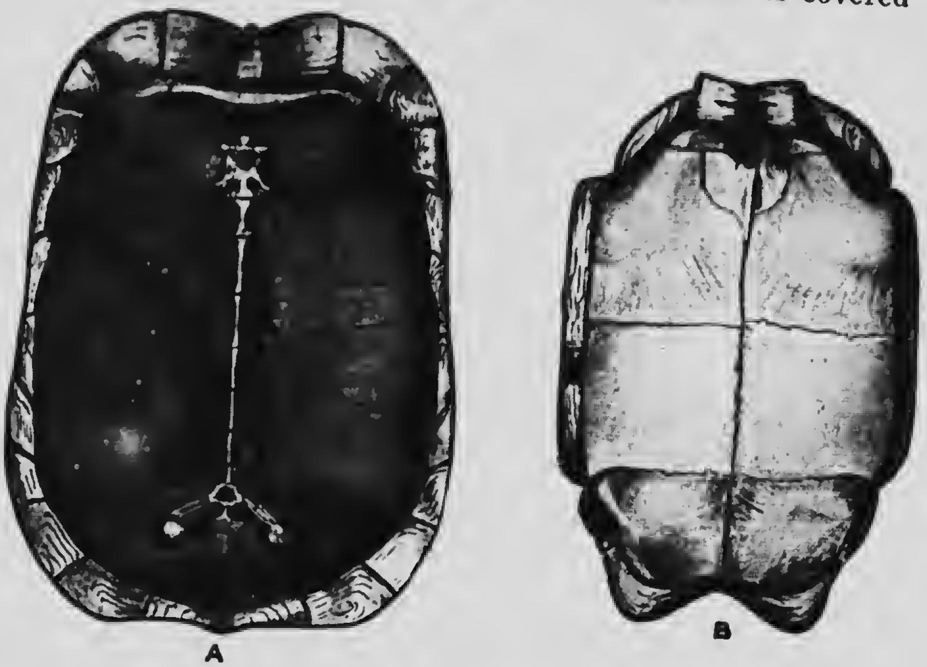


FIG. 69.—A Carapace and portion of vertebral column of Turtle (ventral view). B Plastron (dorsal view) (× ½).

with a plate of fused, enlarged scales—a layer known as **tortoise-shell**—frequently used for making combs, etc. The dorsal scales are arranged in three longitudinal rows with another row around the margin.

Head, Neck, Tail, and Legs.—The head is triangular if viewed from above; the eyes, situated on the outwardly-slanting sides of the head, are small, and have upper and lower eyelids; a transparent, nictitating membrane which can be drawn over the eye from its inner angle, is also present. The **mouth** is crescentic, the jaws being covered with a horny **beak**, hence no teeth or fleshy lips are present. A pit leading down to the ear-drum is present on each side of the head. The external nostrils are situated a little way above the mouth. In its diet the animal is entirely carnivorous. It will lie in the mud and seize some passing fish, or it may rise to the surface and either snap off the leg of a waterfowl, or pull its prize down below to drown. The unlucky fowl is soon torn to pieces and eaten.

The scaly skin on the neck, fore-limb, and hind-limb regions is very loose and flexible, in order that the head and limbs may be readily protruded or withdrawn. A turtle's movement is slow and clumsy, the limb joints appearing ill-defined. The ungainly feet are armed with blunt claws—five on each fore-foot and four on each hind-foot. The name **reptile** (*repo*, to creep) applied to turtles, lizards, snakes, and crocodiles doubtless originates from the creeping method of locomotion, the limbs being either absent altogether (as in snakes and some lizards), or so short and weak that they do not raise the body much above the ground.

Habits.—Snapping turtles are diurnal, *i.e.*, they go about in the daytime in search of their animal food: they prefer warm weather and hence are more abundant in the south. Towards the end of autumn these creatures seek some hole where they can hibernate through the winter. Like other reptiles they are cold-blooded, and breathe by means of lungs. They lay large eggs covered with a white shell.

The means of defence are of an active nature. The animal snaps viciously at any intruder who dares to molest it. A remarkable feature is the duration of life, some turtles living more than fifty years.

Kinds of Turtles.—The two commonest kinds in America are the snapping turtle (*Chelydra serpentina*) and the painted turtle (*Chrysemys picta*). The former grows very large and often has its carapace covered with a mossy vegetable growth. The latter is a very handsome species with yellow and white markings on the head, and brilliant red and black markings on the under side of the shell.

Reptiles.—We may here with advantage state some of the characteristics of reptiles which distinguish these animals from amphibians. In the first place, all members of the group require a warm or even tropical climate; hence the number of species found in Canada, and even in northern United States, is small. Reptiles differ from amphibians in never having gills; in usually laying large shelled eggs; in the possession of scales; and in having nails or claws on the feet if limbs are present. There are probably thirty or forty species of reptiles found in Canada and the northern United States.

Lizards and Snakes.—It is, of course, easy to distinguish a lizard with four limbs from a snake with none, but there are lizards which have no limbs, *e.g.* the slow- or blindworm. We must therefore distinguish between a limbless lizard and a true snake.

Lizards have movable eyelids, whereas in snakes the upper and lower eyelids are absent, the transparent third eyelid being immovably fixed in front of the eye. Again, ear-pits leading down to an ear-drum are present on the sides of the head in a lizard, whereas a snake has no ear-pits or ear-drum. Further, the scales of a snake are not arranged so as to present a smooth surface, otherwise locomotion would be slow; the tail, too, is usually short (*viz.* that portion of the body situated behind the vent); on the other hand, true lizards have a smooth, scaly body and a long tail.

We will now describe a few of our common reptiles.

Blue-tailed Lizard.—This is by far the most common lizard found in Canada and the northern United States. It is about 8 to 10 inches long and has well-developed limbs. The body is covered with small, shining scales, a mosaic of **shields** covering the head. The body is dark-olive with 5 yellowish streaks, the middle streak forking on the head. The tail is usually bright-blue. In old specimens the streaks almost disappear, and with age the head changes to a coppery-red hue.

The active little creature feeds upon insects, snails, and worms, retiring for the winter into some hole or recess at the approach of cold weather. The limbs—two pairs—

Fig. 70.—Blue-tailed Lizard ($\times \frac{2}{3}$).

each bear five fingers or toes, all ending in claws. The limbs have a "sprawling" arrangement, owing to the fact that the knees point outwards, not forwards as in a horse or dog; hence the body is not lifted clear of the ground.

The head is flattened and roughly triangular, with the apex directed forwards. A short neck is followed by the long, rounded trunk, which passes into a very long, tapering tail. The scales on the ventral surface of the trunk are large and arranged in longitudinal rows; the scales on the tail, also much larger than those on the back, are arranged in regular rings. There are two small nostrils near the tip of the snout, and a large mouth around its margin, each jaw possessing a row of small teeth. Upper and lower eyelids, and also a nictitating membrane, are present.

Owing to the fact that the creature has the five longitudinal lines along its body it is called *Eumeces quinquelineates.*

FIG. 71.—Garter Snake (× ⅓).

Common Garter Snake (*Eutænia sirtalis*).—This is the commonest of snakes in Canada and throughout the United States. It will be noticed that the snake, like the lizard and turtle, is covered by scales. These are large and regularly arranged on the head and run in longitudinal rows along the body, the number of rows decreasing towards the tail. The ventral surface is covered by a single row of transverse scutes which overlap, each having the posterior edge free. It is by means of these scutes that the animal is able to move along the ground, as there is no sign of either anterior or posterior limbs. The reptile has a forked tongue which it puts out when frightened, and which is a great source of terror to most people, although in reality it is quite harmless. The colour of this snake is very variable, usually olivaceous, with a narrow dorsal stripe and rows of dark spots on each side; there is also a wide lateral stripe along each side. This species lives in grassy places and in moist woods. It is very fond of earthworms, small frogs, and toads. These creatures take up their winter quarters deep down in the ground or in clefts of rocks, where great numbers of them are often found huddled together. The young are born alive and not hatched from eggs, therefore this snake is viviparous.

FIG. 72.—Brown Snake.

Brown Snake (*Storeria dekayi*).—This very small snake which seldom attains a length of more than twelve inches, is very widely distributed in both Canada and the United States. The whole upper surface of the body is grayish-brown, with a paler streak along the back. The ventral surface is pinkish-white. This harmless little creature seems to prefer rocks and stones to grass and woods. It is often seen crossing the country roads. Its food consists mainly of slugs and earthworms, although beetles may be included. A closely related species, the red-bellied snake (*Storeria occipitomacullata*), with bright-red ventral surface, is also widely distributed.

