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MODERN SCIENCE

BOOK III

BIOLOGY

WITH INSTRUCTIONS FOR SIMPLE
EXPERIMENTS AND FIELD WORK

BY

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PREFACE

THIS book, written in response to a request for a third volume in a series suitable for girls and boys in Senior and Central Schools, presents some aspects of the ways of living which may be studied in familiar plants and animals in the out-door world and in the laboratory. To quote the late Sir Arthur Thomson and Patrick Geddes in their last book *Outlines of General Biology*: "Science is first of all inductive, hence it is some fresh first-hand observation which best sets a bright mind working, and to search more deeply." This has long been my conviction tested again and again among children of all ages as well as students in training. The person I want to meet is not the one "who can show me species I have not seen before," but the one "who can tell me something more about the commonest ones . . . and so help me to understand them better." With this plea of Thomas Henry Huxley for patient observation in mind, I have put forward a number of definite suggestions to stimulate girls and boys to make independent studies of individual plants and animals at different hours of the day and in successive months through a whole year

Daffodils in a narrow window-box are as lovely as any that adorn the most famous gardens; our city blackbirds rival even those which sing in unspoiled woods; failing mountain, forest and lake, I turn to the nearest hillside, copse and pool, with open eyes and ears, and am invari-

ably well rewarded, and challenged too; each fresh observation suggests the need for further study.

The limitation of space has set rigid bounds both to the scope of the book and the development of those aspects of biology which have been selected. Further reading is most important. A great number of books and magazines devoted to natural history and biology have appeared in the last few years but since a short list could not be representative none is given. The glossary of terms introduced in the text will help the less advanced pupils who may use the book to understand it and for those who are older or have a fuller background it may well serve as a method for testing out their understanding. Simple experimental work demanding only an elementary knowledge of physics and chemistry is introduced. Only inexpensive apparatus is required. The use of a microscope though very desirable is not assumed.

Messrs. Macmillan & Co. have kindly made available many illustrations from other of their publications; other diagrams and photographs for which I am not responsible personally are acknowledged, each in the appropriate place. I wish to record my thanks for permission to use them. To the publishers for their consistent courtesy, and in particular to Mr. L. J. F. Brimble, whose advice has been most valuable, I am glad to express my thanks.

M. MUNRO

LONDON, 1939

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CHAPTER 1

WHAT IS BIOLOGY?

ONLY part of the answer to this question will be attempted in this first chapter. When you have studied out of doors as well as in school the many things in which this small book attempts to interest you, a fuller answer will be possible.

In almost every part of our country, though it offers great variety of scenery, we can see throughout the year, green plants, such as the common grasses, and birds, for example, house sparrows, starlings, robins, or blackbirds.

Can you think in what ways these plants and birds resemble one another? At first you may feel baffled, but consider what you know about both in the different seasons of the year, beginning in January. In the public parks during a thaw or after heavy rain when the ground is very soft, you may have read on a board " No Games Today," and while the ground was frozen hard you will probably have watched dozens of birds eagerly drinking the water and feeding on the crumbs put out by people who realize their pressing needs. The park keeper must take care of the grass as well as the more attractive plants in the borders, for all plants *grow* unless they are ill-treated, and by right treatment we can help all those that we cultivate to grow well ; equally, birds like kittens and human babies grow when they are given what are often called the necessities of life. Now this growth of all

plants and all animals, which we often take for granted, depends on other processes shared by them and is in truth not simple but very wonderful.

Growth

You may have planted corms or bulbs in the autumn, and seeds in the spring. Next time you do any planting

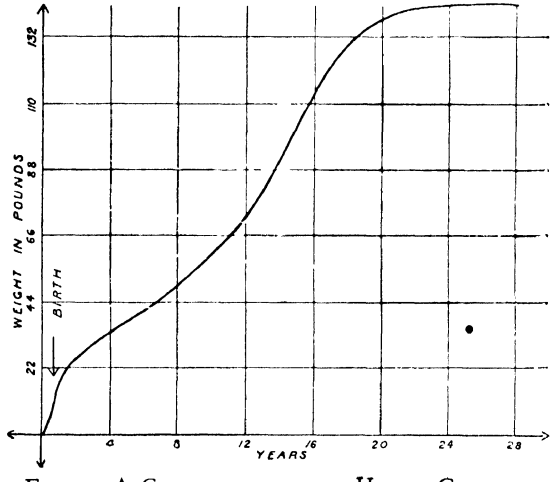


FIG. 1. A CURVE ILLUSTRATING HUMAN GROWTH.
(By courtesy of the B.B.C.)

weigh what you put into the soil and some weeks or months later weigh what we may call the whole crop; it might be five or six crocus corms, or a similar number of hyacinth bulbs to be weighed first in September; seven months later when the flowers were no longer beautiful there would be roots (freed from soil or fibre), stems, leaves and withered flowers to be weighed. You

would notice and record not only an increase in weight but also a remarkable development.

Some of you may go to a welfare centre and see for yourselves, or hear from your mothers, reports of the increase in weight of small brothers and sisters. The height and exact weight with the date are carefully recorded on each visit. It is interesting to plot growth-curves as illustrated (Fig. 1).

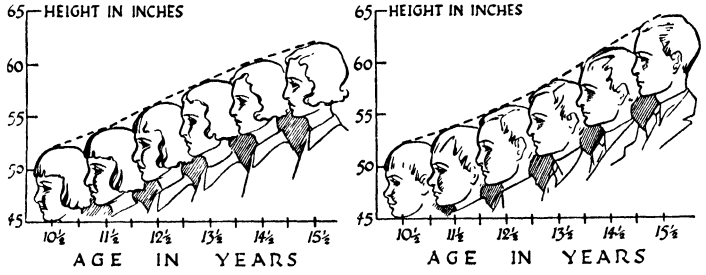


FIG. 2. GROWTH IN HEIGHT OF CHILDREN.
(By courtesy of the Scottish Council for School Broadcasting)

You need to watch growing plants and animals very closely to learn even half their secrets. Do the roots, leaves, and flowers of the hyacinth and crocus lengthen at the same rates week by week? Does a baby's head grow as fast as its body? Do your own height and weight records show equal increases month by month, or year by year? (Fig. 2.) Try to answer the same questions for various animals.

The human baby and the plant for which a growth-curve is shown (Fig. 3A) were supplied with the necessities of life. Now suggest what these necessities are.

Your list will be very like mine, though the sequence or order in which you place the items may be different.

Here is a question which will guide you in giving first place to what is most essential: For how long can a man live without (*a*) air; (*b*) water; (*c*) food?

I think that you will know that the answer to (*a*) is "Less than a minute," to (*b*) "Only a very few days" and to (*c*) "For a few weeks, if he is strong but rests much

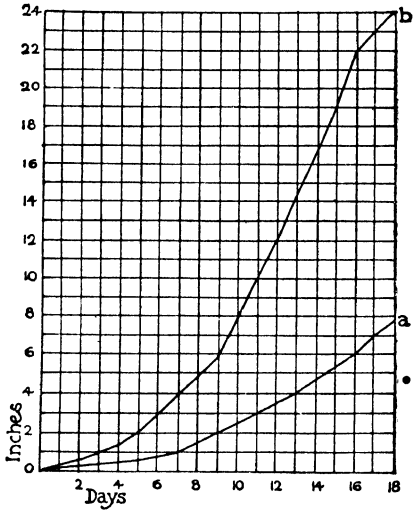


FIG. 3A. GROWTH-CURVE OF BEAN SEEDLINGS.
(*a*) in the light: (*b*) in the dark.
From Woodhead: The Study of Plants (Clarendon Press)

of the time." None of you in asking these same questions about a baby, or even of yourselves, would expect to receive just the same answers, for as you realize, a baby is growing rapidly, whereas a grown man has chiefly to make good the wearing and working of his body. But the answer to (*a*) and (*b*) are really the same. Baby and grown man must have air to breathe or they will soon

die. It is the *oxygen* in the air which they require. In extreme illness, pure oxygen, stored in great metal cylinders, is given to patients. You will often see oxygen cylinders in a chemist's shop. Returning to the green plants, you can perform a few simple experiments to show that they too respond to lack of air containing oxygen, though less quickly, because they need less energy. Indeed, dormant seeds, like some hibernating

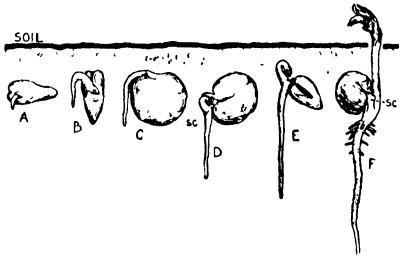


FIG. 3B. GERMINATION OF BROAD BEAN ($\times \frac{1}{4}$).
In whatever position the seed is sown in damp soil the radicle always grows downwards. *sc*, stalk of cotyledon or seed-leaf.
From Yapp: Botany for Junior Schools (*Cambridge Press*)

animals, obtain just sufficient energy to keep them alive without taking in oxygen from the air.

Aquatic animals and plants no less than the land-living or terrestrial forms require oxygen, and this occurs dissolved in the water.

In Book I, Chap. 1, you learnt something of what happens when substances burn in air, that rusting is a form of slow combustion or slow burning, and that in burning, the oxygen of the air is used up while the inert or "lazy" *nitrogen*, together with very small quantities of other gases, are left.

Experiment 1

In a clean saucer on three small pieces of clean wet bath sponge or cotton wool sprinkle mustard seed. Cover the saucer with a sheet of glass. Prepare three little perforated zinc " cradles " each to hold a piece of moist sponge with seeds. Fix strong thread to each at three points. Take three gas jars and label them *A*, *B*, *C*. Smear " Vaseline " in a ring on two flat glass covers to fit the tops of two gas jars later on. The uncovered jar, *C*, should be provided with a " wick " of gauze or blotting paper to carry water up to the sponge, or desiccation may soon occur. Into *C* and *B* pour water to a depth of two inches. Leave *C* open. When you have arranged the supporting threads satisfactorily lower a " cradle " with seeds into each; cover *B*. Into *A*, pour *freshly* made solution of fresh pyrogallol in caustic potash to a depth of two inches. Quickly lower the third " cradle " one third of the way down. Fix the supporting threads as before. Cover. Write on labels the date and time and fix these on the three jars. Sketch them quickly, naming the liquid in each (Fig. 4). Place them in darkness where there is a moderate temperature (about 55° F.—65° F.) After 2 to 3 days examine and sketch again, writing the date.

How do you explain the fact that in *A* very slight germination or none has occurred, while in *C* and *B* growth is obvious? Leave the three jars in the light for three or four days, and observe them at least once a day. Sketch them if you can.

How do you explain the greater growth in *C* as compared with growth in *B*? Which of the three jars provided

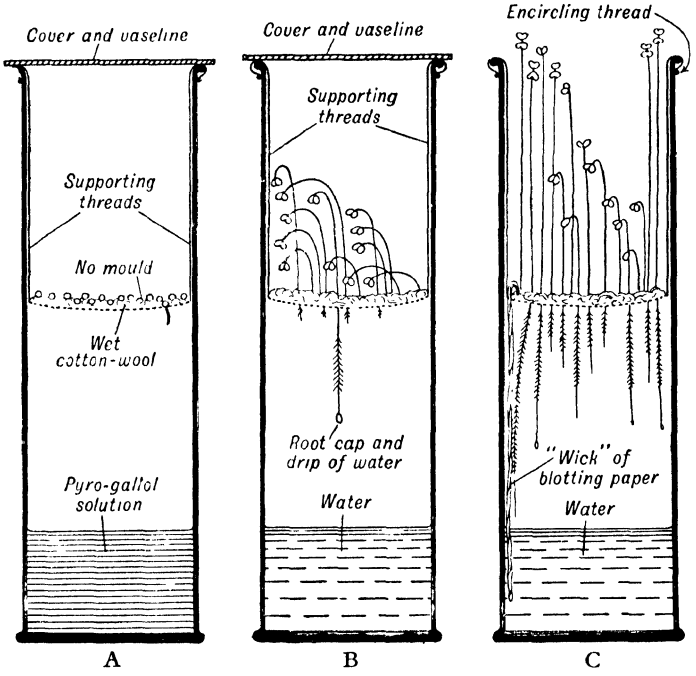


FIG. 4. GERMINATION AND GROWTH OF MUSTARD SEEDS.

Experiment set up June 2. Sketches made June 9.
50 seeds in each jar.

In *A* four seeds showed radicle.

In *B* all seeds had germinated but very few had thrust radicle through cradle. All had collapsed and were tinged pink with bacterial growth.

In *C* all seeds had germinated: on the testas some blue green mould had developed recently.

conditions closest to normal and therefore most favourable for growth? Notice that one condition was changed in *B*, as compared with *C*, and one further condition was changed in *A*. It is essential in all experimental work

with plants (as with animals) : (1) to set up *controls* (such as jar *C* in Exp. 1.) ; (2) to introduce one change at a time ; and (3) to avoid extremes unbridged by any intermediate condition. In jar *B* the air becomes very humid and the seedlings may collapse after a week, possibly because a very small fungus has been thriving at their expense. There may be bacteria at work, causing a deep pink or other colouring.

This experiment appears to show conclusively that :

(1) Without oxygen from the air seeds do not germinate satisfactorily.

(2) When germination has begun, a supply of oxygen is still needed for growth to continue.

A fourth covered jar containing the pyrogallol in caustic potash should be tested with a lighted splint to confirm the assumption that most of the oxygen of the air has combined with it.

Experiment 2

Set up three sets of three jars : (1) As above—After a few days the three lots of mustard seedlings (or seeds), if lifted and planted in pots of soil could all be observed with advantage.

(2) Using the same kind of seed, but submitting them to a lower temperature.

(3) Using some other kind of small seed, for example, canary grass, or cress, and putting the jars in the same place as set (1). Shepherd's Purse and Chickweed might well be tried too.

You will then be able to learn something about the effect of temperature on growth and see that though

mustard seed responds very rapidly to right conditions, it is not exceptional.

Respiration

Germination and, further, growth depend on the process of *respiration*, which is not strictly the same as breathing. We ourselves, like all the higher animals with backbones, for example, horses, dogs, pigeons, and goldfish, make regular breathing movements during respiration, because we have special breathing organs (lungs in all the examples named except the goldfish which has gills). Plants, on the other hand, have no special breathing organs and make no special breathing movements; yet they respire for, through countless very tiny openings on their leaves and stems, they take in oxygen and give out carbon dioxide.

Experiment 3

A good way to demonstrate the presence of these tiny openings is to take a large freshly picked leaf with a smooth shiny surface, for example, ivy, or laurel. Cover it with cool water. Wipe it clean. Plunge it in a beaker of water which is hot but not boiling. Observe the globules of gas which escape, in some leaves from both sides, in others, from the lower side only.

Experiment 4

Write *Distilled water* on two labels, and *Lime water* on two others. Fix these on four clean glass vessels, preferably beakers and half fill these with the liquids named.

Cover one of each with a postcard to keep out dust. Into the other two in turn, blow gently through a clean glass tube, observe what happens, and record it. At the end of the lesson record what has happened in the two covered beakers.

This very simple experiment shows that we (like other animals) breathe out a good deal of carbon dioxide, but also that there is a little present in the ordinary air which we breathe in.

Experiment 5

Here is a simple way of demonstrating two gaseous exchanges in one experiment:

Have ready about two dozen peas which have been soaked in water for 12-16 hours. Take two large glass U-tubes, each with two well-fitting rubber stoppers. Label them *A* and *B*. Into *A*, pour freshly made baryta water to a level corresponding to that marked in the diagram (Fig. 5) and indicate the level XX on the narrow label on each limb. Into *B*, pour olive oil, and mark the level XX. Into one limb of each U-tube, lower one dozen seeds in a muslin bag with a long loop of thread. Fix the bags so that they are just below the stoppers, using a glass "pin" if you can make one. Leave *A*, and *B*, in the dark. After one day and again after two days, observe and sketch. How do you explain the changes of level of the baryta water in *A* and the unchanged level of the olive oil in *B*?

Repeat this experiment with pieces of young mushrooms the gills of which are still pink, or with roots of bulbs grown in water, or in fibre, but after you have

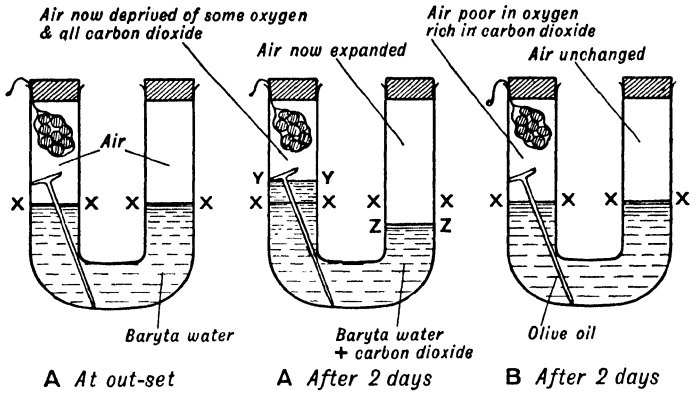


FIG. 5. GASEOUS EXCHANGES IN SEEDS.

The glass " pin " can be used as a prop to keep the seeds above the liquids.

washed them well, and note the time factor in every instance. Which were most active in their respiration?

In *A*, we judge that a certain volume of oxygen has been removed from the air of the left limb. Carbon dioxide of the same volume has been given out by the respiring peas and absorbed by the baryta water—$xy = xz$.

In *B*, the same gaseous exchange has occurred, but since olive oil does not absorb carbon dioxide, its level remains unchanged. The condition of the air in the left and right limbs of *B* should be tested with a glass rod carrying a drop of clear lime water.

Food

You know how the hardiest plants such as the common grasses, when receiving too little water become limp and

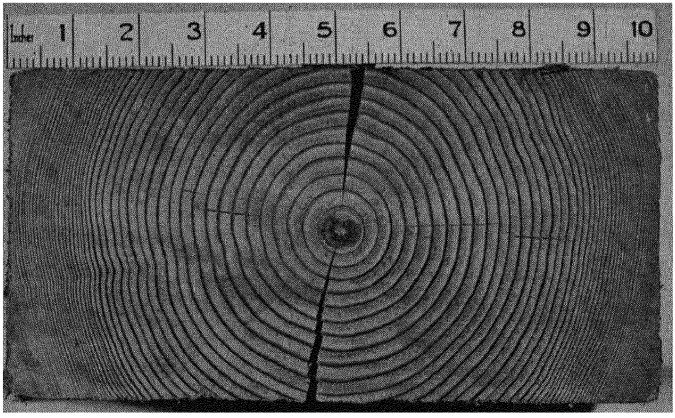


FIG. 6.

ANNUAL GROWTH RINGS BY WHICH THE AGE OF A TREE AND THE RATE OF GROWTH IN BREADTH OF THE TRUNK CAN BE DETERMINED.

(*Crown copyright reserved. Reproduced by permission of the Director, Forest Products, Research Laboratory*)

wither, and it is true to say that when puddles and streams are dried up or frozen, many birds, including house sparrows, die of thirst.

Water, as you have already learned, is a solvent for many things including mineral salts and sugar. Later you will learn something of the importance of water in relation to food, and in other ways in the life of plants and animals. What is taken in by the grasses could not be used by a house sparrow or by man, but animals, like plants, have the power to *assimilate* their food. That is, they are able to convert what they take in, whether as gas and liquid, or as liquid and solid, into their own body substances. Only so, can they grow (Fig. 6). Later you will be able

to show experimentally that all green plants depend for their food very largely on the gas carbon dioxide, present in the air, in addition to mineral salts present in dilute solution in the soil. Animals, on the other hand, depend on other animals, or directly on green plants for their food. Make out lists of the kinds of food given to tame rabbits and domestic cats.

Rabbit		*Cat*
Oats, bread crusts (brown)	grain from green plants	Meat
Hay; cabbage and dandelion (both limp)	green foliage	Milk
Carrots, swedes	roots of green plants	Fish
Water		

It is clear that the rabbit is directly dependent on green plants. What of the cat? The meat is the flesh of animals which are grass feeders, and milk is produced by the cow which in summer is fed on grass, and in winter on hay, and cattle cake (made largely of the seeds of the cotton and flax plants), together with dried pulp returned to the farmer from the factories where sugar has been extracted from the sugar beets which he has grown.

The feeding habits of fish, such as the cod, have been fully investigated, and we know that they depend on small marine creatures which in turn depend entirely on minute green plants in the sea. These plants are so small, however, that they can only be studied with the help of very strong lenses.

Chlorophyll

In looking through the preceding pages you will notice how frequently the word *green* is used, and there is a definite reason for this. This green colouring matter in plants called *chlorophyll* has the power to react to light rays from the sun in such a way that from two very simple substances with which you are familiar sugar is built up. The two substances are the gas carbon dioxide and water in the liquid state. In a later chapter you will learn how to set up experiments which will satisfy you about the truth of the above statement. The plants cannot store large quantities of sugar which is soluble in water and much of it is changed into insoluble starch, and stored whether in corms (in the crocus), in tubers (in the potato), grain or seed, and other parts. Some of the sugar is used up in the growth of root, stem, leaves, flowers and fruit.

Reproduction

There is yet another way in which plants and animals resemble one another. There are many thousands of different kinds of plants and animals living in the world and these continue year after year, and century after century. It is true that some individual animals, such as tortoise, parrot and elephant, are more than a hundred years old. Still more remarkable for their length of life are some individual trees, for example, oak and yew in our own country; the Californian Redwoods attain still greater ages; many of them are more than 3000 years old; but finally even these great trees grow old, slowly decay and die. Yet their *kind* persists. That is, most plants and animals *reproduce* their kind.

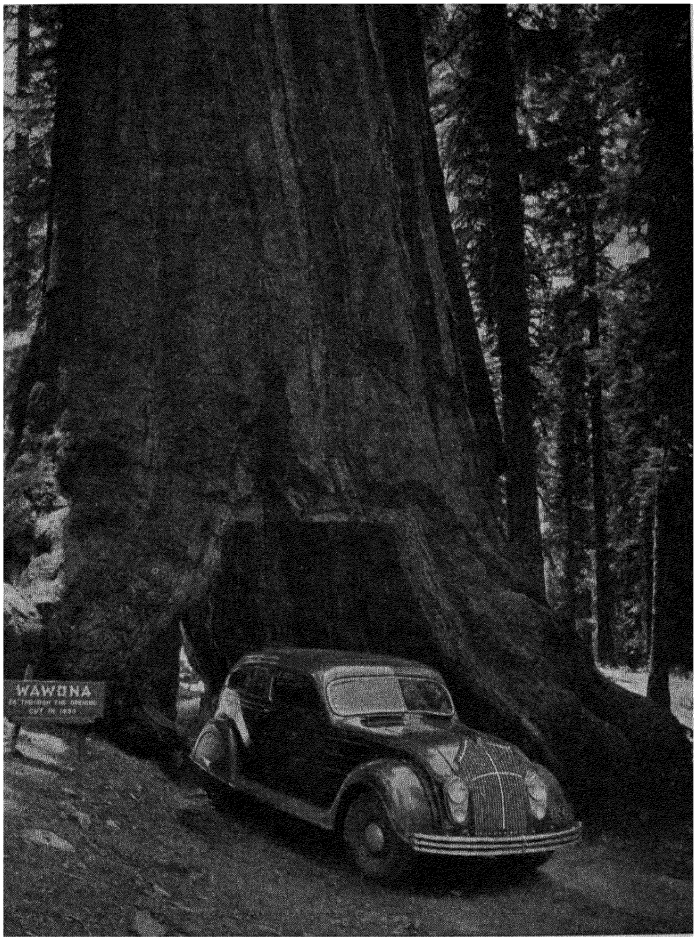


FIG. 7.

THE LOWER PART OF THE TRUNK OF A GREAT REDWOOD.

Experiment 6

Soak a sufficient number of seeds, *e.g.* barley, wheat, mustard or peas, for half-an-hour. Rinse them and fill a thin-walled flat-sided medicine bottle with them. Let water drip in slowly from a tap. Shake the bottle to displace air ; then add more seeds so that they are tightly packed. Tie tapes or fix broad rubber bands round cork. Then stand the bottle in a larger vessel of water. Observe what is happening twice a day and report.

Evidence of the force exerted by growing plants may often be seen in tar-covered paths in bumps and radiating cracks which reveal Dandelion, Bindweed and other hardy weeds.

SUMMARY OF THE CHAPTER

Things to Note

1. Biology is the study of living plants and animals.
2. For animals and plants the necessities of life are essentially similar. What are they?
3. In growing, do different parts of the same plant or animal always develop at the same rates?
4. What gas is taken in and used in the process of respiration? What gas is given out?
5. In what sense is the whole animal world dependent on green plants?

CHAPTER 2

THE SUN THROUGH THE YEAR

You have seen that temperature influences rate of growth, and will remember that my first question about likeness between plants and animals was followed by the suggestion that you should consider some familiar examples of both groups in different seasons of the year, beginning in January ; in this month in our own country, as in many others, the days are short and the nights are long. In most calendars, diaries, and daily papers, you can find out the exact times of sunrise and sunset in London, or some other big city. In late autumn, in winter and in early spring, you may often verify these times for yourselves, whereas, during the rest of the year the days are so long that you will seldom see their opening, or their close. When does sunrise in London coincide with sunrise in Newcastle or Carlisle? In what months are the intervals of time between sunrise in Newcastle, and sunrise in London greatest?

Length of Day

The diagram (Fig. 8A) was made by plotting the times of sunrise and sunset at (1) Greenwich Observatory (in London), and (2) Newcastle,* for each week in the year.

* Since Newcastle lies about 1½° west of the Greenwich meridian the curve for this place is based on times for a point in the North Sea which is 1½° to the east and directly north of Greenwich.

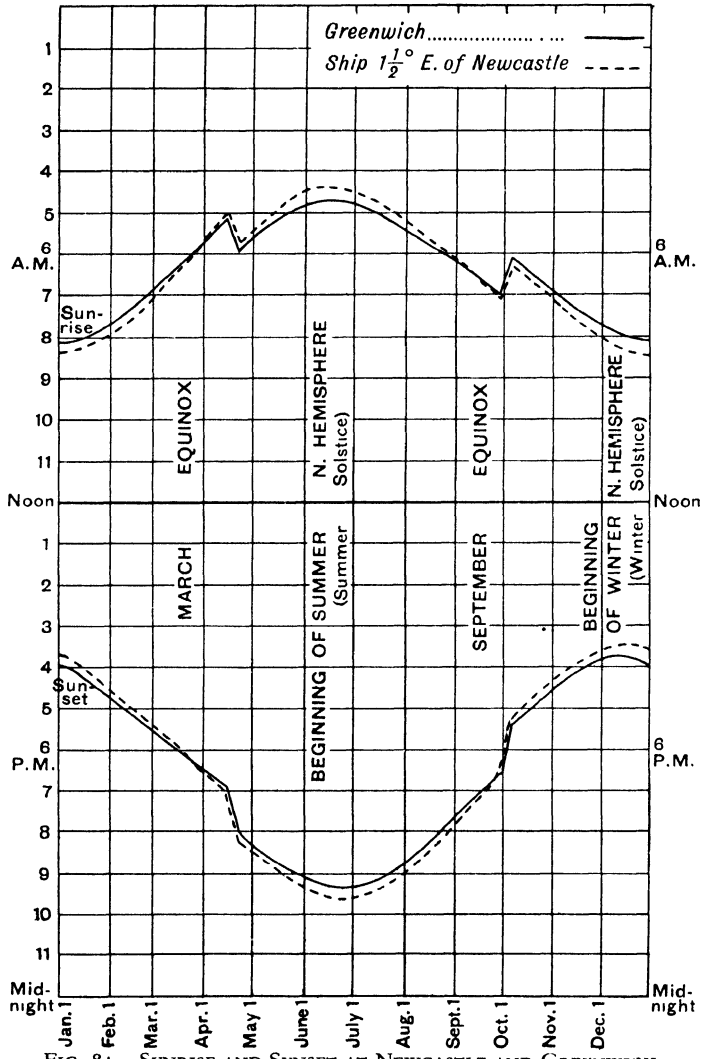


FIG. 8A. SUNRISE AND SUNSET AT NEWCASTLE AND GREENWICH.

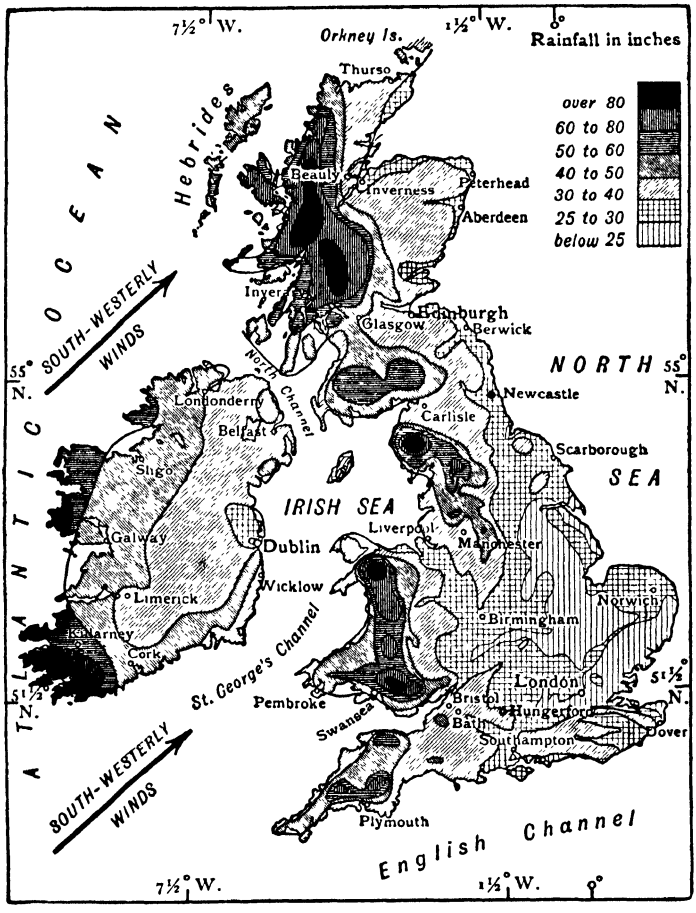


FIG. 8B.

MAP OF THE BRITISH ISLES SHOWING THE AVERAGE ANNUAL RAINFALL AND THE PREVAILING WINDS.

½° of latitude is approximately 35 miles.

For what other places in our own country is the length of day shown for Greenwich correct, week by week? For what other places do the Newcastle curves give the length of day accurately throughout the year? Reference to a globe or an atlas will help you to answer these questions, and similar questions for the whole earth. Notice that the globe is set with its axis of daily rotation (passing through the north and south poles) at an angle of $23\frac{1}{2}°$ to the plane of its orbit in which it takes a year to revolve.