Rattlesnake (*Crotalus horridus*).—This is the most dreaded of all our American snakes on account of its deadly bite. The bite of the other snakes, which have been described, is harmless, but this creature has in the

FIG. 73.—Rattlesnake (× ¼).

front of its mouth a pair of elongated, hollow, sharp-pointed teeth called **fangs**; with these it strikes its victim and at the same time injects a violent poison into the wound, thereby frequently causing death. In colour the rattlesnake is yellowish-brown of various shades with three rows of irregular brown spots forming zizzag-shaped blotches. The tail is black. This reptile attains a length of five feet. The head is flat and wedge-shaped. A constriction—the neck—separates the head from the body. One characteristic feature of the rattlesnake is the so-called "rattle," which is situated at the end of the tail. This structure consists of a series of horny pieces which can move slightly upon one another. By causing the tail to vibrate rapidly the animal is able to produce a rattling sound. The snake inhabits mountain ledges, clefts with many fissures, and other places where there are flat rocks suitable for basking upon. These it leaves to enter the adjoining woods and meadows where food is plentiful. Its diet consists almost entirely of small mammals, such as young rabbits, squirrels, gophers, and rats. If not attacked, the rattlesnake will flee from an enemy and only "strikes" when it is cornered. In the striking attitude the body is wrapped in the form of a loose coil, the front end of the body being erect and the neck arched. Suddenly the head darts forward with the rapidity of a lightning flash and the fangs are buried in

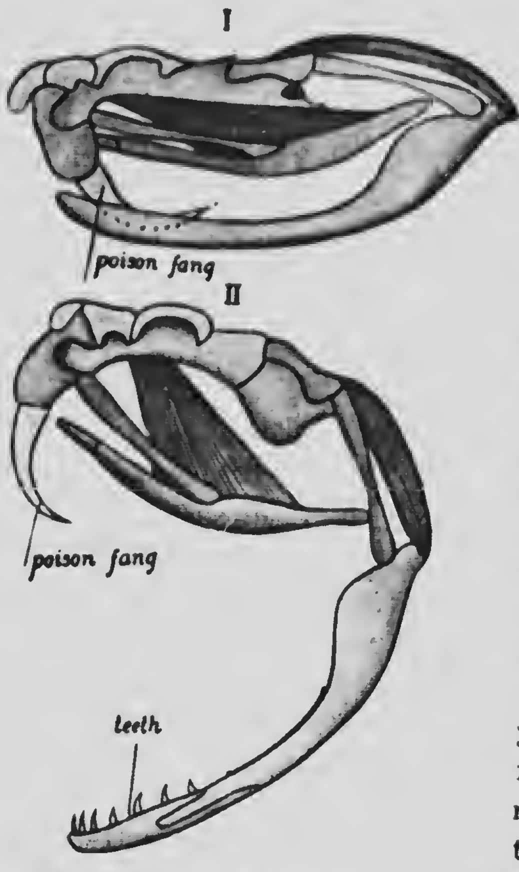


FIG. 74.—Skeleton of Rattlesnake, showing poison fang.

I. Mouth closed.
II. Mouth open.

the victim. The snake does not leap forward bodily, although the head can be extended forward a distance equal to half the whole length of the body. The rattle probably acts as a warning to other animals to give it a wide berth. It may also be used as a call during the breeding season. There is a mistaken idea that a new rattle is added each year and that the number of rattles indicates the age, in years, of the snake. A new rattle is added very time it sloughs its skin, and as this process takes place about three times a year three rattles are added each year. But since the terminal rattles are constantly wearing off, the organ is only a partial indication of the animal's age. The young are born in September, seven to twelve constituting a brood. The winter is spent in hibernation in clefts of rocks. The prairie rattlesnake, found in Western Canada and the United States, is similar to the species described above.

Adaptation to Environment.—The colouration of reptiles and their stealthy movements are of great protective value. The teeth, tongue, and lips of the different species are closely related to the particular diet. All reptiles are cold-blooded and have lungs for breathing; the skin is protected by scales which do not form a warm covering for the body. Being of shy, retiring habits, few reptiles have much need for organs for defence. The shell, with which the eggs are provided, prevents the latter from becoming dried up in the warm climates which reptiles prefer.

PRACTICAL WORK

Procure a turtle and keep it in a vessel of water in a box. Study the animal when retracted under the arched carapace; also when the head and limbs are pushed out, and the turtle is moving rather clumsily along.

Notice the shape of the head, the nostrils, horny beak, scales, tail, carapace, and plastron; observe the dark markings on the horny covering of tortoise-shell.

The limbs bear blunt claws for digging up soil, but these are useless for defence.

Watch a turtle feeding on pieces of meat, little fish, or tadpoles placed in the vessel of water.

If a blue-tailed lizard is captured, keep it in a box with one or more glass sides and feed it on earthworms, slugs, or insects. Notice its colour, how it uses its limbs for walking, its method of breathing, and how it seizes its food. Observe its eyes, the absence or presence of eyelids, the directions in which the reptile can see best. Examine the scales on the head, on the back of the body and on the underside of the tail. Open its mouth and examine its teeth. Make a drawing of the animal.

It is easy to secure a garter snake, which may be kept in a cage made for the purpose. Have a vessel of water in the cage and also place inside a branch of a tree about which it may twine. Feed it on meal worms, or small frogs or toads. Observe its size and shape, the scales on the head and body; notice how it uses the ventral scutes for moving; observe the different methods of movement. Notice the structure of the forked, harmless tongue, and see how this organ moves in a socket. Notice the teeth on the upper and lower jaw. Study the breathing movements.

EXERCISES

1. Compare and contrast a lizard and a snake.

2. What is a reptile? How does it differ from a fish and from a frog?

3. Write a short essay on American reptiles.

4. Describe the habits of the rattlesnake.

5. How does a lizard differ from a newt?

6. What characters have a snake, lizard, and turtle in common that all should be called reptiles?

7. Describe the shell of the turtle.

8. How do snakes, lizards, and turtles defend themselves?

CHAPTER XII

THE COMMON PIGEON

Perhaps the first feature about a common domestic pigeon that would appeal to a child is the covering of **feathers**, and it is the possession of these structures which distinguishes a bird.

Appearance.—The colouring is of an almost uniform bluish-gray, with purple and green tints on the neck and upper part of the breast; the wings may have dark bars upon them. The body is divided into **head, trunk,** and **tail** regions, with a freely flexible neck; the contour of the body is much altered by the presence and arrangement of the feathers, a plucked pigeon having practically no tail region. The **mouth** is provided with a **beak** formed of upper and lower jaws encased in horn; a rather long, pointed **tongue** is present, but no teeth. At the base of the upper jaw, *viz.* where the latter joins the head, the two slit-like external nostrils are overhung by a bare fleshy patch of skin—the **cere.** The eyes are large, strongly curved, and protected by an upper and lower eyelid; a translucent third eyelid, which can be rapidly drawn over the eye, is present also. Behind and rather lower than the eyes are situated the openings of the ears. There are many people who would declare that a bird has no ears,—this is probably due to the fact that the opening of the pit or tube leading down into the ear is not conspicuous, being concealed by feathers, which, if pushed aside, display a hole on each side of the head leading into a passage terminated by the ear-drum.

Just as a horse, frog, or lizard has four limbs, the same is true of a pigeon, since the wings are really modified fore-limbs, with upper-arm, fore-arm, and hand quite distinguishable. The fact that the wings bear long quill

Fig. 75.—Rock Doves.

feathers helps still further to conceal their true nature. The wings of a pigeon are moved by very powerful muscles that may be felt on the breast. The muscles are attached to a strong ridge of bone in the middle line of the breast, or **pectoral**, region. The tail of a plucked pigeon appears as a short prolongation of the trunk; near its tip on the dorsal side an **oil-gland** opens, the fluid secretion of which is used by the bird for "preening" its feathers. At the posterior end of the trunk a **vent** opens at the base of the tail. The **legs**—the true hind-limbs—consist of thigh, shank, ankle, and foot regions, the feet and ankles being covered with **scales** instead of feathers. There are four digits or toes, each ending in a blunt **claw**, and protected beneath by pads.

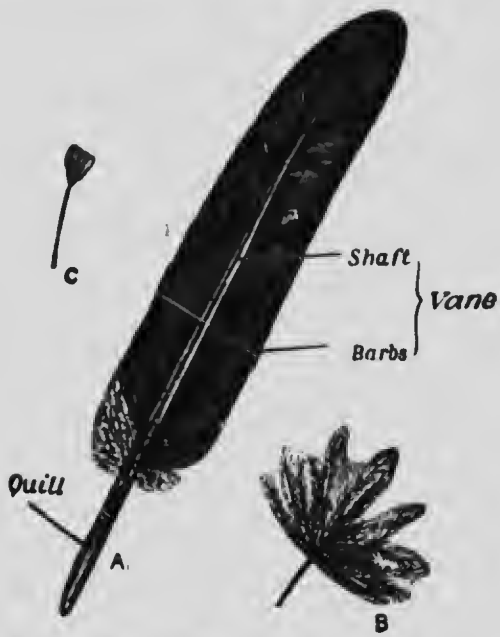


FIG. 76.—(A) Quill feather, (B) Down feather, and (C) Filoplume.

Feathers.—The process of plucking a pigeon will reveal the fact that the feathers are arranged over regions of the body known as **feather tracts**, with intervening regions—**featherless tracts**; in most birds the latter are more distinct than in the pigeon. Since the feathers are long enough to overlap and thus cover the featherless tracts, the body appears to be enclosed in a soft, light coat, which does not conduct heat well and so keeps the heat within the body.

Of the three kinds of feathers, the most numerous and longest are the **contour feathers**, which cover the head, neck, trunk, and tail, and pass on to the limbs; they participate to a great extent in deciding the shape or contour of the pigeon. Of the contour feathers, some on the wings and tail—the **quills**—are especially long and strong, the former enabling the bird to fly, while the latter act like a rudder or steering organ in the air; a layer of **covert** feathers prevents air from passing between the bases of the quill feathers. A typical feather consists of a hollow stalk and a flattened vane, the latter comprising a solid axis, with delicate branches or **barbs** passing off on each side. Scattered among the contour feathers at the base of the legs and wings are soft, small **down feathers**, while still smaller **filoplumes**—rather like the fruits of a dandelion—are left on the body after the bird has been plucked.

Flight.—In one respect, at least, most birds surpass human beings, in that they are constructed for aerial life. The fore-limbs are modified to form **wings**: the powerful quill feathers are arranged in a series on the posterior edge of the wings, the inner side of each feather lying under the outer side of the feather next to it and nearer the body; when the outstretched wings are depressed, a large resistance is offered to the air on account of this arrangement of the quill feathers, and the resulting reaction lifts the bird and carries it forwards. The concave surface of the under side of each wing presents the best possible mechanism for producing this upward and and forward movement, when the wing is depressed by the powerful breast muscles. On the contrary, the shape of the upper surface of the wing and the fact that in the upraising of the latter the air can pass freely between the feathers, results in little resistance, and so in this action the forward movement of the bird is but little retarded. Change of direction is produced by the increased action of either wing and also by the movement of the tail to one side or the other, exactly on the principle of a ship's rudder. A remarkable auxiliary of a bird's flight is the internal structure of the body, the lungs being continued into large spaces—air-sacs—which even pass into the bones of the body in the case of nearly all flying birds.

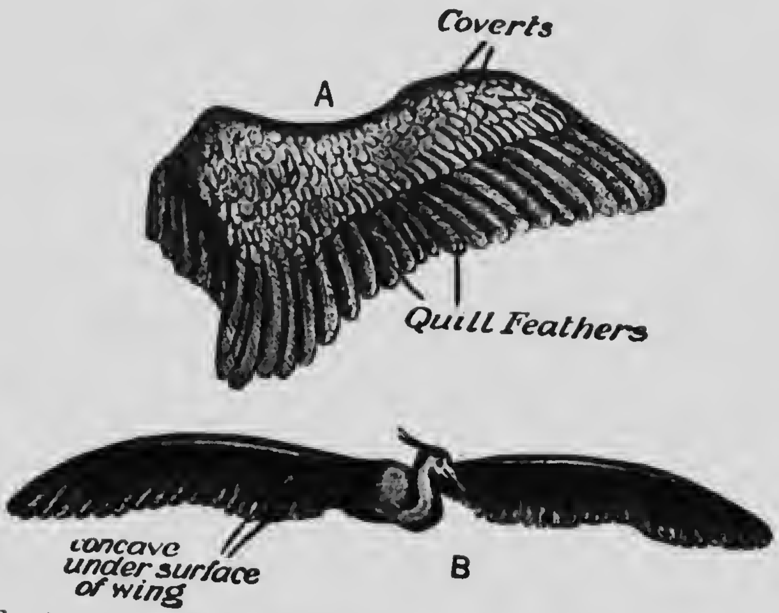


FIG. 77.—(A) Dorsal convex surface of a wing. (B) A Heron in full flight; note the deeply concave under-surface of the wings.

Thus there is a large amount of warm air in a bird's body, rendering it buoyant; and further, the movement of the wing muscles causes air to be driven from the air-sacs through the lungs and *vice versa*, thus effecting respiration.

Habits.—The pigeon, like most birds, is able to produce characteristic sounds—the "cooing" of pigeons or doves to one another is the counterpart of the song of a lark or blackbird. The special organ for producing sound in birds is known as the **syrinx**, a structure located at the base of the **windpipe**—*i.e.* the passage which conducts air from the mouth-cavity to the lungs. The pigeon has a beak adapted for picking and eating seeds—which are stored up in a part of the alimentary canal known as the **crop**. It is easy to distinguish this chamber just above the breast of a well-fed pigeon or fowl, since the seeds of grain may be actually felt through the skin.

Another feature of the pigeon not yet met with in the preceding animals is the possession of warm blood. Th keen sight of a pigeon doubtless compensates for its feeble sense of smell, a faculty poorly developed in birds. The female pigeon lays a pair of perfectly white eggs in a rough nest of feathers, etc. Unlike reptiles, birds do not leave their eggs to be hatched by the sun, but "brood" over them—*i.e.* cover the eggs with the body and thus keep them at a temperature of about 38-40° C. (100° F.). A pigeon broods for fourteen days. At the end of the period of incubation the young pigeons break through the shell and hatch as nestlings covered with a fine down. The parents feed them at first on "pigeon's milk"—a white milky fluid secreted from the crop. The nestlings of birds such as pigeons, which are helpless on hatching, usually blind and almost featherless, are called altrices.

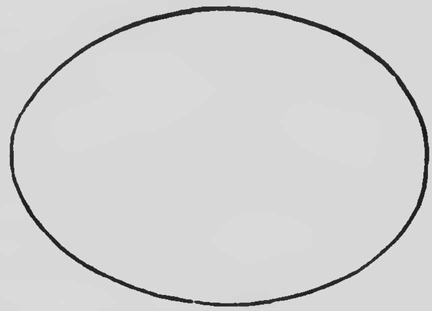


FIG. 78.—Egg of Pigeon (× 1).

Varieties of Pigeons.—The description which has been given applies in the main to all pigeons, but the coloura-

FIG. 79.—The Variation of Pigeons under Domestication. (*See footnote opposite page.*)

tion in particular is that of one sort or variety of domestic pigeon known as the dove-cot pigeon or "blue rock." There are, however, many different varieties of pigeons produced by the artificial selection of man—*e.g.* pouters, fantails, carriers, tumblers, etc., as will be understood by an inspection of Fig. 79.

The varieties of pigeons are illustrative of a very important principle known as **artificial selection.** It is common knowledge that the offspring of all animals tend to resemble their parents in outward appearance, more especially as growth proceeds,—a phenomenon expressed by the adage, "Like father, like child." Now, on considering any family, we can distinguish the children from one another—that is to say, a certain amount of **variation** occurs among the offspring of two particular parents. This phenomenon is the same among lower animals, though not perhaps discernible to most of us. The experienced shepherd can distinguish each member of his flock by little differences in appearance. In like manner pigeon-fanciers have noticed variations among pigeons, and have selected for generation after generation those birds which they considered most nearly perfect from their point of view, in other words, only birds were used for breeding which approached most nearly to a certain artificial standard of selection. Since different fanciers would have different views, so the result of artificial selection through

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Centre—Rock Doves.
1. Carrier.
2. Pouter.
3. Almond Tumbler.
4. Trumpeter.
5. Barb.
6. Fantail.
7. Jacobin.
8. Capuchin.
9. Dragoon.
10. Modena.
11. Scandaroon.
12. Turbit.
13. English Owl.
14. Nun.
15. Mottle Tumbler.
16. Saddle Tumbler.
17. English Beard.
18. Baldhead.
19. Runt.
20. Magpie.
21. Show Homer.
22. Archangel.
23. Oriental Roller.
24. Norwich Cropper.
25. Cumulet.
26. Tippler.
27. African Owl.
28. Working Homer.
29. Mane.
30. Domino.
31. Oriental Turbit.
32. Blondinette.
33. Satinette.
34. Shortfaced Antwerp
35. Priest.
36. Fairy.
37. Frillback.
38. Swallow.
39. Suabian.
40. Fire Spot.

many generations has resulted in a number of varieties of the pigeon, which show certain characteristics in a degree which is patent to us all. The results of artificial selection are associated with domesticated animals only; wild animals have been subjected through countless ages to the action of **natural selection**—a process not regulated by man, but by Nature herself.

Adaptation to Environment.—The pigeon's beak and tongue are fitted for the food it eats, the feathers keep the body warm, the legs and feet are important in perching, and the wings enable it to adopt an aerial existence, thus safeguarding it against many land animals. Of the wonderful adaptations of birds in general as regards colouration, the structure and appearance of the nests, eggs, and nestlings, in addition to their migratory habits and power of song, we shall speak in the next chapter.

PRACTICAL WORK

Domestic pigeons are generally so tame that one may approach and feed them.

Thus the appearance—in particular the colouration. head, neck, trunk, tail, feathers, wings, and legs covered with scales may readily be observed; also the beak, cere, nostrils, etc.

Contrast the appearance of a living bird with that of a plucked pigeon, fowl, or turkey. Notice in the dead bird the ear-pit ordinarily concealed by feathers, the eyes, eyelids, and nicitating membrane, the tongue, absence of teeth, regions of the wing, and the legs with clawed digits, the breast-bone, the food in the crop, the oil-gland, vent, feather tracts, featherless tracts.

From the feathers of a plucked pigeon pick out and draw a contour feather, a down feather, and a filoplume.

At the window of any bird shop you will have an excellent chance of seeing how various breeds of pigeons differ from one another.