This may all seem to be rather remote from biology, but is really very important. A particular instance will make this clear. In the Tropical House at the Zoological Gardens in London in recent years, visitors have been able to watch a great number of tiny humming birds whose native haunts are in the humid forests of Brazil. The house is kept very warm (air 80°-85° F.), and the air remains humid through the action of a tiny fountain and the presence of moist soil and living plants. Specially designed glass bottles of this shape (shown in Fig. 9) are suspended from the shrubs. These bottles contain a highly nutritious liquid food. To obtain this, the birds hover, moving their wings so rapidly that they are often almost invisible or blurred, and one has to look closely to see the shooting forth and withdrawal of the long tongue beyond the narrow tapering beak. Much energy is expended in keeping the body poised in mid-air while obtaining food, and since these flashing gems of changing colour are attuned in Brazil to a day of ten or fourteen hours, in their London home in winter, electric lights are used to make their days long enough for them

to sip sufficient food; they cannot feed in the dark. You will like to know what this food is:

Morning	- -	Honey, protein, milk and water.
Afternoon	- -	The same.
Evening	- -	Honey and water only.

The bottles are thoroughly cleaned three times a day. The high temperature of the Tropical House would cause

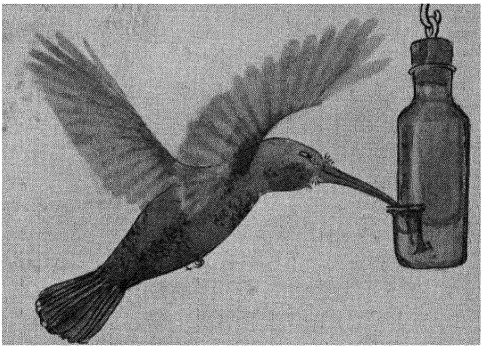


FIG. 9.
GREEN-BREASTED HUMMING BIRD FEEDING
(*London Zoo. Autumn* 1938)

the souring of the richer mixture during the long night period.

In their own country, the humming birds depend on the nectar of long tubular flowers, and I have seen some of them eagerly darting at a bunch of freshly cut snapdragons held by the keeper inside their aviary.

In England one of our native moths is very aptly called the Humming Bird Hawkmoth on account of the rapidity of its wing movements when it is sipping nectar

from such long, narrow tubular flowers as the Valerian. It was fascinating to watch this insect one June day in Sussex. Not until it settled could I tell whether it was a moth though I recognized the movements as very like those of the humming birds I had watched one June afternoon in front of a lilac bush not very far from New York city. The narrow tapering tongue was stretched

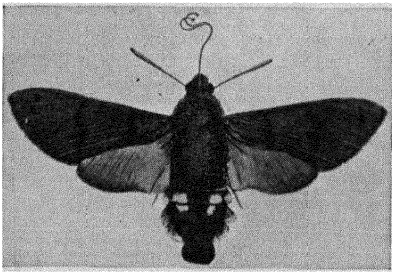


FIG. 10.
HUMMING BIRD HAWKMOTH.
Notice broad scales at sides and rear end of the body.

far forward when in use. It is coiled and withdrawn between times of feeding (Fig. 10).

Observation of Details

This digression suggests quite clearly, I think, three important ideas: First, animals in two very different groups (namely, insects and birds in this example) are able to secure the same kind of food in very much the same kind of way though they are built on quite different plans; second, observations on living creatures and plants should include dates and localities in some detail; third, before plants or animals are removed

from their natural haunts, the conditions to which they are accustomed must be studied so carefully, that the right kind of provision can be made for them in their new homes. You may wish to begin making records of what you yourself notice from time to time. Here are a few of my own:

BIRD: **CORNWALL** **APRIL 1936**

The Swallow TRURO **16th**

Saw one, the first this year for me, flying over the water and beach at low-tide in the evening near Boscawen Park. Weather: cool, but bright (after heavy hail and snow in morning).

17th

Saw two birds, on way to Malpas. Cool, dry, sunny.

FALMOUTH *Morning.* **21st**

Watched two birds flying over beach and putting-green on top of cliff. Three times within half an hour, the birds rested on the turf, and appeared to be pecking something there. Weather: very rough, with a cool wind and driving rain.

22nd

Watched two birds at same place. They did not settle. A fine day.

Other brief card records of which some are for London can be kept as follows. A pair for the same or approximately the same date in two years in the same place often proves particularly interesting or a pair like this:

ORCHARDS **MAY 9th 1935**

KENT, STOCKBURY

Apple and cherry trees laden with blossom. A full yield is expected.

ORCHARDS **JUNE 10th 1935**

KENT, STOCKBURY

All apples and the whole of the early cherry crop ruined. A disastrous season.

BIRDS	4 p.m. MAR. 21st 1936
S.W. London	
Black-headed Gulls remain on or near ponds during daytime.	

BIRDS	4.30 p.m. MAR. 21st 1937
St. James's Park, London	
Black-headed Gulls still present in large numbers on lake.	

FLOWERS	JAN. 31st 1936
London Parks and Gardens	
20 different kinds counted.	

FLOWERS	JAN. 31st 1937
London Parks and Gardens	
26 different kinds this year.	

Can you see any advantage in keeping a record on separate cards rather than in a note book? Sometimes I need to put together information on one group of animals, for example, "British Gulls," or the "Mallard," which is the commonest of all our ducks and fully repays study throughout the year. At other times I may wish to put together all my observations for the first week of spring in successive years, and compare dates for the opening of leaf-buds on trees, the opening of flowers, and the appearance of honey bees and butterflies.

In arranging such records on cards which are readily filed in boxes or small drawers under definite headings, you make it easy to pick out any you may need, and it is a simple matter to put them back in their right places (see Fig. 11).

Moreover, as your records increase in number and variety, it is quite simple to subdivide any section. You

may begin with "Green Plants," and later find it convenient to separate the "Herbs," from "Shrubs," and "Trees," which as you know are woody. Later on you may want to subdivide further and it will still be quite simple to do so. Whenever you wish, you can start a new section, for example for "Fungi," which as you probably know are plants containing no chlorophyll, and living in a very different way from green plants.

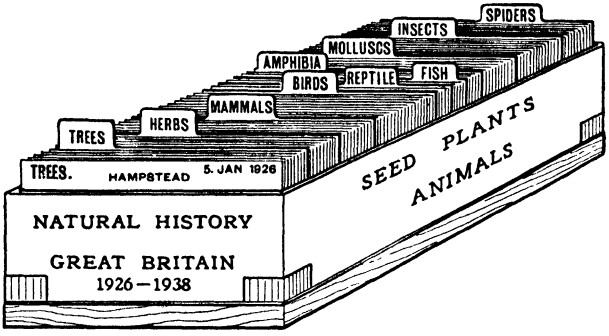


FIG. 11.

CARD-INDEX TO WHICH ADDITIONS ARE BEING MADE IN 1939

There is another great advantage. A group of people can combine in pooling their findings and yet retrieve their own later on.

Some of you may be thinking this is all too difficult or tedious, but I hope you will give the method a trial, for until you begin, you cannot tell how much you are able to see and hear all through the year.

I expect you have all seen the card index in some office or library, and the principle is the same : ease of reference, and when necessary, ease of rearrangement.

You will notice that in each of the records entered

on pages 23 and 24, notes on the weather as well as the actual date are given.

These serve to illustrate how in this country our climate is exceedingly variable and sometimes with very serious results. Compare the May 1935 entry for Stockbury with the June 1935 entry for the same place. Can you recall the devastating late frost of May 16th in that year? Some of you may remember how very scarce home-grown apples were that autumn, and how high were the prices of cherries. Yet in spite of this kind of exceptional severity, together with unusually hot, dry, or wet spells of weather, we have good reasons for speaking of the seasons of the year. The old expression " As the days lengthen, so the cold will strengthen ", reminds us that it is after the shortest day in the year has passed that winter really begins. Look again at the diagram on p. 18, see in which week the shortest day occurs and study Fig. 12.

Effect of Sunshine

If all the daylight hours were sunny, how many hours of clear sunlight should we enjoy (1) in London during the whole winter? ; (2) In Newcastle during the whole winter? It is quite a simple problem if you take the average length of day for each of the thirteen weeks, add these together, and multiply by the number of days in the week.

If you could choose, where would you prefer to live in the *winter* months in England assuming that all parts were equally cloudy?

When winter comes to an end, what are the hours of sunrise and sunset in London and in Newcastle?

Are there many other places in : (1) Great Britain ; (2) the rest of the world ; where on this same date,

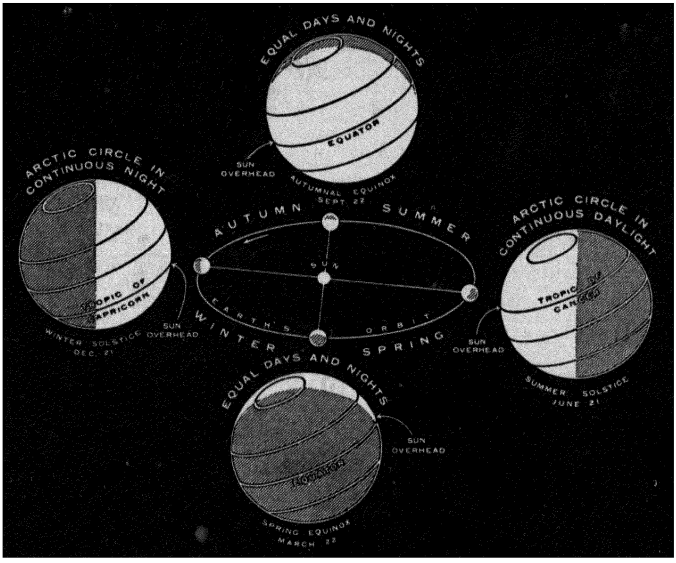


FIG. 12.

THE EARTH IN RELATION TO THE SUN AT THE EQUINOXES AND SOLSTICES

March 22, the sun rises six hours before noon, and sets six hours after mid-day or noon? Where does the sun appear to rise and where does it appear to set on this date?

Have you heard of the equinoxes? What is the meaning of this word, and when do the equinoxes occur? What is meant by 6 A.M., and 6 P.M.?

What towns (1) in Great Britain; (2) in the rest of the world, have noon at the same time as Greenwich?

You will remember that Greenwich is in London, and has a very famous Observatory. A globe on which the

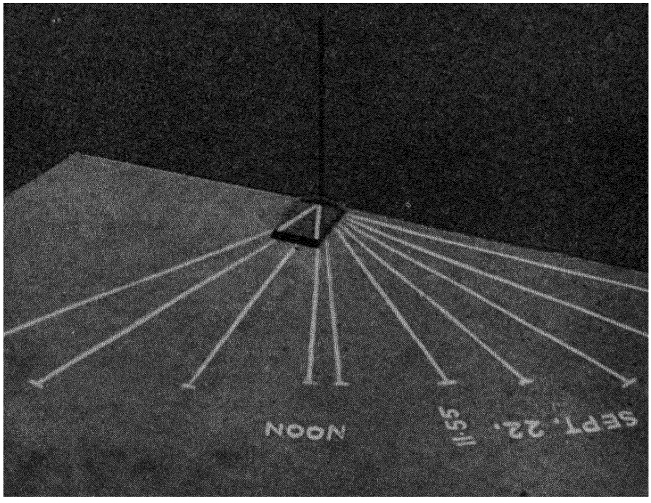
meridians are marked, or failing that, a world map, will help you to give the correct answers.

Though it is interesting to make measurements of shadows of vertical objects cast by the sun in mid-winter while the days are still very short, it is generally more convenient to begin rather later, perhaps in February when the sun, as we say, is more "powerful". If your classroom has a southerly aspect and you have an iron retort stand with a heavy base and a tall vertical support, mark the shape of the base neatly in chalk or pencil on a bench or on the floor. Choose some place on a sunny day at 9 o'clock, so that the shadow of the *vertical* rod falls entirely on one *horizontal* surface. Any other vertical object will do, for example, jumping stand, or rod in pot of soil. Draw a chalk line throughout the shadow. Measure accurately: (1) the length of this shadow; (2) the height of the rod. Write them down in columns on a card with locality and date. At 12 noon, draw and measure the shadow again. What do you notice: (1) about its direction; (2) about its length?

At 3 P.M., repeat the two observations on direction and length of shadow. On the bench (or the floor) you will have a figure somewhat like Fig. 13.

You may be interested enough on a sunny day to plot and measure other shadows at other times.

Side by side with diagrams showing similar observations a little later in the year, try to make measurements and sketches of rapidly growing plants such as Jack-in-the-hedge (also called, Garlic Hedge Mustard), or Sunflowers. You will notice that as the noon-day shadows grow shorter, many plants shoot up at a great rate unless



M. Munro

FIG. 13.
THE CHANGING LENGTH OF A SHADOW.
Daylight-saving times were written down. By the clock it was 1 p.m. at noon.

there is a shortage of water or a hard frost. Do they grow more during the day or during the night?

When does the longest day of the year fall in Great Britain? How long is this day in London? How long is it in Newcastle? Where does the sun appear to rise and where does it appear to set on Midsummer Day? Someone who is on night duty might answer this for you. Measure the length of the noon-day shadow of your vertical rod at the first opportunity after the middle of June, in case there is a cloudy period ahead. If you are unfortunate until Midsummer Day has passed, take ad-

M. Munro

FIG. 14.
A VALLEY NEAR LUGANO.
In the foreground a vine-yard. The shadows thrown by the stakes in late afternoon point east approximately.

vantage of the first sunny noon afterwards. You must allow for summer time being in force.

Fig. 14 is a photograph of a rather steep-sided valley in Switzerland which shows a wooded-slope on one side, while on the other there are cherry and peach trees already full of blossom in late March. Can you explain this striking difference? If you cannot, study the sloping slate roofs of houses facing in opposite directions after a shower of rain when the sun is no longer obscured by clouds. Which roof dries more quickly: one facing south, or one facing north? Better still, study roofs after a fall of snow which has not been accompanied by wind, but has come down in calm weather. When the

sun becomes effective which roofs are cleared first, those with a southern aspect, or those with a northern aspect? On a frosty morning, even a molehill will show the importance of slope and aspect as Rooks well know.

This question of exposure to sun in a cloudy country such as ours, is very important as you will realize if you think about :

(1) Fruit trees trained on orchard walls.

(2) Banks in garden and field where the earliest flowers appear, even in January in southern England.

(3) The placing of lambing pens in the fields in winter or early spring.

(4) The pleasantest rooms in your school or home in winter time.

(5) The designing of summer houses (such as those used by patients in hospital grounds), which can be turned round to give the best aspect hour by hour.

In the last few years, in many of the large blocks of residential flats which have been built, higher rents are charged for those with a sunny aspect, than for others which are identical, except in their aspect and face the north, north-east or north-west.

It is interesting to notice that different people react differently to the same strength of sunlight and heat when the duration of skin exposure is just the same. In many other ways each person is *individual*, and unlike all other people. Among bulbs (of one definite kind), you will notice how, when given identical conditions in soil, light, warmth, and moisture, some will begin to grow much sooner than others and maintain the lead in growth of foliage and flowers.

Such individual differences cannot always be explained, yet we cannot ignore them, and we need to be guarded in drawing conclusions as in making statements about any living plants and animals which we are studying.

As Swinburne wrote " tides of grass break into foam of flowers " in June, and during the summer months,

N.E. FIG. 15. *M. Munro. S.W.*

ASH TREES, CHAPEL-LE-DALE, ON A LIMESTONE TERRACE AT FOOT OF INGLEBOROUGH.

Altitude 1000 ft. The sea is 12 miles away.

growth and ripening lead on to harvesting. Meadows and fields of grain are suddenly transformed by the work of the farmer when sun, air, and water have played their parts. When the fields are bare, we tend to look more closely at the hedges ; in many parts of the country where their position is exposed, we notice how Hawthorns, and

other woody plants of shrub height as well as those which have reached the stature of trees (say twenty feet), are extremely unequal in their development of branches.

Notice the trees in Fig. 15. Compass points are indicated and locality is given. You will notice that it is on the side away from the prevailing winds, the south

FIG. 16. *M. Munro*

A WELL-GROWN BEECH DAMAGED DURING A FIERCE GALE NEAR STOCKBURY, N. DOWNS

westerlies in most parts of Great Britain, that the branches are long. Growth has been possible on the *leeward* side of the trunk, but on the *windward* side the leaf and flower buds have remained dormant, or perished. In choosing favourable aspects, we take account of wind as well as sun.

Some of the fiercest gales of the year occur near the time of the autumn *equinox* at the close of summer and in a gale the air travels at 50 miles an hour or more.

Occasionally even in the south-east of England the wind travels at more than 80 and 90 miles an hour (Fig. 16). This movement of air, as you may already know, depends on differences in atmospheric pressure, and these differences depend on the temperature and humidity of the air in various regions. You will probably study the weather of your locality, and the climate of the British Isles in some detail in your geography lessons. These will help you to realize what a very important influence the sun exerts on the earth and all its inhabitants.

On sunny days as near as possible to the autumn equinox, using the same vertical rod as before, measure the lengths of the shadows it casts at 9 A.M., noon, and 3 P.M., notice where it appears to set; then verify the times given in the diagram at the beginning of this chapter for London. How do these times and positions

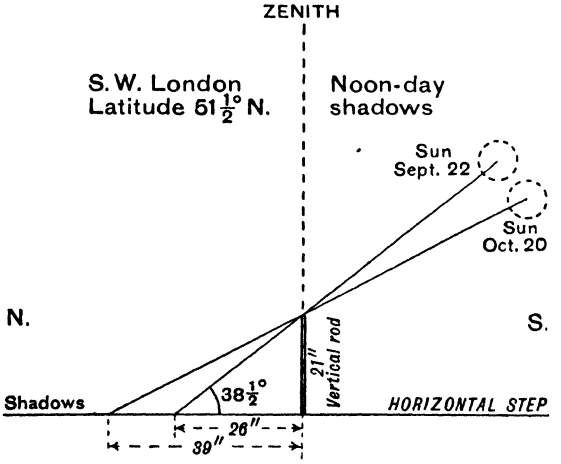


FIG. 17.

compare with those observed six months ago in March? You must remember to allow for summer time being still in force in late September (Fig. 17).

During the Michaelmas term (which many people misname the winter term), the " evenings draw in ", and as soon as summer time comes to an end early in October, we realize that the year is on the wane though many weeks of delightfully warm weather may lie ahead. There is abundant material for study in every lane and wood, yet soon there may be a hard frost which will prove very clearly that there are degrees of hardiness among our garden plants. Which are some of the first to appear flabby or flaccid? Do any of these revive as the weather becomes milder again, or have they been killed outright? Here are two entries which answer these questions for one district in one particular month.

GARDEN PLANTS	NOV. 10th 1937
S.W. LONDON	
Runner beans, Dahlias, Wallflowers	The foliage is limp in all these plants.

GARDEN PLANTS	NOV. 15th 1937
S.W. LONDON	
Wallflowers have revived. The runner beans and dahlias remain limp and black in their foliage. The flowers suffered less. The pods of runner bean contain good firm seed.	

Soon it will be time to make preparations for Christmas parties before the end of term. It is a good plan to bring in no more twigs than can be arranged in jars of water for decoration, since otherwise they wither very soon (Fig. 18). When you are collecting, use a sharp knife so that no twigs are torn. If they are cut across

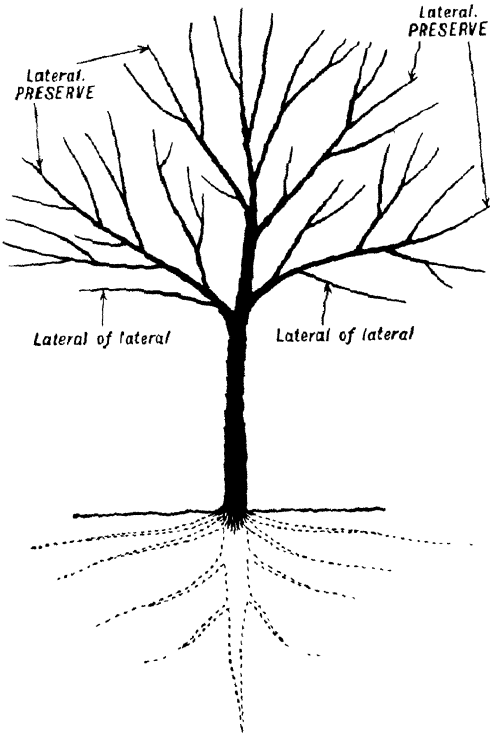


FIG. 18.
A YOUNG TREE

cleanly, those remaining on the tree may resist attack by fungi and other pests. Here is a golden rule for biologists young and old:

Preserve the lovely form of shrubs and trees; remember each has a long history and a future of its own. Many trees are very much older than your grand-parents.

FIG. 19.

ROUNDELS BY LUCA DELLA ROBBIA, 15TH CENTURY

Giving length of day and night and seasonal activities in Northern Italy. The four months in which the equinoxes and solstices fall have been chosen.

(By courtesy of the Victoria and Albert Museum)

Practical Measures

Cut only twigs which are laterals of laterals, using a sharp knife. Spare all the leading twigs of even the biggest trees. Leave every sapling untouched. Its shape may be spoilt for many years if even one twig is taken.

The four illustrations in Fig. 19 based on a series of twelve roundels in enamelled terra cotta by Luca della Robbia in the 15th century, in northern Italy, serve to sum up much of what you have learned in studying this chapter. You can make twelve sketches and show changing length of day for your own nearest farming region month by month.

Winter, spring, summer and autumn are expressive of the influence of the sun; the plants and animals live lives which are attuned to this rhythm of the year. Farm, garden, and orchard work are closely related to the seasons.

SUMMARY OF THE CHAPTER

Things to Note

1. The seasons of the year are determined by the position of the earth in relation to the sun.

2. Plants and animals respond in their own times to the seasonal changes.

3. Different plants and animals are dependent on one another in a number of ways.

4. Plants and animals of given kinds are not identical, but show individual differences.

CHAPTER 3

DEPENDENCE OF PLANTS AND ANIMALS ON WATER

In studying Books I and II, you learned many things about water and its properties.

The following questions will set you thinking about ways of showing the dependence of living things on water : At what time of day are most flowers for market cut? How are they packed? How are they transported? How are they cared for (1) by the florist, and (2) by the buyer? When and where should we gather wild flowers? How shall we care for them on the way home? Where shall we place them in the home to preserve their fragrance and beauty as long as possible? Why do we change the water in the vases after a few days, or sooner?

I will deal with the second set of questions and leave you to enquire about the others yourselves and pool the answers that you receive from people who handle choice flowers all through the year.

I make it a rule to collect wild flowers early in their season and either very early or rather late in the day, in places where there is shade and where they abound, and even there, only in small numbers. Next I find a few large leaves of the Dock, Coltsfoot, or Burdock, which are all very common on the roadside and near streams, and wrap these round the stalks of the flowers and their foliage ; when possible, I pack a little moist moss round

them, inside the big enveloping leaves. Nearly always, I have in haversack or pocket, a few large envelopes. These are excellent in providing still further protection from the warmth of my hands and from the air which would continue to take moisture from the flowers, now no longer equal to the demand. Without protection, they would soon become limp or flaccid, and though they might revive with care later, they would certainly not last nearly as long as they would have done with common-sense attention. Of course, garden flowers, and sprays of foliage need the same kind of care. Sometimes, and especially in summer, I take a bowl of water into the garden, bend the twig below the surface and cut it under water. Now why is this advisable do you think? If you do not know now, try to answer this question when you have carried out the experiments for which instructions are given later in this chapter.

Having brought flowers and foliage into the school or house, we must find clean jars, or vases suited to the length and strength of the stalks. Next, it is very desirable to remove the leaves that would be drowned in the water and soon *decompose*, giving the flowers a poor chance of keeping fresh. (The upper leaves are, of course, left intact and add much to the beauty of the posy as well as making the arrangement simpler.) Until they have revived fully and lifted their heads, it is best to avoid full sunlight, all draughts, and places near a fire, stove, or hot pipes for cut flowers. In cool, still air, they will lose less moisture than in warm, moving air, and they cannot always take up water fast enough at first. They have been severed, and time is needed for adjustment to new conditions. Though there may be plenty of water left in the

vase, pour it away after a few days, wash the vase (and if this is of a simple, open shape, it is very quickly done), put in fresh water, cut off the lowest part of the stems, wipe what remains on soft damp paper, and put the flowers back in the vase. There is a very good reason for doing all this as you will understand on performing a simple experiment.

Experiment 1

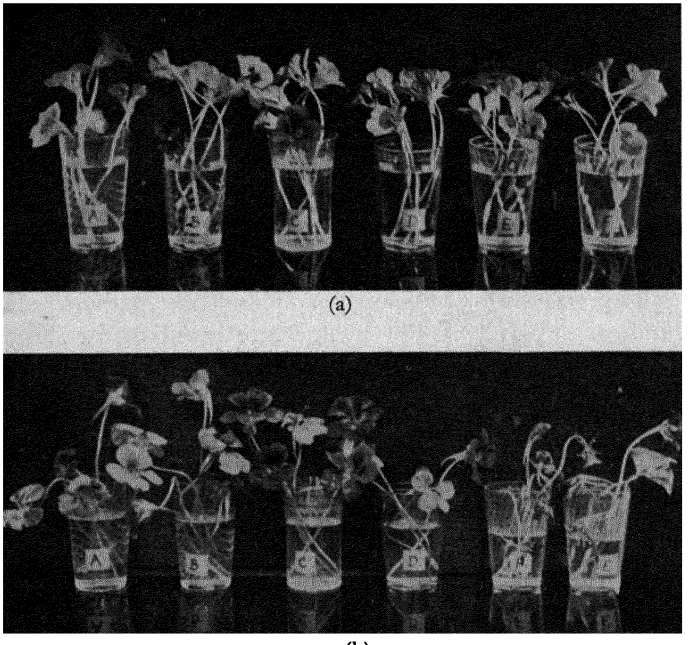
Take six clean glass jam jars, 1 lb. size. Label these *A*, *B*, *C*, *D*, *E*, *F*. Put fresh water in all to the same depth. Take a bunch of flowers all of one kind, for example, Wallflowers or Buttercups, etc., freshly gathered from the right kind of place and with many buds and few fruits showing. Now divide it into six small bunches, *a*, *b*, *c*, *d*, *e*, *f*, for the six jars bearing the same letters.

(*a*) Let all the leaves remain	}	Place *A* and *B* in a cool,
(*b*) Gently strip off lower leaves	}	draught-free place.
(*c*) Treat as (*a*) - - -	}	Place *C* and *D* in a cool,
(*d*) ,, ,, (*b*) - - -	}	draughty place.
(*e*) ,, ,, (*a*) - - -	}	Place *E* and *F* in very
(*f*) ,, ,, (*b*) - - -	}	warm place.

After three days, and sooner if you can, examine the six jars. After five and seven days from the start, re-examine them and tabulate your observations each time in columns with dates. They may be unlike what you find here (Fig. 20).

Experiment 2

For this experiment you need a harmless coloured fluid such as eosin, or red ink in water, and some pale



(a)

(b) *M. Munro*

FIG. 20.

SIX TUMBLERS EACH WITH FIVE FLOWERS OF TROPÆOLUM (CALLED NASTURTIUM)

(*a*) Freshly gathered from shady corner of garden.
(*b*) After five days. Notice water levels.

A and *B*. In sunny window kept closed.
C and *D*. In sunny window often opened.
E and *F*. In a kitchen often hot.

flowers which will last several days. Among the best are Paper White Narcissus which, after the Christmas holidays are generally plentiful and very cheap. Many plants will serve e.g. bleached leafstalks of celery.

Take three clean glass jars ; into two, labelled *A* and *B*, pour coloured fluid—into the other, labelled *C*, pour plain water. Place one or two of the cut flowers in *A*, and *C*. In *B*, place a few twigs of willow, or poplar, Keep the jars in good atmospheric conditions, that is, avoid hot air and draughts. Inspect daily and record your findings. In *B*, you can half strip one of the twigs, lengthways. If you wish to carry out similar observations in the summer, choose some rapidly growing plant which is succulent and somewhat transparent (the right word is translucent) ; Marrow is excellent, so, too, are Balsam and the waterside Jewel weed. When the coloured fluid has risen through the soft stems, cut very thin slices, some lengthways, and some transversely, with a sharp scalpel or other knife, place them with a drop of water between two glass strips (called slides) and examine with a strong hand lens over a black matt surfaced background for preference. In the transverse slices, you will notice a beautiful, open, lace-like pattern in which are arranged a number of spots stained red, and in the lengthways strips, you will see long strands stained red. Examine the former still more closely for round holes within the red patches.

Structure of the Stem

Structures which are long in one direction, and round and hollow in the transverse sections, are tubular, and you will realize that it is in the walls of these tubes that the red colouring matter has been trapped, because it is through them that the water has risen. The soil water free from colouring matter rises in the same way. You can imagine how soon such very narrow tubes may be

clogged with decaying matter when in a vase so that the passage of water is impeded.

In making out the details of structure in these stems as suggested above, you have been recognizing a few of their different *tissues*. A particularly good plant to study at any time of the year is the Elder; take a shoot having a diameter of about half an inch, cut it across at some level where there are neither leaves nor buds, and examine it closely using a magnifying glass. Starting on the outside you can readily make out these tissues in concentric rings and show them in a simple sketch:

(*a*) A pale brown thin skin, the *epidermis*, now dead.

(*b*) A pale brown narrow layer of *cork*, also dead.

(*c*) A dark green narrow layer of several living tissues, able to go on growing and making food.

(*d*) A faintly green wider layer of living tissue called *phloem* or *bast* through which some soluble foods descend.

(*f*) A rather darker and much wider layer of living tissue called *xylem* or *wood* through which the sap ascends and probably, some soluble foods descend.

(*g*) In the centre, a most beautiful lacy-looking tissue called *pith*.