Study the skeleton of a pigeon or fowl. (The bones from one used for the table will do). Notice (1) the skull with a cavity for the brain, and a front projection forming the beak; (2) the backbone made of separate pieces (or vertebræ) which move freely on each other in the neck, but are rigidly attached further back to make a firm bone for the attachment of the leg and wing bones; (3) the ribs rigidly united to the backbone and also to the (4) breastbone, which is very large with a keel on it to give a large surface for the attachment of the wing muscles; (5) the bones of the wings and legs.

Pluck a dead pigeon, place it on its back, and open it by removing the walls of the abdomen and the breastbone with the overlying muscles. Study the alimentary canal which begins with the gullet, swelling out into a crop, then passing into a thick soft-walled stomach, the last-named passing into the gizzard and finally into the very long coiled intestine. Notice the large liver, the heart with the blood-vessels coming to it and passing from it. Underneath the liver the bright-red lungs are packed into the recesses between the ribs; each lung has a tube or bronchus passing from it; these bronchi unite to form the ringed windpipe.

QUESTIONS

1. In what ways does a bird differ from a reptile?

2. Name the different kinds of feathers found on birds; describe each, and state on what parts each kind of feather is found.

3. What is artificial selection? How does it act?

4. Name the different adaptations by which birds are fitted for flight.

5. What is meant by calling a bird a warm-blooded animal? What other kinds of animals are warm-blooded?

CHAPTER XIII

MORE ABOUT BIRDS

Since birds provide a favourite study for naturalists, and since, moreover, so much can be seen and learned from them, we may well devote a chapter to birds in general.

Nests.—The nests differ widely both as to locality and structure. Generally speaking, a bird's nest is constructed with much care; in some cases with astounding workmanship. The locality is correlated with the food: thus killdeers, curlews, and larks have a nest on the ground, since they inhabit moorlands which are usually devoid of trees; phœbes, sand-martins, and kingfishers build near streams; woodpeckers and sparrow-hawks prefer to make nests in woods.

The guillemot, however, is a sea-bird which builds no nest, laying its single egg on the hard ground or upon a rocky ledge.

Killdeers take advantage of some hollow depression among tufts of grass in a pasture, and lay four darkly-speckled eggs difficult to distinguish from their surroundings.

Blackbirds and robins usually build in shrubs or trees, constructing a cup-shaped home which consists of hay or grass outside, and, in the case of the robin, a lining of mud within. Such a water-tight structure undoubtedly suffers in very wet weather, since the falling rain cannot drain out, and the water-logged eggs become addled.

FIG. 80.—Nest and Eggs of Lesser Tern.

The mourning-dove constructs a simple platform of sticks, on which it lays two white eggs. Crows, sparrow-hawks, and many other birds use twigs and sticks for nest building.

The humming bird may be taken as a common example of the more intricate housebuilder; its nest, consisting of spiders' webs, moss, and lichen beautifully interwoven, is lined with woolly material.

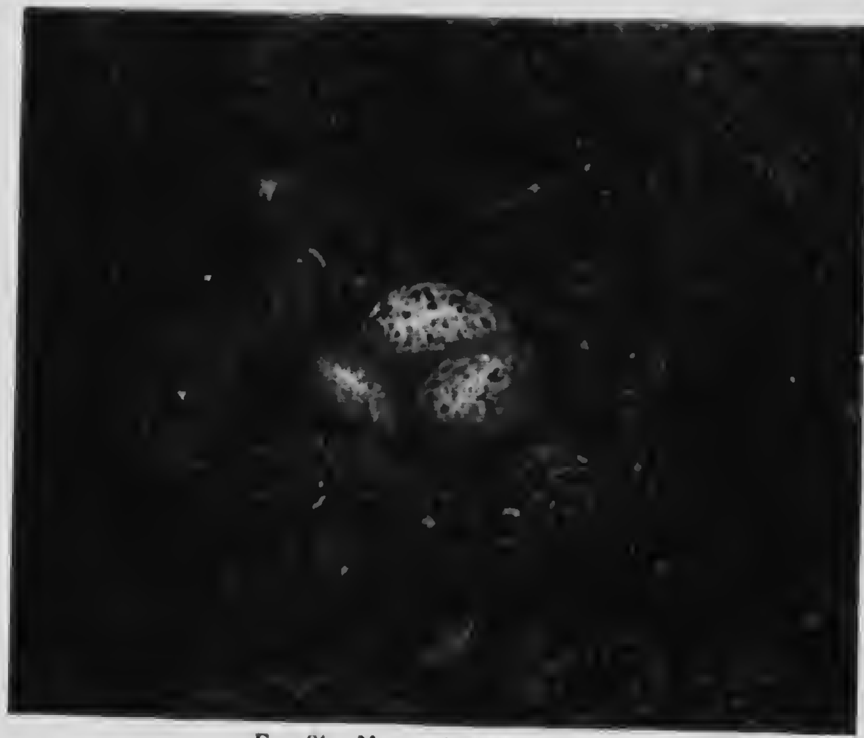


FIG. 81.—Nest and Eggs of Gull.

Cliff- and barn-swallows make a nest of mud collected from some puddle, the edge of a pond, or river bank. The mud is rendered more sticky and adhesive by admixture with saliva. Small soft feathers are used for lining the nest.

Meadowlarks and ovenbirds build a domed nest.

Kingfishers and sand-martins excavate a burrow in the sandy or muddy bank of a stream, and deposit a number of white eggs; in the case of the martin the eggs are laid on feathers at the blind end of the burrow, whereas the kingfisher makes a rough nest of bones and other hard parts of the fishes upon which it lives. Though much constancy exists with regard to the locality of the nest, it must be borne in mind that the natural possibilities of the breeding ground cannot fail to be an important factor: some birds usually accustomed to building in trees will construct a nest on the ground when trees are absent.

FIG. 82.—Nest of Catbird.

Again, the idiosyncrasies of individual birds have resulted in robins, sparrows, etc., building their nests in remarkable places, *e.g.* the pocket of an unused garment, letter-boxes, and the like.

Eggs. —The egg is protected by a firm envelope of calcareous material; the shape is roughly oval, tapering more rapidly at one end than at the other. This last feature is most accentuated in the eggs of wild birds like sea-gulls and guillemots nesting upon ledges of rock; again, killdeers, curlews, and other birds, which have a nest on the ground, lay eggs of this kind. If such an egg be rolled

FIG. 83.—Sparrow's nest with Eggs.

along a flat surface it will move in a circular direction. This beneficial property is instrumental in saving many eggs; the wind may set in motion a sea-gull's egg, but will not blow it off a rocky ledge; a plover's egg, also, may be slightly displaced, and yet it will not roll out of the nest.

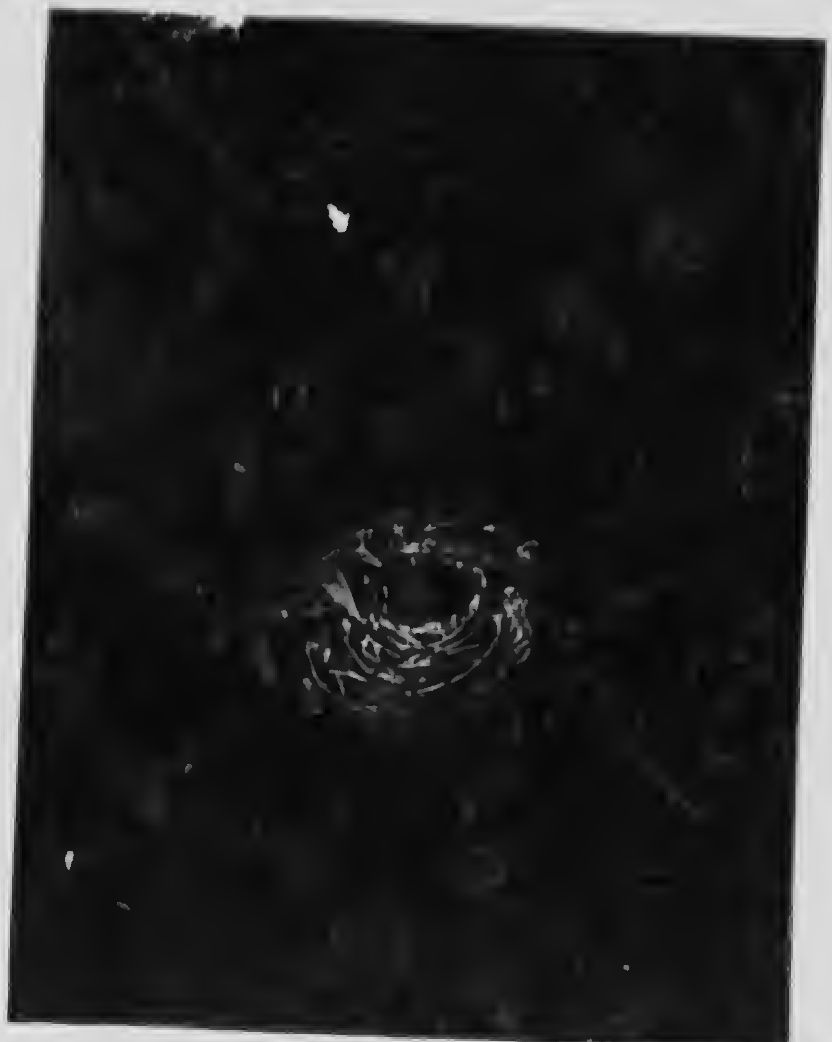


FIG. 84.—Wren's Nest.