This pith, like the outermost layers is already dead, and each of the units of which it is readily seen to be made up has a white wall, now enclosing only air. The play of light on these more or less spherical cells gives the whole tissue an attractive frothy appearance. Very few tissues show the individual cells of which they are made up so clearly as the pith of Elder but you may be able to see some of the largest tubes in layer *f*. Each of these is made up of a large number of wood cells end to end and

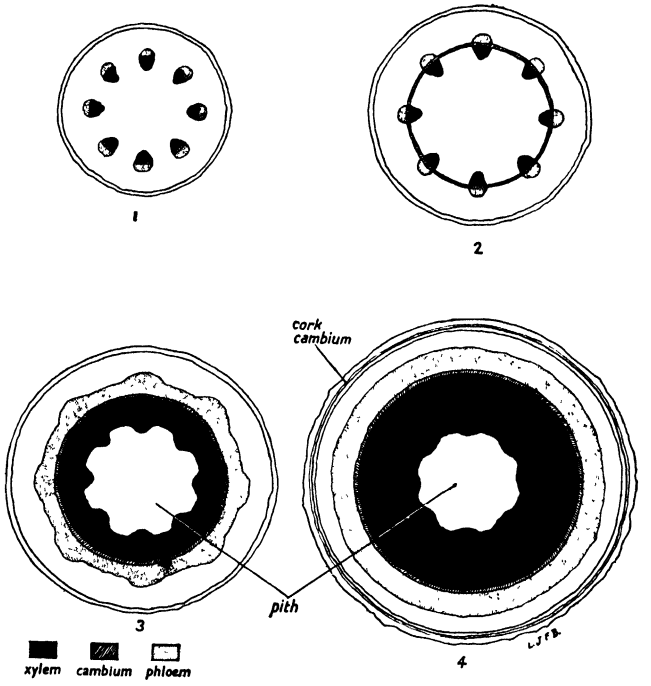


FIG. 21.

TRANSVERSE SECTION OF A STEM AT FOUR DIFFERENT LEVELS
1, the youngest and highest, 4, the oldest and lowest, to show how the tissues are arranged.

is called a *vessel*. But the wood layer like most of the tissues is by no means so simple in structure as the pith (Fig. 21, 3).

You may wonder why, in the list of layers, we skipped from *d* to *f*. There is an excellent reason : between them lies an extremely narrow layer but one of the most active and most important since by its activity it gives rise year

by year to extra layers of bast on its outer side and to extra layers of wood on its inner side, as well as keeping pace, or perhaps we should say, setting the pace for the increase in height as well as in girth of the twig, the branch or the trunk. Here we cannot pursue either the way in which this wonderful layer, the *cambium* (*e*), works or the results of its rhythmical activity year by year with a great maximum when the sap is rising, and a well-marked lull during winter, but these are clearly shown on page 12.

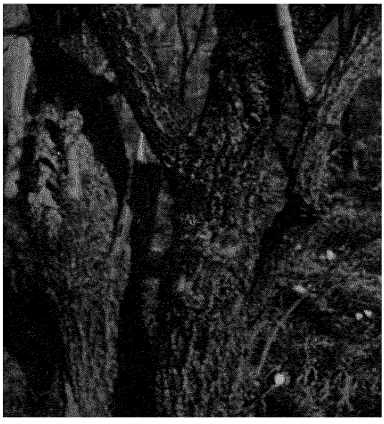


FIG. 22A. *M. Munro*

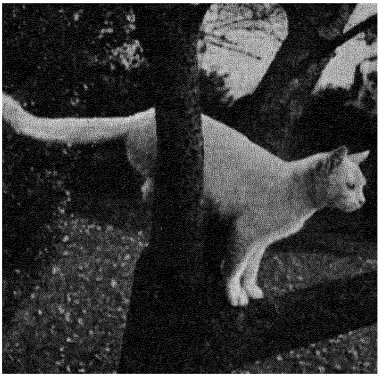
PART OF AN ELDERBUSH.

Showing smooth epidermis of young branch in contrast to furrowed bark of older branches. Lugano, March.

Examine the outside of the Elder stem with the aid of a lens to see the individual cells of which the epidermis is made. They gleam since they are now stretched, empty of all but air, and dead like the pith. You cannot fail to notice that this pale brown gleaming surface tissue is broken at intervals by little bosses called lenticels which contain *loosely* packed cork cells. But for this arrangement the *closely* packed cork cells would seal up the living tissues inside and make any diffusion of gases, including water vapour, impossible. There would be no normal respiration in the stems and the life of the plant would be endangered. It is true that the leaves are much more

active in respiring and in passing out excess moisture but there are long intervals between them and moreover for many weeks early in the season of active growth they are of small size, and for many weeks at the end of this same season their work gradually slows down (Fig. 22).

Take a cork stopper and notice how it is made of a very compact tough tissue traversed by narrow cylindrical passages containing a powdery substance. Are these passages transverse or lengthways? Do you recognise them as lenticels? In the cork stopper you have a small piece of the extremely thick bark of a certain kind of ever-green oak which grows in parts of the Mediterranean region. These Cork Oaks are the sole source of cork for stoppers, table mats, bathroom mats, cork linoleum and many other articles. This substance is a poor conductor of heat, and waterproof. These properties give it an immense value for the living plant whether like the Elder it makes only a very thin layer, or like the Cork Oak a very wide layer part of which is removed periodically by men trained to avoid any injury to the living tissue inside for this is capable of laying down year by year a little



M. Munro

FIG. 22B.
YOUNG TOM-CAT.
About to take a spring from a White Poplar in which large diamond shaped lenticels are seen. Pennard, Sept. 1938.

more of this most valuable commercial product, cork. The Cork Oak grows quite well in sheltered gardens in the south of England.

Let us return to our experimental work. It is quite simple to devise methods by which the quantity of water required by similar plants or similar twigs, in different conditions of the atmosphere, can be estimated approximately. Given some long-necked flasks, cotton wool and adhesive paper, what would you suggest doing? Test-tubes serve quite well in place of flasks. Keep an accurate record of this as for all experimental work.

Animal Tissues

For animal tissues the briefest reference must suffice. In your hand, notice the skin bearing hairs in some parts only and nails on the *digits*; feel the muscles and press these against the *bones*. Notice the veins which look rather blue and feel the *pulse* in the walls of an artery which are thick and made of many different tissues. In the window of a butcher's shop look at lean meat which is essentially *muscle*, traversed by countless *veins*, *arteries* and *nerves*; the largest of the nerves may be seen as cream-coloured tapering and dividing threads. The *fat* in a joint is another kind of tissue and covering the bones at their smoothly curved ends you can see the gleaming, bluish white, compact smooth *cartilage* or gristle. Near the tip of your nose and in the outer ear lobe you can feel that there is cartilage, an elastic tissue free from nerves and incapable of registering pain.

You have all heard of many other groups of tissues such as the brain, marrow, liver and kidneys. Moreover, the blood is a tissue although it is fluid and travels

ceaselessly through our bodies by way of the left side of the heart, arteries, tiny tubes called *capillaries*, and veins which lead it back to the right side of the heart, an organ whose action is that of a double pump throughout life (Fig. 23). The blood on the right side is impure and is pumped to the lungs where it is oxygenated and freed from its load of carbon dioxide. It then returns to the left side of the heart. The blood consists largely of water but it performs many kinds of work and contains a great variety of things; among these is a complex substance which contains iron, is known as *haemoglobin* and gives the red colour. It is very unstable in the chemical sense, but its instability is of an orderly kind.

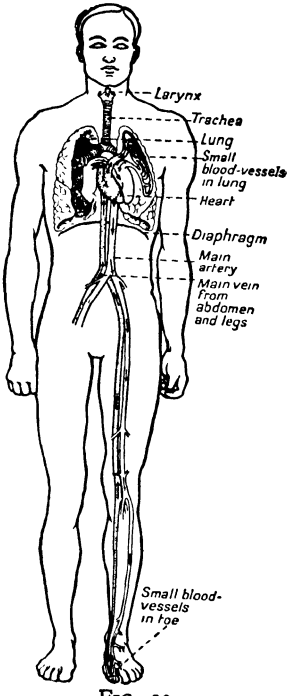


FIG. 23.
THE HUMAN BLOOD SYSTEM.
The arrows indicate direction of flow of the blood. The left side of body is on the right in this diagram.
From Mackinnon · The Animals' World (G. Bell & Sons, Ltd)

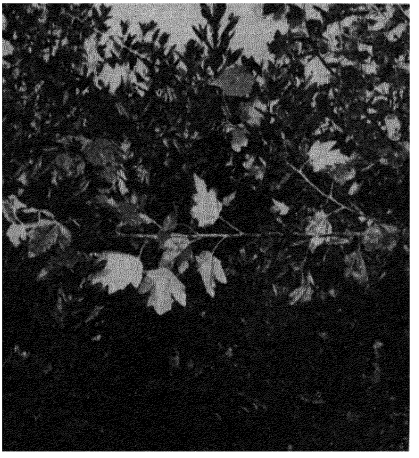
All the water we take in as food or drink which is not used up in growth and repair of tissues, is lost in perspiration, the *urine* or the *breath*.

Circulation of Water in the Plant

Has it occurred to you to ask yourself what happens to the water which is taken into the plant or twig?

Experiment 3

Choose some clean evergreen leaves uninjured so that both the upper and lower surfaces are intact. Plunge a few of these into an open vessel of hot water. The temperature should be about 110° F. Look closely at some under surfaces as well as upper surfaces. The bubbles



M. Munro

FIG. 24.

THE LEAVES OF THE WHITE POPLAR.

These bear a white felt of fine tangled hairs on the lower surface.

of colourless gas you see are bubbles of air. How are they distributed? What do they tell us about the inside of the leaf? They have escaped because on raising the temperature of the air inside, we made it expand. Had there been no exits, the skin might have been broken, but wherever it could, this air made its way out through some of the countless minute holes, and as you will have

seen, in many leaves it is only on the lower side that you can demonstrate their presence.

Look now at the two surfaces of some of the evergreen leaves which have not been plunged in hot water. Do you notice any differences in colour or polish? In very many kinds, the lower side is paler and duller than the upper, and for three reasons;

(1) It has above it many relatively large air spaces.
(2) It has a thinner skin.
(3) There is less chlorophyll in the cells just above it (Fig. 24).

You are now in a position to investigate loss of moisture more thoroughly.

Experiment 4

Take four large clean evergreen leaves of equal size and labelled, *A*, *B*, *C*, *D*, and with loops of thread attached. Those of laurels are excellent. Seal the lower end of each stalk with vaseline or wax, but treat them differently on their wide surfaces: *A*. Smear all over above and below. *B*. Smear all over above only. *C*. Smear all over below only. *D*. Leave unsmeared both above and below. Weigh each carefully. Suspend all four by the loops, where they can remain undisturbed and free from dust for some days. Weigh after 7, and again after 14 days. Tabulate the readings with dates.

Experiment 5

Select twigs bearing smooth leaves such as those of lilac or lime. Cut them under water if possible and leave

them in a cool place until you have all the apparatus quite ready.

You need two test-tube stands *A* and *B*, each with three test-tubes, twelve glass slides, twelve rubber bands, cotton wool, dry cobalt chloride paper which is Cambridge blue in colour, already cut in strips 1″ × 1½″ and stored in a tightly corked wide test-tube. Place the twigs in water in test-tubes. Apply a strip of the dry cobalt chloride paper to both sides of one leaf on one of the twigs. Quickly fix two glass slides with two rubber bands so that you have a kind of sandwich. Treat one leaf on each of the other five twigs in the same way. Place the stand *A*, in a sunny place and the stand *B*, in a shady place, or *A*, in a draught, and *B*, where the air is still. Observe continuously without any interruption, and note accurately the times when you can see a change of colour from blue to pink in the test papers. Watches with second hands are useful.

You will, of course, put the date, the hour and a note on the weather. On a misty or thoroughly damp day no satisfactory result could be obtained.

Now take a piece of the bright blue dry cobalt chloride paper and blow on it with your lips parted; put another piece in water. The colour change in the test paper is due to the passing out of moisture. (This does not afford any *proof* that it is pure water which causes the colour changes in the experiment.) Do we *see* any water passing out of the leaves in a garden during the daytime? We do not, but as you already know, water, like other substances exists in different states, and one of these is invisible vapour. Putting together some of the things you have learned you will realize that every tall green plant whether

herb, bush or tree, may be thought of as a most remarkable fountain, though one in which we *see* neither the ascending water nor the myriad-pointed stream, finer than we can picture, which issues from every leaf; the rate is suited to the supply of water in the soil, and to the demand made by the air. When a gale is blowing the demand is enormous. Whenever the supply is insufficient or locked up in the soil, as during frosty weather, the fountain plays more feebly or fails and the plant suffers or even dies unless it can adjust itself. Only in part can the ascent of the sap against the pull of gravity be explained as yet. The great Redwoods of California and the Eucalyptus trees of Australia exceed 300 feet in height. To these heights the sap ascends. All our *deciduous* trees lose their leaves in the autumn, having first sealed up every scar in the neatest and most effective way possible, by building a thin sheet of waterproof cork. But sometimes, long before leaf-fall, and indeed, on occasion, as on May 16th 1935, there comes a killing frost or a scorching cold wind as in June, 1938. In either case those leaves which manage to remain on the twigs are blackened or browned all round the edges, or even completely, and the young opening buds are killed outright so that dormant, lateral buds have to take their place later on (Fig. 25). The wind alone has the same kind of effect, and in exposed places even where the climate is very mild, as at Falmouth in south Cornwall, you will find ivy and oak leaves scorched without exception on the cliff promontories, though in the shelter of such promontories no damage can be seen.

You will understand better now the point of setting up some of your twigs in draughty places, and others of

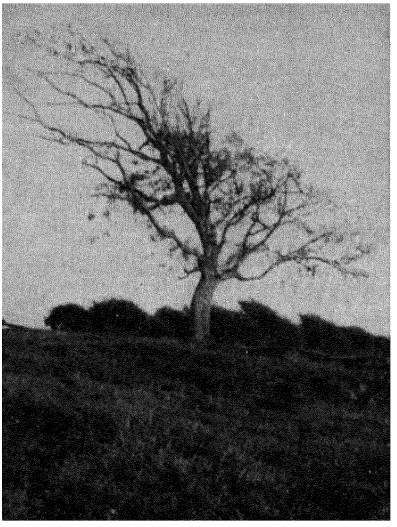


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FIG. 25.

INJURY BY WIND.

Ash tree, Pennard, S.-W. Wales, seriously injured in June and photographed in August, 1938.

the same kind where the air is still. You will appreciate the advantage of making sunken gardens especially near the sea, and of planting live wind screens, made of lovely dense evergreen Cypress or Holm Oak, round orchards, especially where there is no other shelter from our prevailing south-westerlies.

Transpiration

The loss of water vapour by the plant is called *transpiration* (Fig. 26). All the mineral salts which the plant takes from the soil for food must be in very dilute watery solu-

tion. So again, the role of water is all important. What is needed is abstracted from the solutions by the living plant and the excess of pure water not required for growth or storage is passed out as invisible vapour into the air, there to be condensed sooner or later into the many visible liquid forms which water has. Can you name these?

Now that you have learned a little about the green plants' requirements, you will understand why gardeners prefer to use a hose or water cans in the *evening* to give the plants the fullest value during a dry spell of weather.

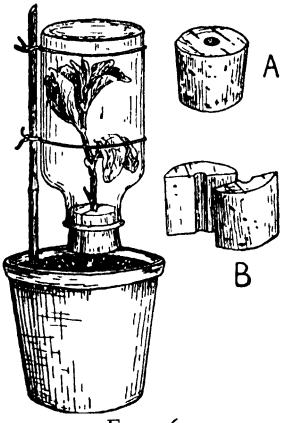


FIG. 26.
TRANSPIRATION.
A green shoot rooted in damp soil is fixed in an air-tight jar.
From Yapp: Botany for Junior Schools (Cambridge Press)

Here is another set of questions to set you thinking about ourselves and members of the animal world in general: (1) When are you most thirsty? (2) When is your underclothing so damp that you wish to change at once? (3) On farms where there are very few streams or ponds, have you seen water troughs? (4) In what kind of weather are frogs, land-snails, and earthworms active in meadow and garden?

You will all agree that the answers to the first two questions are generally the same, and that it is after vigorous exercise that you are eager for a long drink and a change, the reason being that you have lost a lot of moisture from your body in perspiring and also in breathing deeply and rapidly. When we breathe on to a

cold bright surface, for example, a mirror, we notice a mistiness and this is condensed water vapour. Even when we are sitting still we are continually losing water vapour through our skin and through our nostrils, but the rate of loss goes up with vigorous exercise. This loss must be made good or we suffer acutely. In addition to the water provided in what we drink, there is much contained in what we eat, as you can see in Chapter. XI.

When our clothes are wet or even damp, they cannot absorb the body's perspiration and we feel uncomfortable, for the skin can no longer carry out properly its great work of regulating the temperature of the body. As the moisture is evaporated from the skin, heat is lost and no matter what the air thermometer registers we maintain a temperature of 98.4° F.

Some fur-bearing animals, for example, dogs, lose moisture only through the mouth and tongue surfaces and this explains their panting after a hard run, and supplies an urgent reason for the fuller provision of drinking troughs. Horses, as you will have noticed, may show streams of moisture on their glossy coats after vigorous exercise; they, too, need long drinks of cool clean water on the high roads.

Some of the lower land animals such as earthworms, respire entirely through their skin; later on you will understand better than now how it is that we find them actively moving outside their burrows only when the weather is damp and fairly mild. In dry air they are soon *asphyxiated* for lack of normal respiration and die. Whenever you study them indoors, a shallow tin with some moistened fallen leaves and a glass cover is excellent. In some ways a test-tube with moist leaves and a plug of

cotton wool is better. Similarly, frogs, which use their skin as well as their lungs for respiration, are seen to leap or crawl actively on land only in damp places. Land-snails employ a very simple method in avoiding the danger of *desiccation* in dry weather, even in spring or summer, though there may be an abundance of juicy food available. If you look under big leaves, stones, clinker, bricks in a rockery, or in the crevices of an old wall you will probably find several which have built a temporary door (called the *epiphragm*), across the shell opening, and are inactive while awaiting the return of moist weather. They may remain sealed up like this for weeks or months in a hot dry spell and this is their regular method of *hibernating*, that is protecting themselves from unfavourable conditions in winter. Can you name other moist-skinned land animals which hibernate? Can you make a list of *annual* flowering plants which die down in autumn leaving a bare space of soil where in the spring there may be a crowd of seedlings? Has it occurred to you that the seeds alone in their tough coats have survived the winter? You have already learned that in the new year warmth alone will not suffice to promote germination; water must be present too. In the spring look for patches of self-sown poppies and other weeds as well as garden plants. Many kinds of seeds can retain their truly wonderful vitality for years, and you have only to provide the essentials for active life, including water, and they will respond, root, stem, leaves, flowers and fruit appearing in due order (Fig. 27).

Some animals such as the lung fish of certain hot regions, which breathe by gills like ordinary fish while the rivers are flowing, seek the mud in summer when the

waters dry up and they can no longer be active, encase themselves in a compact rounded lump of mud, and so survive the dry hot summer. While they are in this

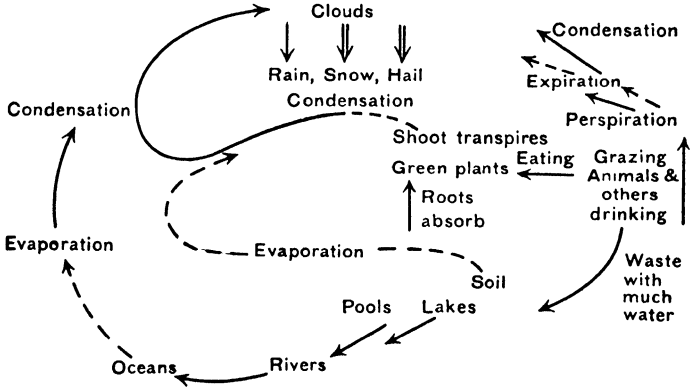


FIG. 27.

state of *aestivation* they use their lungs for slow breathing and only become typically active again when the rains come and the river courses are filled afresh.

SUMMARY OF THE CHAPTER

Things to Note

1. Water is needed by all growing plants and all active animals.

2. A few special methods of escaping desiccation among animals.

3. The transpiration stream in plants.

4. The preparing in advance of the season of difficulty by deciduous trees and shrubs.

5. Water circulates continually in Nature.

CHAPTER 4

RESPIRATION IN PLANTS AND ANIMALS

OXYGEN is vitally important for everything which is alive. This oxygen is taken either from the air or from what is dissolved in water by the vast majority of plants and animals.

Experiment 1

Use freshly soaked peas from which the testas (or coats) have been removed and a test tube which you can completely close with your thumb. Fix a long narrow strip of adhesive paper lengthways on it. Remembering that mercury is very expensive, carefully pour some into a small bowl set on a tray or large dish; put ready a stand with a clamp at the right height; fill the test tube with mercury, place your thumb over it, invert it and lower it into position. Fix it with the aid of a cotton wool pad. Now introduce the soaked peas at the lower open end of the test tube. They will rise at

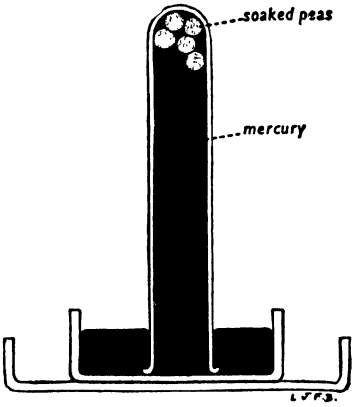


FIG. 28.
RESPIRATION OF PEAS.

once to the top, displacing their own volume of mercury so that the level in the bowl will rise a little (Fig. 28). Leave the apparatus undisturbed; sketch the contents of the test tube on successive days and mark the successive levels of the mercury. A colourless gas collects above the mercury and forces it down. When the test-tube is nearly free of mercury plug it with a cork taking care to let none of the gas escape. What gas do you think it may be? If you say carbon dioxide you are right. Fortunately this is a heavy gas so you can easily apply a test with the tube upright and the open end uppermost. A lighted splint when introduced is extinguished at once. Plug the tube, then apply a second test by shaking up a little clear lime water which, as you would expect, will turn cloudy.

Anaerobic Respiration

Where has this carbon dioxide come from? Only one answer is possible: from the seed itself. The dormant dry seed has been made active by moisture and a suitable temperature. Certain substances in the seed have acted on the complex insoluble food reserves containing oxygen and changed them into simpler substances, one of which is gaseous carbon dioxide.

This process is called *anaerobic respiration* in contrast to ordinary *aerobic respiration*, in which the free oxygen of the air or that dissolved in water is used. In the anaerobic process the oxygen is not taken from the air. The value of this experiment lies in the fact that you can actually collect and test the undiluted carbon dioxide. You will understand this behaviour of the seed a little more fully after reading the next chapter.

Do those seeds in the test-tube germinate? No, they do not. The energy released in this kind of respiration is enough for the support of life but not enough for the growth of seeds into seedlings such as you can watch when you provide in addition to moisture and a suitable temperature, air.

Experiment 2

Get some yeast from a baker. Have ready two small clean flasks labelled *A* and *B*, and two larger vessels to contain hot water.

Into *B* put a mixture of about 40 c.c. luke warm water and as much crumbled yeast as will rest on a farthing. Into *A* put the same quantities of lukewarm water and yeast but add a level teaspoonful of sugar (glucose for

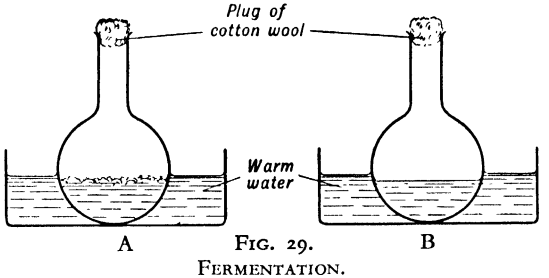


FIG. 29.
FERMENTATION.
This flask contains yeast and a solution of glucose.
This flask contains only yeast and water.

preference). Stir with a glass rod. Plug both flasks with cotton wool and let them stand in the hot water baths or in a warm place for two hours, or preferably longer. Have ready two clean glass rods with large rounded ends and some clear lime water in a beaker (Fig. 29).

Remove the plugs from the flasks and quickly put

your nostril near the open necks. Write down what you smell in *A* and in *B* and let others do the same. Re-plug the flasks while you get ready a drop of lime water to be held above the mixture inside flask *A*. Withdraw it after a minute or two. Write down any change in appearance. Then in the same way introduce a drop of lime water above the liquid contents of flask *B*. What change has occurred?

You have evidence of two changes occurring in *A*. There is the smell of alcohol and the cloudiness of the lime water which suggests that carbon dioxide has been evolved.

The yeast is really a mass of minute living plants without any green colouring matter and belonging to the *Fungi*, a group of plants including the edible mushroom, all the toadstools and the moulds, some white, others blue-green in colour, which you will have seen on damp bread, on jam or bruised fruits.

In Nature the wild kinds of yeast live on the sugary juices of ripe fruits. Other kinds which have been specially produced for the purpose are used for making dough rise so that the loaves of bread are light when baked and not heavy; yet other kinds, called brewers' yeasts, are used in the making of beer from germinating barley plants.

Fermentation

The changes which the yeast brings about in the sugar (as in flask *A*), in the dough and in the germinating barley are all similar and are spoken of as *fermentation*.

The chief thing to try to understand is that the complex sugar is acted on by some substance in the living yeast

plant with the result that alcohol and carbon dioxide are given off, and *energy is released*; this energy takes the form of heat, in part.

This substance has been isolated from yeast and given the name *zymase*. It is an example of a group of substances called *enzymes* which may be defined as substances present in very small quantities in plants and animals, having the power to aid chemical reactions without being used up in the process.

The particular enzyme called zymase exists not only in yeast but also in fruits such as ripe apples, and in seeds and in many parts of most plants.

We must turn back to the first experiment in this chapter. There you saw that the seeds in anaerobic respiration gave off carbon dioxide, while in the next experiment you found that yeast in fermenting the sugar, gave off carbon dioxide as well as some alcohol. Under a microscope you could watch the yeast cells growing and multiplying. In the peas the food reserves include starch which is readily changed by the seeds' enzymes into sugar. There are some parallels to be noted, therefore, in the materials worked on and in the end products in these two processes which are called anaerobic respiration and fermentation. Though many of the details have been worked out, chemists and botanists are still busy making new experiments in the hope of solving the many problems which remain.

Experiment 3

On this page reference has been made to energy being released when sugar, which is a complex substance, is acted upon, and simpler substances are produced. This

experiment will help you to realize the truth of this statement. Take two thermos flasks with well-fitting corks each bored to fit very closely a thermometer. Label the flasks *A* and *B*.

Into *A* put two dozen boiled peas washed in dilute formalin to prevent the growth of bacteria. Into *B* put an equal number of peas which have been soaked for twenty-four hours. On successive days read the thermometers and record your readings of the temperature in parallel columns with the dates. I have generally found a difference of about two degrees centigrade. Of course, other germinating seeds or any actively growing flower heads may be tried.

Respiration and Energy

Wherever growth is active food reserves are being used up and broken down into simpler substances with release of energy. Energy is most easily recognised in the forms of heat and movement, but it is most easily measured in the form of heat.

You have already learned something about the conditions needed by seedlings for ordinary respiration which, since *air*, containing oxygen, is required, is called *aerobic*. Very careful experiments have been devised and have shown that green plants which usually respire in this ordinary way, can respire in the other way (called anaerobic) when deprived of oxygen. It seems probable, too, that the first stages in the two kinds of respiration are the same or very closely similar but that when there is no oxygen present carbon dioxide and ethyl alcohol are produced, whereas when oxygen is present carbon dioxide and water are produced.

Respiration in Animals

We must turn now to animals and try to understand a little more about their methods of respiration. Some of them are very small and live in vast numbers in moist soil and in water where there is air dissolved. Such small animals are able to take in all the oxygen they need at all points of their surface and equally, they are able to pass out carbon dioxide as a waste product from all parts of their surface.

The majority of animals possess blood which is always being pumped round the body through the regular action of the tubes or vessels in which it flows, and in those which possess a heart, by the action of the heart itself.

Experiment 4

On a day when the ground is damp dig quickly with a big fork at the edge of a heap of manure or a pile of vegetable refuse such as uprooted cabbage stumps, potato haulms, or lawn mowings. You will probably turn up some large earthworms. Put a few of these with some moist soil in a tin box. Put one of the worms in a shallow dish with a few moist leaves. The worm is accustomed to darkness and the cover will make it less restless. Look attentively and you will see quite clearly the large vessel full of red blood which lies under the transparent skin and muscles throughout the length of its body on the upper side. With the help of a pocket lens you can see the chief vessels which branch out left and right from the central one. There are countless smaller vessels, all connected and all carrying blood to or from the skin which is extremely thin and always

moist. Through it and through the very thin walls of the smallest blood vessels oxygen from the air passes in to the blood while carbon dioxide passes out by the same route. It would be extremely cruel therefore to let the worm get dry. It would no longer be able to carry on respiration and would gradually die—for it has only one means of obtaining oxygen—through its moist skin. It would be equally bad to leave the worm under water

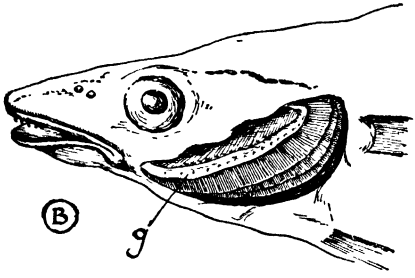


FIG. 30.
GILLS OF FISH.
Head of Whiting from which the gill-cover has been removed on left side to expose the gills and one supporting gill-arch, *g*.
From Phillips and Cox: First Book of Biology (University of London Press, Ltd.)

for there it could not possibly get enough oxygen to keep it alive since it has no gills. Can you explain now why you have to dig very deep for worms during dry weather?

Some animals like the frog have definite *organs* the special work of which is to carry on respiration. The young frog tadpole has gills but as it grows up it loses these and inside the body a pair of lungs grows. Both gills and lungs are called *breathing* organs and as you know we have lungs and can study our own breathing movements. The frog is rather remarkable in being

dependent on its skin for part of its respiration. This skin is smooth and damp; you will realize that it would be cruel to keep frogs in any kind of cage (or *vivarium*) without damp moss or turf, and a water bath, even for a day.

The accompanying diagrams (Fig. 30 and Fig. 31) will help you to understand in what ways gills and lungs are

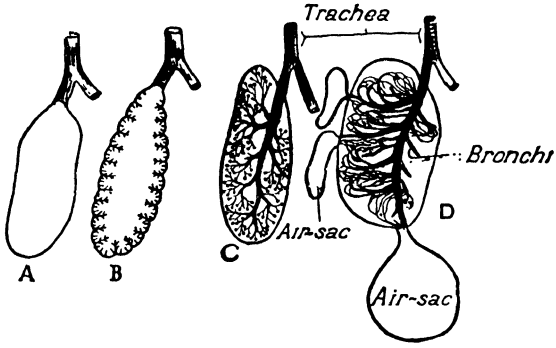


FIG. 31.