The number of eggs common to a species is commensurate in general with the number of enemies the species has to contend with.

The colouration of eggs varies much, and this is closely connected with the nature of the nest. Some eggs are perfectly white; some, like the robin's and cat-bird's, are deep blue; others, such as those of the killdeer and sparrow-hawk, have large blotches; buntings have eggs with streaked markings, whereas waxwings, vesper-sparrows, and myrtle warblers have delicate spots on a uniform background. No doubt, as our knowledge of birds' eggs increases, we shall correlate the colour of an

FIG. 85—Red-eyed Vireo on nest.

egg with its chances of preservation from injury. Thus, birds whose nests are such that the eggs will be in semi-darkness have eggs entirely white, or with a white colour predominating, *e.g.* martins, kingfishers, owls, swallows, tits, etc.—the white appearance of the eggs precluding the possibility of injury by the parents when returning to the nest. Then, again, the appearance of a plover's, curlew's, or lark's egg is in complete harmony with its surroundings, and so the eggs usually escape detection.

Lastly, it would appear that, in many cases, when the eggs are brightly coloured, as in the case of the cat-bird, thrush, and hummingbird, it is the nest which has been constructed so as to be difficult to discover, by reason of its structure, *viz.* the sticks of the catbird's or the interwoven lichen of a hummingbird's nest.

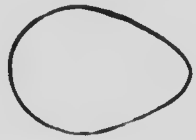


FIG. 86.—Egg of Sand-Martin (× 1). The white egg tapers more rapidly at one end than at the other

FIG. 87.—Ringed Plover on nest.

Nestlings.—We noticed that the young pigeon is comparatively helpless, and that it must be fed and kept warm by the parents. Such birds are together spoken of as altrices. Sparrows and crows are absolutely featherless when born; pigeons have but little covering; thrushes, however, have patches of down feathers, known as "nest-

FIG. 88. Nest of Woodcock.

ling downs," on the shoulders and head, whereas this covering is still better developed in owls. At a later date the contour feathers begin to develop, and it is a remarkable fact that as this goes on, the down feathers are carried out on the tips of the feathers growing beneath them, so that they are, as it were, pushed away from the body by the growing contour feathers.

The young of some birds are able to feed themselves almost at the time of hatching. These are distinguished as **præcoces,** and have a plentiful covering of down feathers; familiar examples are ducklings and chickens. In such cases the structures, which are of the first importance in getting food and escaping enemies, assert them-

Fig. 89. Young Wood Thrush.

Fig. 90.—Ducklings.

selves soonest in development. The duckling's wings are not prominent in the earlier stages, but rather the legs and webbed feet for swimming, and the beak suited to its particular diet; in chickens, the wings—the means by which their remote ancestors escaped from enemies—grow quickly, even though the adult may not be able to fly very well; the beak for feeding and the feet for scratching and

Fig. 91.—Chickens.

perching, are also most prominent in early development. Another interesting feature among young birds is the presence of stripes, *e.g.* chick, robin, blackbird,—undoubtedly a protective colouration device for saving them from enemies in their tender years, since the combination of dark and light stripes renders the young birds indistinct and blurred; hence they appear almost invisible at a short distance.

An observer seeing a nest of young starlings, thrushes, or blackbirds for the first time cannot fail to be astonished at the large mouths of the nestlings. The sides of the mouth possess thick, fleshy folds—usually of bright yellow colour—presumably helpful to the infant irds in the process of feeding, by preventing any food which the parents place in their beak from falling out of the mouth.

FIG. 92.—Song Thrush and Sparrow.

B. ks, Food, and Feedin —There is a close relation between the beak of a bird nd the nature of its food. Robins and blackbirds live on worms, snails, and fruit. They need a beak with a point or extricating a snail from its broken shell, and at the same time strong enough to hold a worm; the beak is therefore like a pair of forceps, pointed and not very long. Such an organ would not serve a seed-eating finch or sparrow, as in these birds crushing power is essential; hence, their beak is short but strong. In the grosbeak—which feeds on hard seeds—an arrangement exists in the mouth whereby the food is prevented from slipping out of the beak while being crushed, two little transversely grooved knobs in the lower jaw working on each side of a similarly grooved long ridge on the roof of the mouth.

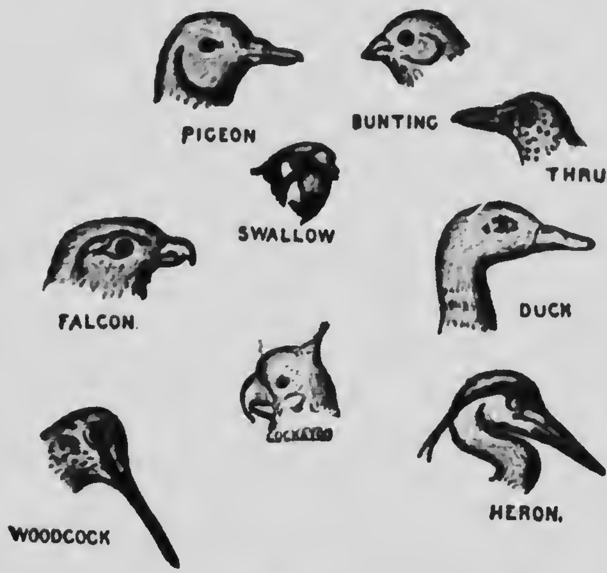


FIG. 93.—Beaks of various birds.

Swifts, swallows, and martins spend a good deal of time on the wing, with mouth wide open to catch insests; hence they have exceptionally large mouths and weak, short beaks which can be rapidly closed. The sticky tongue also helps in trapping the prey.

A heron lives on fish; standing patiently in one spot for long intervals together, it will suddenly dart its long dagger-shaped beak into the water and seize an unwary fish.

The beak of a snipe or woodcock is particularly interesting. The upper jaw is longer than the lower, and so constructed that even when buried deep in mud the tip of the upper jaw can be raised a little. Moreover, numerous nerves pass to the upper jaw and render it very sensitive. Hence when a woodcock searches for its food by probing about in the mud, the upper jaw can feel the

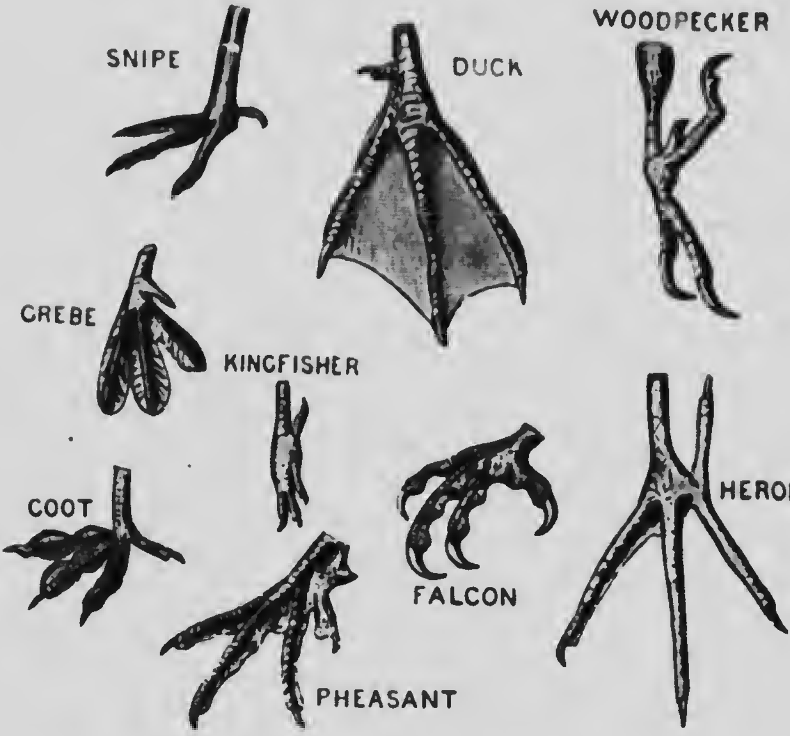


FIG. 94.—Feet of various birds.

food and compress it against the lower jaw, and thus hold any insect or worm, while the beak is being withdrawn from the mud.

We are all familiar with the beak of the duck—flattened, with transverse ridges on the palate. The duck pushes its beak into muddy water, and, by pressing the fleshy tongue against the grooved palate, contrives to hold any worms and insects, etc., while the water drains out. Thus its beak is adapted as a strainer. Eagles and hawks have a hooked upper jaw for tearing flesh. The parrot uses its beak for climbing.

Feet, Neck, and Wings of Birds.—It must often surprise us to note the expert manner of a canary feeding,—picking up seeds, crushing them, and differentiating husk from food by means of its beak alone. Some birds, *e.g.* the crow (and some hawks), have short legs and use the feet for holding food, while they tear off pieces with the beak. The eagle has powerful claws or talons to help in this function. Many water-birds, ducks, etc., have webbed feet—a thin web uniting the toes—rendering them powerful swimmers; moreover, others which are expert in the water (*e.g.* the coot and water-hen) have long unwebbed toes. Parrots and cockatoos, as well as some hawks and owls, will stand on one leg and hold their food up to the beak with the other—using their beak like a hand. Prairie hens and the common fowl scratch for their food, being provided with rather short, blunt, moderately spread-out, scaly toes for tearing up soil; often, too, they possess powerful spurs for defence (pheasant and fowl).