FOUR DIAGRAMS OF LUNGS ON DIFFERENT SCALES

A. Simple cavity in an Amphibian.
B. Frog. *C*. Mammal.
D. Bird with very large air-sacs connected with the lung proper.

From Dakin · Elements of General Zoology (Clarendon Press)

similar. Both provide by much folding a very large surface and both are continually moist.

Watch under a microscope the blood rushing through the tiny vessels in the gills or tails of frog or newt tadpoles which you had placed in water in a small clear watch glass. You could easily count with the help of a friend using a watch, the rate of the pulse of these animals. Failing that however, you may be able to rear some young trout and with your naked eye observe the beating of the heart.

Our blood which is pumped through all the different parts of our body including fingers, toes, scalp and gums has all to pass through our lungs and as often as blood comes there it is changed chemically. One set of vessels carry from all parts of the body by way of the heart *to the lungs used blood* which is heavily charged with carbon dioxide. Linked with these is another set of vessels which carry *from the lungs* by way of the heart to all parts of the body *blood* which has given up part of its load of carbon dioxide and become *freshly charged with oxygen.*

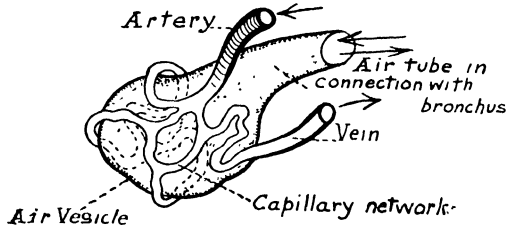


FIG. 31E.

AN ALVEOLUS, ONE VERY SMALL PART OF A LUNG (HIGHLY MAGNIFIED).
From Johnstone: The Mechanism of Life (Arnold)

This exchange of gases is made possible by the nature of the red colouring matter in blood called *haemoglobin* and the extreme thinness of the moist walls of (*a*) the smallest blood vessels in the lungs; (*b*) the tiny air sacs in the lungs called alveoli (Fig. 31E).

Haemoglobin is very complex and chemically very unstable. When it has picked up from our body waste materials it becomes greedy for oxygen and when it has picked up oxygen from the air in our lungs it is ready to unload part of this wherever it is needed, but always in exchange for something else.

In other books I hope you will read about the very special provisions for a full supply of air which are to be found in birds and in those insects such as bees, butterflies and beetles which have become masters of the air.

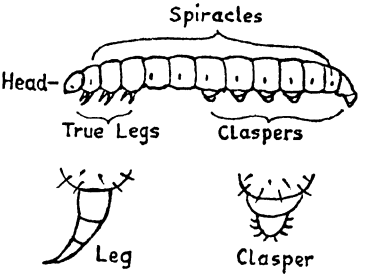


FIG. 32A.
BREATHING IN BUTTERFLY LARVA.
On the two segments where wings will be developed later there are no spiracles. Upper figure × 1. Lower figures enlarged.
From Frohawk · British Butterflies (Ward Lock & Co)

In Fig. 32A there is a picture of the larva or grub of a butterfly and you can count the spiracles or entrances for air on one side of the body. Through each entrance fresh air passes to travel along a wonderful set of branching, tapering tubes *direct* to every part of the animal's body, whether in the grub stage, or any later stage in its life-history (Fig. 32B).

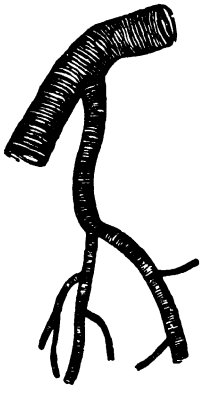


FIG. 32B.
Very highly magnified. Part of branching air tube of an insect, linked in life with a spiracle.

Experiment 5

You can gain some idea of the size of the great air sacs which in a bird are connected with its lungs but lie beyond them, if you follow these suggestions: In season get a Wood Pigeon or other bird from a poulterer's shop. Pluck the feathers from the lower parts of the breast and

of the neck. Insert the tapering end of a narrow piece of bent glass tubing with both ends smooth, into the windpipe or trachea towards the breast. Wipe the free, broader end with clean cotton wool and Milton. Then blow gently into the tube. You will notice how the body becomes larger and larger. To *see* the great air sacs, indicated in Fig. 31D, because of their extremely thin walls, you would have to open up the body very carefully; otherwise you would tear them. Thanks to these great air sacs each time a bird breathes, the blood in its lungs has *two* chances of collecting oxygen instead of only one.

When you remember how much travelling a bird does in collecting food alone you will begin to understand the value to it of this special provision for the getting of oxygen into its blood and carbon dioxide out of it.

SUMMARY OF THE CHAPTER

Things to Note

1. Plants and animals respire day and night.
2. Aerobic respiration.
3. Fermentation compared with anaerobic respiration.
4. Release of energy in all three processes.
5. The breathing organs of back-boned animals and some others.

CHAPTER 5

FEEDING AND ASSIMILATION IN PLANTS

The Food of Plants

In many houses and especially in country cottages you will have seen in pots, plants of many kinds and of different sizes, some grown from seeds but others, like the geranium, from cuttings. Even in a 6-inch pot of soil a geranium will continue to grow for many years and bear flowers every summer.

Like an oak or any other seedling, in order to grow a pot plant must have food. Its shoots with their leaves are spread out in the air while below the soil it has a much-branched, root system which in time may become "pot-bound". The plant will be watered occasionally; but very rarely will anything else be provided. It seems clear that the two possible sources of food are the air and the moist soil (Fig. 33).

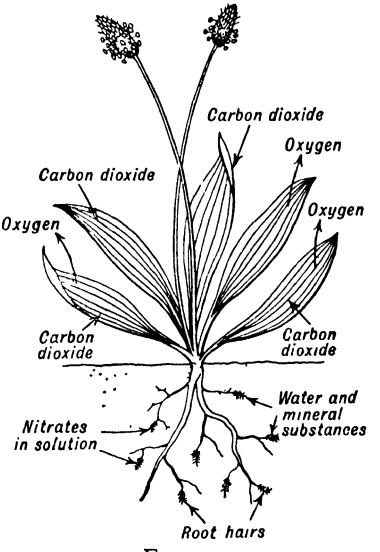


FIG. 33.
PLANTAIN.
A plant in relation to air and soil.

In Book II, Chapter I you learnt about the composition of the air and you know something as to what remains when plants are burned. Partially burned branches of trees yield charcoal and in our open fireplaces logs are blackened in burning and then reduced to a fine whitish grey ash.

Later, in Book II, Chapter XI, some account of soils was given and in Experiment 1 you saw the importance of supplying a nitrate in the food solution for a seedling, e.g. barley. It is very surprising to learn that only a few kinds of green plant can make use of the nitrogen of the air which amounts to nearly 80 per cent (a very high proportion), and that though the carbon dioxide of the air amounts to only about 0.03 per cent (a very small proportion of the whole), this is the only source of carbon for green plants everywhere. Though the soil may be rich in carbonates the plants growing in them obtain the whole of their carbon from the carbon dioxide in the air. In order to prove the truth of this statement you must know that there are substances having a strong affinity for this gas ; one which is convenient to use is caustic potash, another is caustic soda, and a third is soda lime.

Experiment 1

Fit up the apparatus shown in Fig. 34 in duplicate. Use caustic soda or potash in the test-tube in *B*, but for *A*, the control, use only water. Select variegated shoots which have been in darkness for forty-eight hours, and place both in sunlight. In the afternoon of the third day test a lower leaf from *A* and one from *B* for starch, having first sketched each for the distribution of its green and white parts. Test these substances too : to powdered

starch, white bread, potato, white sugar and powdered alum in turn, add a little dilute "iodine solution", made by dissolving crystals of iodine in a solution of

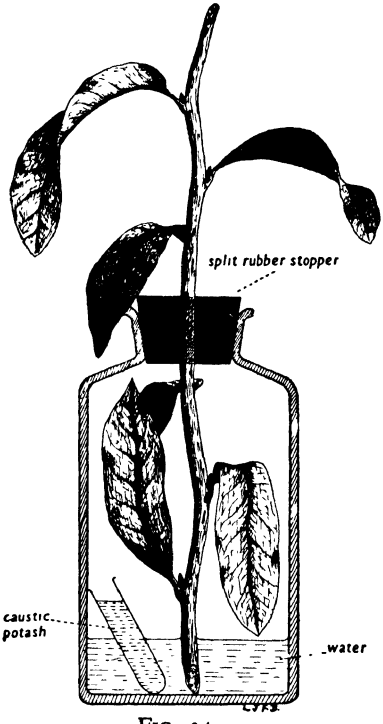


FIG. 34.
A GREEN SHOOT EXPOSED TO LIGHT
Caustic potash absorbs carbon dioxide.

potassium iodide. The privet or geranium leaves must first be dipped into boiling water, then heated cautiously in alcohol so that the chlorophyll may be extracted, then

dipped in warm water to make them flexible and spread on a white saucer. Finally, the iodine solution is poured over them.

The results should be tabulated thus :

		Purple reaction to iodine solution	
Powdered starch		No	
White bread		Yes	
Potato		Yes	
Powdered alum		No	
Lump sugar		No	
Geranium leaf from *A*	white part	No	after exposure to sunlight
	green part	Yes	
Geranium leaf from *B*	white part	No	
	green part	No	

What conclusions do you draw ?

We must not assume that starch was the first thing made by the green parts of *A* nor that all green plants contain starch in their leaves even at the close of a long sunny day. Test for starch the foliage and also the underground storage organs of *Montbretia* and the Bindweed ; test also the foliage of variegated Ash-leaved Maple and variegated *Tropæolum* called " Nasturtium " ; carry out these tests after a sunny period of some hours in each instance and tabulate the results.

You know that many plants store sugar and not starch and you realize that sugar is soluble in cool or warm water whereas starch is not. You will not be very surprised to learn that sugar is made in the green foliage of most plants. Often it is transported in its soluble form to various parts of the plant and then acted upon by enzymes in a way that results in starch being stored, for example, in the potato tuber, buried deeply in the soil. Some green plants, however, for example the onion, never make starch.

Experiment 2

To demonstrate sugar in green leaves after they have been exposed to sunlight.

Take young leaves from cabbage or onion and crush these with a little water very thoroughly, using a pestle and mortar. Filter the extract. Add to half the green liquid a small quantity of *Fehling's solution.** Boil for two or three minutes. Test older leaves in the same way.

A yellow-red or brick-red *precipitate* shows the presence of a sugar, which is *glucose*, in the *leaf*.

To the second half of the green liquid add a few drops of dilute sulphuric acid. Then add Fehling's solution and boil. If there is now a brick-red precipitate a sugar of another kind, namely *sucrose*, is indicated as the sugar which was present at first.

Test some of the young foliage of the same plants for starch at different times on a sunny day if you have time.

Let us now consider the *relationships* of some of the substances which we have just been studying :

1. Water contains hydrogen and oxygen.
2. Carbon dioxide contains carbon and oxygen.
3. Sugar contains carbon, hydrogen and oxygen.
4. Starch also contains carbon, hydrogen and oxygen, but in proportions different from those in sugar.

These statements are too simple to explain that when water and carbon dioxide are made to combine in a green plant in the production of sugar there is some oxygen left over, but this you can demonstrate for yourselves during

*Fehling's solution is copper sulphate solution, made strongly alkaline at time of experiment by addition of a solution of Rochelle salt and sodium hydroxide.

warm, bright weather and you can, at the same time, gain fresh proof of the need for light by keeping a second jar in the dark and noting what happens.

Experiment 3

Boil a pint or more of water and let it become cool. Select some vigorously growing *Elodea* or Canadian pond weed, four wide-mouthed clear glass jam jars or large beakers, four short-stemmed funnels and four test-tubes. Arrange the apparatus as in Fig. 35. Label the jars or beakers *A*, *B*, *C*, *D* and put the date. In *A* put ordinary *tap water at room temperature* and place it in bright light indoors; in *B* put the boiled water at room temperature and place it beside *A*; in *C* put water like that in *A* but place it in a dark cupboard; in *D* put water like that in *A* and *C*, place it in bright light but in a cool place.

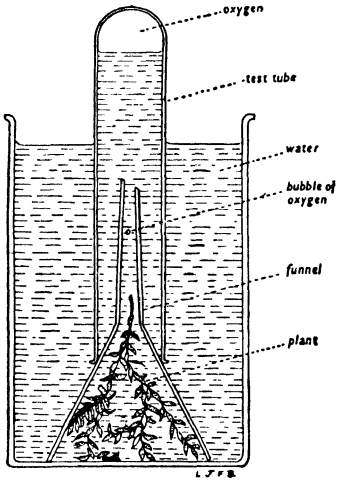


FIG. 35.
CANADIAN PONDWEED, ELODEA, EXPOSED TO SUNLIGHT.

Observe the ascent of small bubbles of a colourless gas from the *Elodea* and the rate at which it collects in the tops of the test tubes. In what weather is the *Elodea* most active? Do the leaves lose any of their green colour? How is it that there is no activity in *B* at first but later a slight production of a colourless gas?

You can entirely prevent activity in this jar *B* by pouring a thin layer of olive oil over the water at the outset. How many hours (or days) are needed for test tubes *A*, *C* and *D* to become nearly full of gas ?

Have ready some corks of the right diameter and marked with indian ink letters ; carefully remove the test tubes with all the gas they contain away from the necks of the funnels and fit in the corks *under the water* in the beakers. Fill fresh test-tubes with water of the right kind and slide these over the funnel necks so that the experimental work may continue. The gas you have collected has a less *specific gravity* than water. You suspect from what you have read that it is oxygen ; apply a glowing splint and it will burst into flame. Oxygen has been released by the *Elodea* exposed to sunlight and provided with *air*, *including carbon dioxide*, *dissolved in the water*. For how many jars were both conditions true ? Has the temperature made any difference to the rate of activity ? How could you have given the *Elodea* shoots in *B* favourable conditions ? You might try again, with fresh actively growing Canadian pond weed using boiled water into which you have breathed vigorously.

You will remember that expired air from our lungs is rich in carbon dioxide and also contains much nitrogen and a moderate proportion of oxygen for the blood in the capillaries of our lungs can take up only about a fifth of the oxygen which is breathed in. In the very first experiment in this book you learned that oxygen is essential for the growth of seedlings and in Chapter IV you saw how to prove that in respiration green plants give out carbon dioxide and further, that this process goes on during both day and night.

We will now put down side by side, for comparison, two very important statements about

GREEN PLANTS

Daylight	Darkness
Respiration: Oxygen taken in; carbon dioxide released.	Respiration: Carbon dioxide given out; oxygen used.
Food-building: Carbon dioxide taken in. Oxygen given out.	—

You might think that in daylight the two kinds of work would mask one another but generally the food-building is the more vigorous process and so we can actually collect oxygen as in the experiment you have just performed with water-plants. Another name for this remarkable food-making process in green plants is *photosynthesis* which means light-building up. Light supplies a kind of energy called radiant energy which the chlorophyll is able to use; in the sugars and starches another kind of energy is stored up and can be used by the plant in growing and also by us when we eat sugars and starchy foods.

The soil is a source not only of water which is needed for the making of sugars and starches, but also of mineral salts, these salts being present in dilute solutions.

The following elements are known to be necessary to plants in addition to carbon, hydrogen and oxygen: nitrogen, potassium, phosphorus, calcium, magnesium, sulphur, iron. Other elements are required in still smaller quantities, but these vary in different plants.

Experiment 4

Before you make up a solution containing the above elements, however, be prepared with a number of healthy seedlings of maize, pea, bean or oat, which have germinated on damp sawdust or blotting paper.