As we should expect, a wading bird, such as the heron, possesses rather long, well spread-out toes to prevent it from sinking into the mud; the curlew—living on marshy land—has long legs, with corresponding long neck and beak. Perching birds, *e.g.* the finches, have short legs, and in many climbers (parrots, woodpeckers) two toes point forwards and two backwards, the pairs of toes grasping either side of a perch or bough. In the kingfisher, where the feet are little used, three claws are close together—not a useful arrangement for a bird which walks much. Hence we must conclude that there is a meaning in the shape of the beak, length of the neck and legs, and nature of the foot of birds.

That the wing has a relation to the habits may be inferred by comparing the small rounded wing of the sparrow or wren, which spend but little time in flight, with the elongated wing of the swallow and swift, which are almost continually in flight.

FIG. 95.—Cockatoo feeding.

Colouration and Migration.—As a rule the female is of a much more sombre hue than her mate, and in such cases the young resemble the female in their first plumage; when the sexes are similar in colour, the young may either have a dull livery of their own, or resemble the parents more or less closely.

The common sparrow, goldfinch, and many other birds present a seasonal colour change, the plumage in general being bright in the spring and dull in the winter. Many northern birds migrate to other lands—some come in spring, breed, and leave in the autumn, while others come in the autumn and stay only for the winter. Migration appears to depend upon the supp'. of food, and

FIG 96.—House-Sparrow bathing.

indirectly therefore on the temperature. Insect-feeders (*e.g.* swallows and martins) can obtain plenty of insects in Canada during the warmer weather only: they leave for southern lands when this supply fails. Similarly, hard winters drive birds, accustomed to live in southern parts of Canada, further south. Thus, most of the summer birds, like martins, cuckoos, robins, warblers, winter in the southern United States, Mexico, and South America.

Birds collect in great numbers before migration, preparatory to departure, and start their journey in the night; although usually flying high, they escape the wind to some extent during a gale by flying low over the water. It is remarkable with what unerring instinct they make this journey and reach their proper destination, the

FIG. 97.—Young Oyster-catcher hiding.

younger, inexperienced birds in some cases journeying in advance of the parents.

Song.—There are few of us—even the most unmusical and unpoetical—to whom the music of our singing birds does not appeal. Even apart from the mere sound, we are recalled to some thought of what is beautiful in Nature.

It has been already stated that in general the males have a more brilliant plumage than the females, and this rule applies also to the power of song. We may safely conclude that in any species of singing bird, it is the male in which the accomplishment is most perfected, and although many females can sing, it is more than probable that some inferiority exists in their note either as regards loudness, pitch, or timbre.

The importance of some distinctive cry is readily appreciated, if one thinks of the risks of loss to which a flock of migratory birds is exposed when travelling at top speed throughout dark, and often stormy nights.

Moreover, in some cases, *e.g.* where migration does not occur, and where the birds are brightly coloured, there are practically no vocal talents.

Hence recognition and distinction of the species or the sexes appear to be the main secret of the brilliant plumage or the song of birds: the differences in vocal power to be met with in the different species must be explained in another way.

At the courtship season of birds, the males of species possessing a bright plumage may often be seen displaying this, so as to appear most attractive; among singing species this is the period of greatest vocal activity; hence it would seem that the female acts at such times like a person in love: without even knowing why one particular male individual offers such an irresistible attraction, she succumbs to his attractive powers, whether they take the form of vocal effort, brilliancy of plumage, or other display. The greater this attractive power or love charm in the male, the more readily will the female succumb to it and choose him for her mate.

Thus, the stronger the love charm the male possesses the more certainly will he find a partner—whether the charm is due to song, beauty of form or colour, or to any other fascinating characteristics. Hence we meet with sounds in birds ranging from the simple recognition note of the gull or crow to the varying note of a sand-piper expressing recognition, warning, joy, or grief; thence to the birds with a call of frequent repetition (*e.g.* woodpecker); so to those with a combination of various possible tones resulting in a long and affectionate chatter (warblers and ovenbirds), until finally a continuous song consisting of numerous flutelike tones has been produced (bobolink).

This unrhythmical form of song has been substituted in the best singing birds by a succession and modulation of the simpler vocal sounds repeated rhythmically (*e.g.* in the goldfinch, purple finch, horned lark, and catbird).

PRACTICAL WORK

During your walks in the country, look out for the nests of different birds—note their structure, the eggs (the colour, size, and number), and so try to confirm or disprove any statement made in this chapter.

Note that a house-sparrow's nestlings are devoid of any feathery coat (but they are hatched in a nest lined with feathers which keep them warm); that young robins have a few down feathers on the head and shoulders; that chickens and ducklings have a covering of feathers when hatched.

Note the wide gaping mouth, with thick yellow margin, of young robins and blackbirds.

Compare the wings, legs, feet, beak, etc., of a chicken and a duckling.

Try to observe completely the nesting habits of a single pair such as the robin; note which partner builds the nest; how the material is carried; how constructed; how long it takes to build; when laying begins; the number of eggs, colour, size, and shape; how long the female takes to lay the clutch; how long she sets on the eggs; if the male assists with the setting; appearance of young; habits of young; how the young are fed; how long before they leave the nest, etc.

Make a series of observations (either in some zoological gardens, a museum, or elsewhere) of a great many different kinds of birds, noting in each case the shape and size of the beak, the length of the neck, the length and shape of the wings, the length of the legs and the nature of the feet; correlate these observations with the diet and mode of life.

Correlate in this way the structure of beak, wings, neck, and legs, with the habits and food of a bird.

Keep a diary, noting the first and last appearance of different kinds of birds which migrate during the year; also note which birds do not migrate.

EXERCISES

1. What is meant by "præcoces" and "altrices?"

2. What is meant by adaptation to environment? Illustrate by reference to birds and their nests.

3. Give a short account of the migration of birds.

4. Give a list of birds of your neighbourhood that are (*a*) summer residents, (*b*) winter residents, (*c*) permanent residents, (*d*) birds of passage.

5. Write an account showing how the beaks of birds are adapted to their methods of life.

6. Explain the purpose of colours in birds.

CHAPTER XIV

SOME FAMILIAR MAMMALS

Mammals.—The popular use of the term "animal" or "beast" instead of "mammal" to indicate a sub-division of the Vertebrates has already been noticed in Chap. VIII. We hear some people remark "such and such a creature has scales and is a fish or reptile, not an animal." The truth is, of course, that beetles, flies, fishes, reptiles, birds, horses, dogs, etc., are all animals.

One of the noteworthy features of a mammal is the possession of **hair** on the body. Some few mammals, *e.g.* the whale, have scattered bristles on the lips only; in some cases the hair may be of finer texture and called "fur"; in others wavy, as is the "wool" of sheep.

The hair may be very long in special regions of the body; as, for instance, the mane of a horse or beard of a man, whilst in the hedge-hog and porcupine the hairs become enlarged and form protective "spines." Frequently the hairs may be of two kinds—the larger ones forming an outer coat, whereas short, fine hairs, thickly spread among the larger, form an *under-fur* (seal, beaver).

The two fore-limbs of a mammal may resemble or differ from the hind-limbs, but in practically all cases digits protected by **nails** or **claws** are present on the limbs.

Besides the possession of hair, a distinctive feature of mammals is their method of nourishing the young. The latter are born alive (with few exceptions), hence no eggs are laid, and we speak of mammals as viviparous animals. In their early life the young are fed upon milk which is sucked from the breasts (*mammæ*) of the mother. Hence the name "mammal." The milk glands of the mother may, however, open on little projections, or **teats**, ranging over the whole ventral surface of the body and not on the breast region only.

FIG. 98.—Wild Rabbits.

Although mammals differ from birds in being viviparous, yet both agree in the possession of warm blood—hence birds have feathers, and mammals have a coating of hair, in order to keep the heat in the body. It is interesting to find that in the whale the absence of a covering of hair is compensated for by the possession of a thick coating of fat or "blubber."

General External Characters.—With few exceptions the body in mammals is rather darker above than below, A neck usually separates **head** from **trunk**, whilst the **tail** in many mammals is of little importance, and hangs down at the posterior end of the body. Nevertheless, the tail is sometimes useful in swimming (beaver, otter, whale), for climbing (monkey), in warm countries for protecting the body from the attacks of flies (lion, ox, bison, etc.), and in some cases aids the hind-legs in supporting the body (kangaroo). Just as in birds, so also in mammals, we find that there is a close relation between the length of the limbs and neck. For example, horses feed on grass and other vegetation and have long necks, since they require long legs for escaping enemies by swiftness; sheep have horns for protection and usually have rather short legs, and since they feed on grass, only a short neck is required. When cropping grass very close, sheep often shorten their fore-legs still more by bending up the distal end and resting on the "knees."

Prominent ear-flaps, with a passage leading down to the ear-drum, usually project from the head; a horse or wild rabbit may often be seen to turn the flaps in such a direction that a sound may be more clearly perceived. The sense of hearing or else the sense of smell is well developed in most mammals. The whole skin is generally sensitive to touch, but many animals have parts of the body, *e.g.* lips, snout, whiskers of cats, pointed muzzle of mouse, modified to accentuate the sense of touch.

The sight of some mammals is particularly good, the eyes being protected by upper and lower **eyelids**, upon which the hairs are specially long and form **eyelashes.** A third eyelid—the **nicitating membrane**—is translucent, *i.e.* allows some light to pass through, and may be drawn across the eye from its inner angle. The nicitating membrane of a cat's eye is nearly always in use during sunny weather; in ourselves, however, it is much reduced, persisting as a little red knob at the inner angle of the eye.

Mammals are **diœcious**, the male being distinguished from the female in size, colouring, or it may be by the possession of horns, more hair, larger teeth, etc.

Breathing.—Just as we may feel the bony, vertebral column of a cat or rabbit through the skin, so also may we feel the **ribs** in the anterior region of the trunk. The ribs mark off a special part of the trunk, known as the **thorax**, from the **abdomen**. If the finger be pressed against the skin of a cat or rabbit, between the ribs on the left side of the body, the beating of the heart is felt,—the heart being inclosed in the thorax along with the lungs. The stomach, intestine, liver, kidney, etc., are located in the abdomen. The structure dividing thorax from abdomen is a partition of tissue called the **diaphragm**. By the action of certain muscles, movements of the diaphragm and the ribs are effected; the cavity of the thorax is thereby expanded; air rushes in at the mouth or nostrils in consequence, and passes by way of the glottis into the lungs. Thus, breathing is effected by changes in the size of the thorax, the **inspiration** or "breathing in" of a mammal being of the nature of a suction-pump action.

Feeding.—Mammals, in general, use their fleshy **lips** for grasping food, although the **tongue** frequently aids in feeding; the rough tongue of a cat or a tiger acts like a file in scraping a bone clean. The way in which a sheep or cow twists its tongue round blades of grass before clipping them off with its teeth is well known; the fact that there are no front teeth in the upper jaw, those in the lower jaw biting against the gum above, is related to this method of feeding.

Teeth.—The mode of life—more especially the diet—reflects itself in the shape of the head, jaws, and teeth. We may classify mammals into (*a*) **carnivorous**, those feeding upon the flesh of other animals; (*b*) **herbivorous**, those feeding upon vegetation; and (*c*) **omnivorous**,

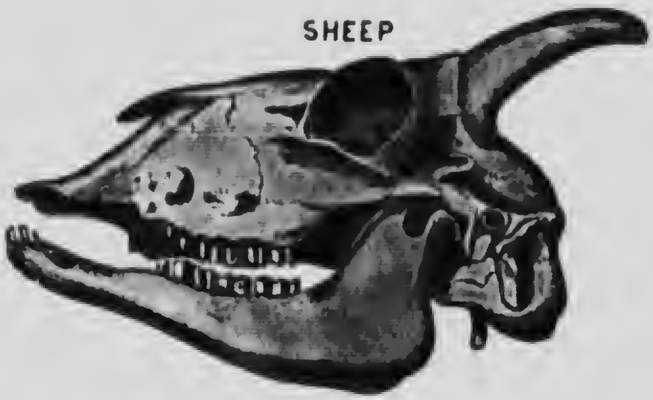


Fig. 99.—Skull of Sheep.
Notice the absence of front teeth in the upper jaw (× [illegible]).

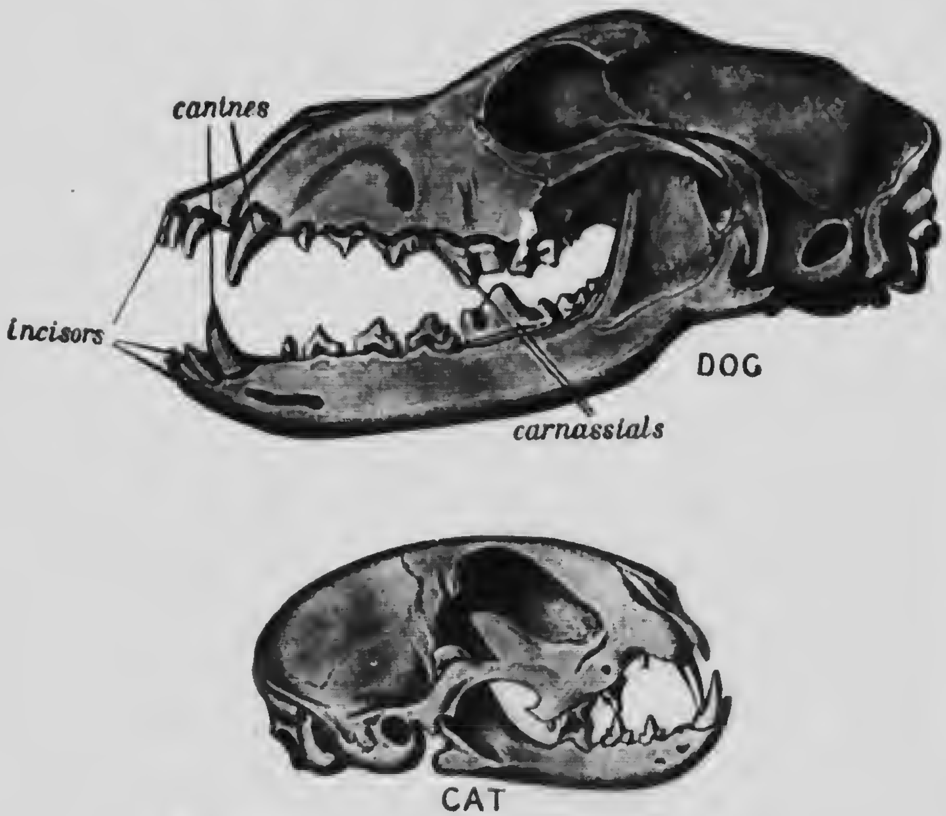


Fig. 100.—Skulls of two carnivorous Mammals (× [illegible])

animals like pigs, rats, etc., which have, like ourselves, a mixed diet.

The squirrel is vegetarian mainly, although it will often plunder a bird's nest and eat the eggs or young. A cat has short, extremely powerful jaws; a dog's are longer and, in proportion to the size of the animal, not so powerful. In both there are four special piercing teeth—the **canines**, long and pointed, and also two shearing teeth—the **carnassials**—on each side of the mouth-cavity among

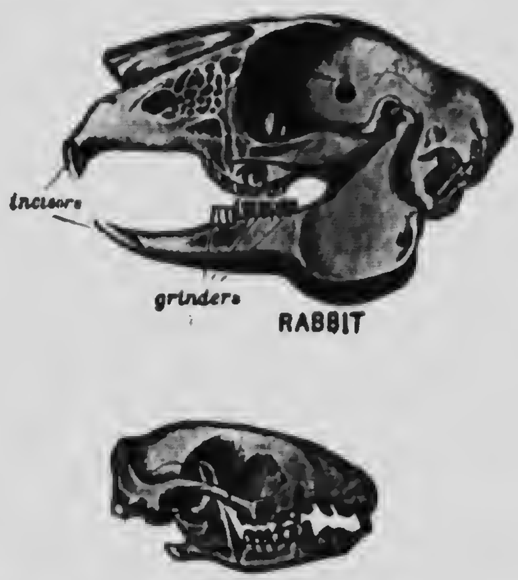


FIG. 101.—Skulls of Rabbit and Hedgehog (× ½).

the grinding teeth, and these work against one another like the blades in a pair of scissors or shears.

In the same way it is easy to distinguish the dentition of a horse. The canine teeth are small or absent, and the front teeth—**incisors**—are separated from the grinding teeth behind by a space, or **diastema**. We have utilized this fact in domesticating the horse, and direct a horse by reins attached to a steel "bit" placed in the diastema.

The teeth behind the diastema in young herbivorous animals have tops or crowns raised into crescentic ridges (horse, cow, sheep, deer), whereas a pig or hippopotamus has conical elevations on these teeth. In the adults of these herbivorous forms the crowns become flat by constant use.

In some herbivorous animals—the **ruminants**—so-called because they take a meal and then at leisure force the food back into the mouth and carefully chew it—the grinding teeth are practically alike in size and shape, all having broad tops, although some of these—the **premolars**—have, like the incisors and canines, been preceded in the

PIG

FIG. 102.—Skull of Pig (× ½).

young by teeth called **milk teeth,** whilst some at the back of the mouth called the **molars** have never been preceded by milk teeth. In many mammals—*e.g.* cats, dogs, and ourselves, the premolars differ in appearance from the molars. Gnawing animals, like the rabbit, gopher, rat, and mouse, have two upper and two lower incisor teeth, which are continually growing, and would grow so long as to be useless and cause the animal's death by starvation, were it not for the fact that the gnawing habit results in the ends of these incisor teeth being continually worn away.

Omnivorous animals have numerous teeth which seem to be sufficiently adapted both for a carnivorous and for a herbivorous diet.

Locomotion.—An expert zoologist could identify an animal by the shape of its skull and the number, shape, and size of its teeth. There is, however, another feature in mammals which is wonderfully adapted to the animal's habits and environment—the **limbs**. Speaking generally, we expect to find mammals possessing great swiftness (horse and deer) with rather thin legs—the proximal part of the leg down to the knee or elbow being short (in horses this region is concealed in the body); the wrist or ankle-joint is some distance from the ground, because the hoof corresponds to our finger-nail or to a cat's claw—the cow or deer actually walking on the tips of two fingers or toes, whereas the horse walks upon the single finger or toe present on each limb. For this reason such animals are said to be **digitigrade.** The short proximal end of the limb moved by powerful muscles and followed by a long, thin distal region is quite in accordance with the principles of leverage, and results in the maximum of speed being attained at the expense of the minimum of muscular exertion.

Again, swift animals like deer have the fore-legs close to one another, also the hind-legs; animals with legs wide apart—bull-dog or elephant—usually have a compartively heavy body and little speed. Notice the legs of a cat: they are short, ending in powerful claws, and effective in springing upon and seizing the prey; the soft pads under the feet enable the animal to move softly and to alight gently after a spring; moreover, the swift movements of a cat or lion consist of rapidly repeated leaps. The cloven hoof of a sheep, goat, or deer seems to be a factor in its sure-footedness when feeding in its natural mountainous environment. The blunt claws of foxes, dogs, and wolves are useless for climbing or for seizing food; probably their claws are for scratching away earth and leaves in search of food.

The slender, free toes of a squirrel or mouse, with curved claws, are suitable both for climbing and for grasping objects. Thus the hind-limbs enable a mouse to sit up and

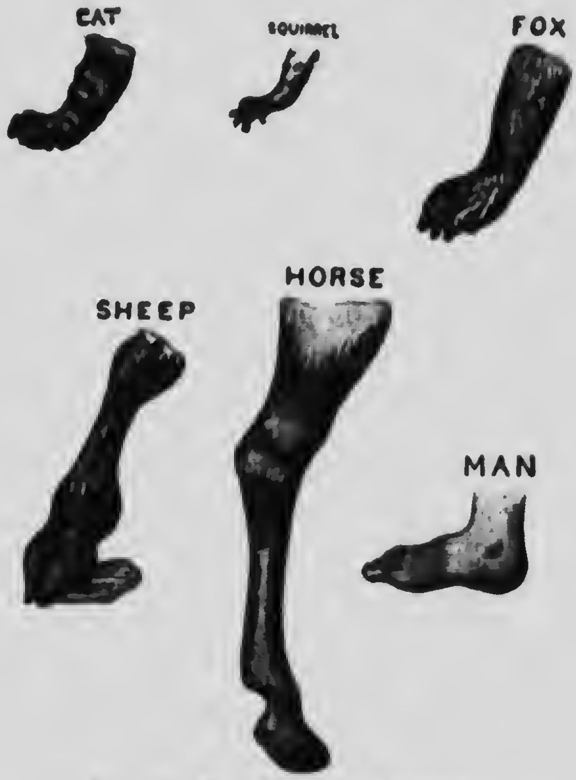


FIG. 103.—Feet of various Mammals.

use the fore-limbs exactly like hands for holding the food while it is being eaten.

Badgers, otters, and bears walk, like ourselves, on the sole of the foot, and they are therefore called **plantigrade**; a great many mammals—cats, dogs, mice, etc.—walk on part of the sole only, and are hence called **sub-plantigrade.**

The fore-legs of a rabbit are rather short, while the hind-legs have very long soles, which come in contact with the ground when the animal is running or feeding. When moving quickly by a series of rapid leaps, the hind-limbs are very useful, only the distal ends touching the ground. The soles of the long hind-limbs are covered with hair, the blunt claws at the ends proving useful in making burrows.

Sleep.—We are acquainted with the hibernation or winter-sleep of amphibians and reptiles; birds and mammals do not usually hibernate, but have regular periods of rest and inactivity. Animals which sleep during the day and are active at night are called **nocturnal**; those which sleep at night and move about in search of food, etc., in the daytime are said to be **diurnal**.

Adaptation to Environment.—After the foregoing description of the modifications in the teeth, jaws, legs, claws, feet, tail, etc., of familiar mammals, the reader will have no difficulty in finding many more cases of adaptation to environment among mammals. Perhaps the colouration of the body may be briefly dealt with. We cannot connect the colouring of our domestic animals with any attempt at protective colouration, because there has been no attempt to breed by artificial selection with this aim in view. Hence the colouration of our domestic animals has, so to speak, run riot. This is not the case in the wild rabbit. The livery of this rodent is of a grayish-brown or whitish-brown hue, with a white tail behind. The brown or sandy colour closely harmonizes in appearance with woods in which the ground is covered with withered leaves, and it is thus not always easy to see a rabbit crouching among the leaves. It has been suggested that the white spot on the tail serves a useful purpose. Rabbits live together in numbers, and when danger threatens, the startled animals rush wildly away from their foe, those in front, with the white surface of the up-turned tail fully exposed, serving to guide those which are behind. The hare has a brown colouring, which closely harmonizes with the braken and shrubbery in which it is accustomed to shelter, since it does not burrow like some rabbits: one very interesting feature about the "varying" hare—which inhabits regions covered with snow for a considerable part of the year—is that the summer brown coat is exchanged as winter approaches for a white coat much less noticeable in snowclad districts.

Protection.—Many herbivorous animals, like the horse or deer, trust mainly to speed for escaping from an enemy, although the horse can deal a powerful blow in self-defence with its hind-feet. Deer, oxen, sheep, and goats have either **antlers** or **horns** with which they protect themselves against other animals and also against one another, since there is often a fight between animals of the same species. The claws of a cat and the teeth of both cats and dogs render them dangerous adversaries, especially when they are defending their young—a period at which all mammals are most bold and reckless. Of course, mice and squirrels trust to their climbing powers when pursued; in each case the large tail behind may be seized and bitten off by an oncoming foe, but while the separated tail or fluff is being dealt with by the enemy, the little creature may be afforded just sufficient respite to enable it to attain a place of safety.

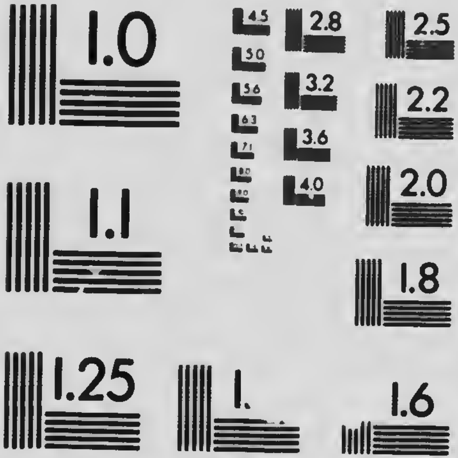
Some rabbits burrow in the ground, and have neither the speed of hares, nor any special organs of defence other than the blunt claws; when danger threatens, they rush into their burrows.

The passive means of defence of a porcupine are familiar: the animal simply rolls itself into a prickly ball when attacked.

Intelligence.—Mammals have been domesticated by human beings more than other vertebrates have, because

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



of their high degree of intelligence. Hence they are useful as servants, protectors, and pets. If the size and complexity of the brain is any criterion of an animal's intelligence, it is only necessary to compare the relative size and structure of the brain of a dog or rabbit with that of a fish or reptile to see how much higher are the former in the scale of creation.

PRACTICAL WORK

Examine a cat, dog, or rabbit, in order to see the characteristic features of a mammal.

Note the hair or fur; head with mouth-cavity, with different kinds of teeth, fleshy lips; eyes with upper and lower movable eyelids, the eye-lashes, and the nictitating membrane; the whiskers; ear-flaps, with a passage leading down to the ear-drum; flexible neck; trunk with four legs; and tail.

Compare the tail in a cow, horse, dog, gopher, and mouse; the teeth in a cat, dog, rabbit, horse, pig, etc.; the feet and claws in a dog, cat, squirrel, rabbit, mouse; the hoofs in a pig, sheep, cow, and horse; the horns of sheep, cows, and goats.

Watch a cat or dog cleaning a bone, a sheep or cow eating grass, and a rat or mouse gnawing some object. After feeding, sheep and cows may be observed to "ruminate" ("chew the cud").

Compare the manner in which animals like horses, cows and sheep, tread (digitigrade), with that in which sub-plantigrade animals—dogs, mice, etc.—tread.

Plantigrade animals (like the bear, badger, and ourselves) rest the whole sole of the foot on the ground during movement (compare also the hind-limbs of a rabbit).

Notice that the colouration of the body of many wild animals is protective (*viz.* aids in enabling the particular animal to escape detection by enemies). In domesticated animals the colouring varies considerably in the same species and has lost its protective value.

EXERCISES

1. Enumerate the distinguishing characteristics of fishes, amphibians, reptiles, birds, and mammals. How do all these animals differ from an earthworm?
2. Make a rough classification of mammals.
3. Why are we ourselves included among the mammals?

INDEX

Black-faced numbers indicate that there is an illustration of the topic on that page