Take 1000 cubic centimetres of water and add the following :

0·25 gm. potassium phosphate,
0·25 gm. potassium nitrate,
0·25 gm. magnesium sulphate,
1 gm. calcium nitrate,
2 drops of ferric chloride solution.

This will provide the seven elements listed above together with a minute quantity of chlorine.

Take clean, wide-mouthed bottles and well-fitting corks, each with three holes. Bottle *A* will contain the complete solution but one will be deprived of the nitrate and instead it will contain potassium chloride and a different calcium salt from the one listed above.

Much time and care is needed for the setting up of the whole series of bottles from each of which one of the seven elements is withheld. If time is limited you should test the effects on the seedlings of the lack of nitrogen, and of iron. You should also set up one or more seedlings with only distilled water and a few with distilled water and a little baked soil, e.g. loam. Cover each bottle with dark paper and blow air into the solution at intervals, since the soil normally contains air rich in carbon dioxide.

While you are waiting for the seedlings to respond to the various mineral salts with which you have provided

FIG. 36. *M. Munro*

12 Oct., 1938. Six experimental jars with cuttings of *Tradescantia* set up in early June—Potassium, Phosphorus, Calcium, Nitrogen, Iron are omitted from jars 1, 2, 3, 4, 5 respectively. Full solution on right.

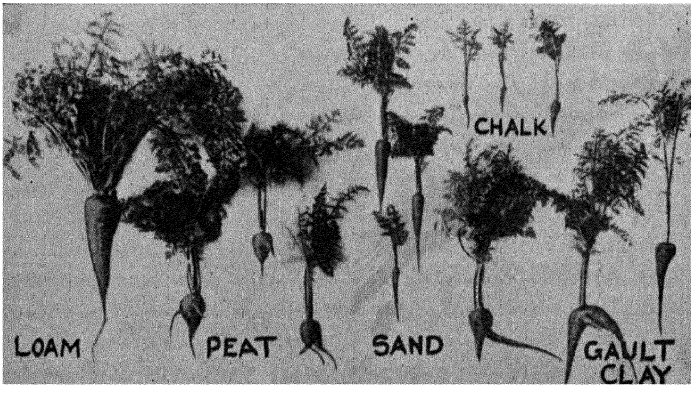


FIG. 37.
CARROTS GROWN IN DIFFERENT SOILS
(By courtesy of Mr. S. T. Parkinson)

them, carry out some simple experimental work with soils. These carrot plants show how important is the study of soils (Fig. 37).

Experiment 5

Take some moist soil, smell it and feel it with your fingers. State whether the soil clings to your fingers or is crumbly, and whether it is dark or light in colour.

(*a*) Drop some of it into a glass vessel. Watch what happens.

(*b*) Stir up thoroughly a second portion with a little water. Then drop a spoonful of this watery mixture into a tall gas jar nearly full of clear water, invert it over your hand so that the whole is thoroughly mixed ; allow it to stand in the normal position where it can remain undisturbed till the next day at least. Sketch what you see after a few minutes and again after half an hour. No single set of sketches can give an accurate picture for soils in general, because they vary from place to place according to the nature of the underlying rocks, the cultivation of the soil and other things, but all soils respond to this very simple kind of *mechanical analysis* in which the force of *gravity* and the solvent action of water play important parts. Keep the gas jar covered.

In part *A* of this experiment you will have noticed colourless gas bubbles rising and judged that these consist of *air*, while in part *B* you will have noted *large*, *small* and *very small rock particles* sinking at different rates and settling at the bottom of the jar. Is the liquid above them clearer than it was ? Look again to-morrow. It becomes clearer very gradually, the reason being that the suspended

particles are *extremely small.* Indeed the smallest cannot settle.

Do you think that the almost clear liquid is pure water ? Notice carefully the floating plant remains called *humus* at the top. There may also be some humus above the other solid material which has settled.

Experiment 6

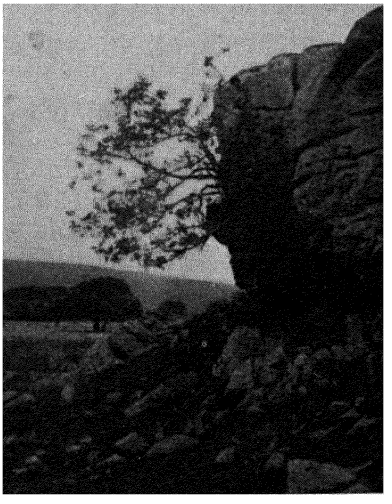
Filter this clear-looking liquid so that it is as free as possible from humus and sediment. Pour it into a wide necked bottle *A*, fitted with a cork having three holes. Into a second bottle *B* put distilled water. Carefully fit in suitable seedlings or cuttings which are equal in size and vigour. Label them on their brown paper light-screens and put them in a favourable place where they can remain for some weeks. Add distilled water when necessary and introduce air through the tube provided. Report on the growth of the two sets.

Now make out a list of most of the *constituents* of the soil :

Air.
Rock particles of varying size.
Water with mineral salts in solution.
Humus (partially decayed plant and animal remains).

The gardeners will know that this list is incomplete. What have we omitted ? If possible do a little digging at the week-end ; almost certainly you will notice some earthworms, and along the edges of lawns and paths you can see the openings of their burrows, often plugged with fallen leaves, drawn in after dusk. This activity of the

earthworms helps to account for the amount of humus in many soils and for their good drainage and aeration; these lowly animals are among the most valuable of the gardener's friends.



M. Munro

FIG. 38.

A Mountain Ash rooted in narrow joints of limestone where a small amount of soil occurs. Chapel-le-Dale, July, 1938.

Some other soil creatures are big enough to be seen by the unaided eye, but there are countless extremely small plants called *Bacteria*, and extremely small animals called *Protozoa* which play a very important part.

One of the greatest soil experts is Sir John Russell, the director of the Rothamsted Experimental Station at Harpenden (in Hertfordshire); he writes about these

minute plants and animals of the soil: "They bring about decay, and thus clear away the residues of previous plants leaving the soil clear for a new race. They do even more: they make the old plant material into new plant food." They are able to do what typical green plants cannot do and they are working day and night though at varying rates according to the varying temperature and other conditions.

There are some green plants which live most intimately connected with certain kinds of bacteria. Find a place in a field, a lawn, or a path where clover plants are growing. Make the soil thoroughly moist and then dig up a complete plant, place it in a bowl of water for a few minutes, then take it out and look for little round lumps on the roots. These lumps are called *root-nodules*. Look for similar root-nodules on vetches, lupins, peas and beans. What do you know about the shape of the flowers in all these plants? They are all like those of the sweetpea and gorse in their general form; their fruits are all similar too, and are called pods or *legumes*. Hence the family of plants to which they all belong is called the *Leguminoseae* and we use the adjective *leguminous* for these crops and others: clover, lucerne or alfalfa, horse beans and soya beans (Fig. 39).

Many centuries ago the poet Virgil wrote of what had already been known for a very long time in Greece: "Sow your golden corn on land where grew the bean, the slender vetch or the fragile stalks of the bitter lupin." The reasons for following this excellent advice were not understood in Virgil's time nor were they understood even in Western Europe a hundred years ago, though it had been discovered that after the growth of clover the

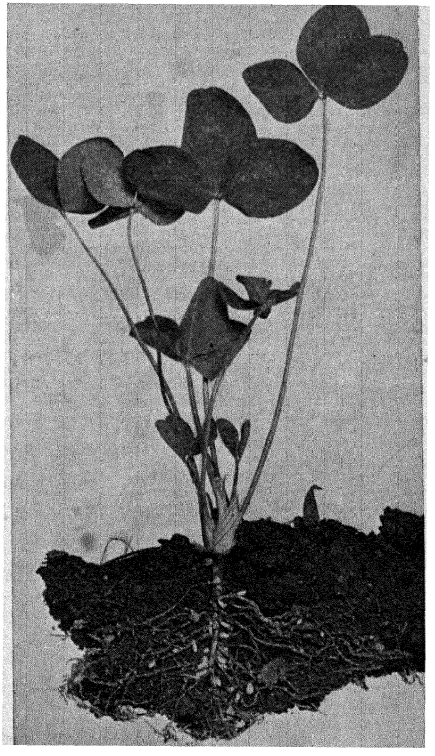


FIG. 39.
ROOT-NODULES.
A clover plant whose roots bear nodules containing great numbers of nitrogen-fixing bacteria.

soil was richer in nitrogen compounds than before this crop had been sown. The clue lies hidden in the root-nodules at which you have been looking. The solution to this problem was not found until 1886 (Fig. 40).

You have already learned something about ammonia, nitric acid and nitrates in Book II, and on page 137 there is a table which gives the percentage of nitrogen in a number of common fertilizers.

FIG. 40.
NUDULE BACTERIA.
Very highly magnified. Stages in the life cycle of one kind of bacteria, which inhabits the root nodules of clover.
From Andrade & Huxley: More Simple Science (Blackwell)

You have noticed in the water culture experiments how seriously plants deprived of nitrogen compounds suffer. In this connexion, the rotation of crops followed since the middle of the 18th century by farmers not only in many parts of Great Britain but also in other countries, will be of interest:

1. Turnips eaten in fields by farm animals whose manure fertilizes the ground.
2. Barley, a first cereal crop.
3. Grass and Clover. Part eaten in field by farm animals. Part cut as hay for winter fodder.
4. Wheat, the second cereal crop. Then 1, 2, 3, 4 again.

Animal husbandry is profitably combined with crop growing.

Fig. 41 puts all this together in a helpful way; it does not introduce the term *nitrites*, which are compounds of nitrogen, oxygen and a base as are the corresponding *nitrates*; the nitrates are richer in oxygen than the nitrites and certain kinds of bacteria bring about the

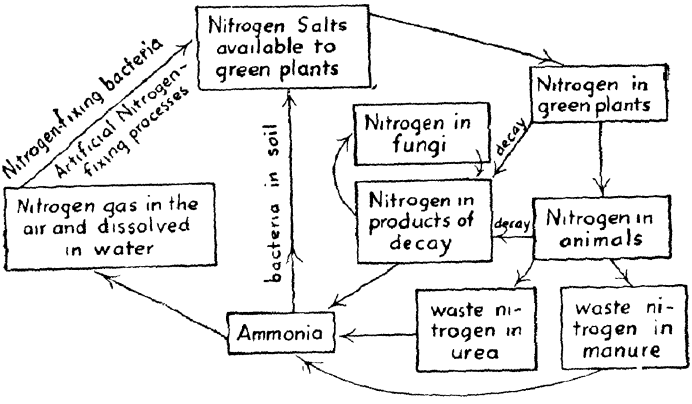


FIG. 41.
From Andrade & Huxley : More Simple Science (Blackwell)

change ; this change is essential, for the great majority of plants cannot make any use of nitrites whereas nitrates are a valuable source of mineral food for them.

Assimilation

The glossary will help you to understand the term *assimilation* but a rhyme may be more easily memorized :

> " It's a very strange thing, as strange as can be,
> Whatever child T. ate turned into child T."

And whatever a plant can extract from the air and the soil and convert into new roots, shoots, leaves and flowers, it has *assimilated.* There is very little taken in and not so used except excess water (Fig. 42).

The green plants, since they assimilate their gaseous and liquid food when light and temperature are suitable, are able to grow in all directions, making new rootlets

with countless root-hairs and new shoots with countless leaves. These root-hairs and leaves, more numerous each year, are able to take in greater quantities of raw food to supply all the different parts of the growing plant.

Through these actively growing parts deep in the ground and high up in the air water circulates but in it

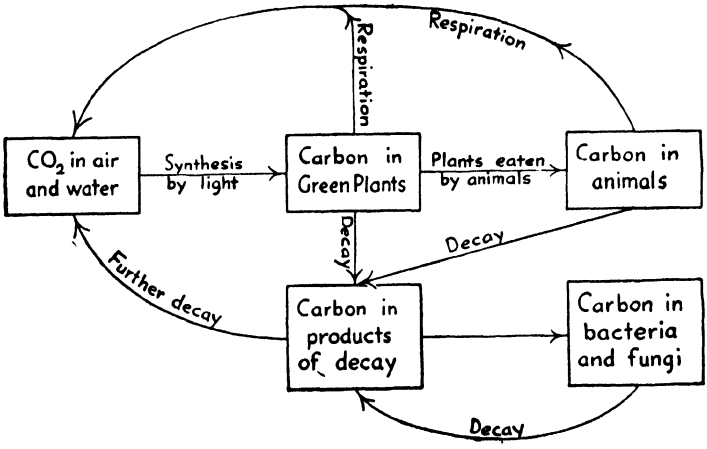


FIG. 42.
From Andrade & Huxley : More Simple Science (Blackwell)

are dissolved mineral salts where it ascends to the leaves and sugar where it descends from those wonderful green sun-trap factories. The plant has to make many compounds besides sugar and starch, e.g. oils and *proteins*. Oils are often *aromatic*, e.g. those in the skin of an orange and they have the property of making paper almost transparent. The proteins may be very watery as in white of egg and all the juicy portions of plants, or more concentrated.

In two test tubes shake up (*a*) a little white of egg with water, and (*b*) a little bean or pea meal with a solution of common salt. Add to each just *one drop* of dilute copper sulphate solution and then an excess of caustic soda solution. Look for a delicate violet coloration in each which demonstrates the presence of protein.

It is interesting to notice that the one natural order of plants bearing root-nodules with nitrogen-fixing bacteria provides the chief supplies of vegetable proteins. This may help you to remember that *proteins contain nitrogen.* Proteins are the only nitrogen-containing foods which we (and the animals) can assimilate and those of vegetable origin are much less expensive than such animal proteins as lean meat, fish, eggs and cheese.

This is a strong argument for maintaining a right percentage of nitrates in the soil. Farmyard manure is best for many reasons : one reason is that it is bulky and helps to make (*a*) a porous sandy soil more retentive of water, and (*b*) a heavy clay soil lighter, that is, better aerated. Failing a proper supply of farmyard manure in gardens we can add a mixture of salts, called Adco, to all green clippings and weeds, and use this when it is ready, with great benefit to the soil.

SUMMARY OF THE CHAPTER

Things to Note

1. The conditions needed by green plants for carbon assimilation or photosynthesis.
2. The chief constituents of the soil.
3. The role of leguminous plants, especially in crop rotation.

CHAPTER 6

FEEDING AND ASSIMILATION IN ANIMALS

You will find this chapter much less difficult to follow than the last, partly because you frequently watch animals feeding and know from your own experience something about both feeding and assimilation. Part of what you eat to-day is needed to renew the muscles which you will use in working your lower jaw up and down when you have your meals tomorrow. Without sufficient food you would use up your muscles and fatty layers and become very thin and weak.

When an animal, such as a puppy is thriving, we often say we can almost see it growing, and by weighing it we gain proof that it has grown week by week. Other kinds of animals you will be able to watch in their early development are water snails, certain insects such as butterflies, and back-boned forms, e.g. trout, frogs, and perhaps guinea pigs, or rabbits (Fig. 43).

You can refer to the rabbit and cat as plant-eater and flesh-eater but the terms commonly used are *herbivorous* and *carnivorous*. Some animals, like bears and badgers, favour a mixed diet. All four are *warm-blooded* and *fur-coated*, i.e. *mammals*, and in nature, wild rabbits and wild cats as well as bears and badgers, travel long distances in search of food. Similarly among *birds*, which are *feathered*

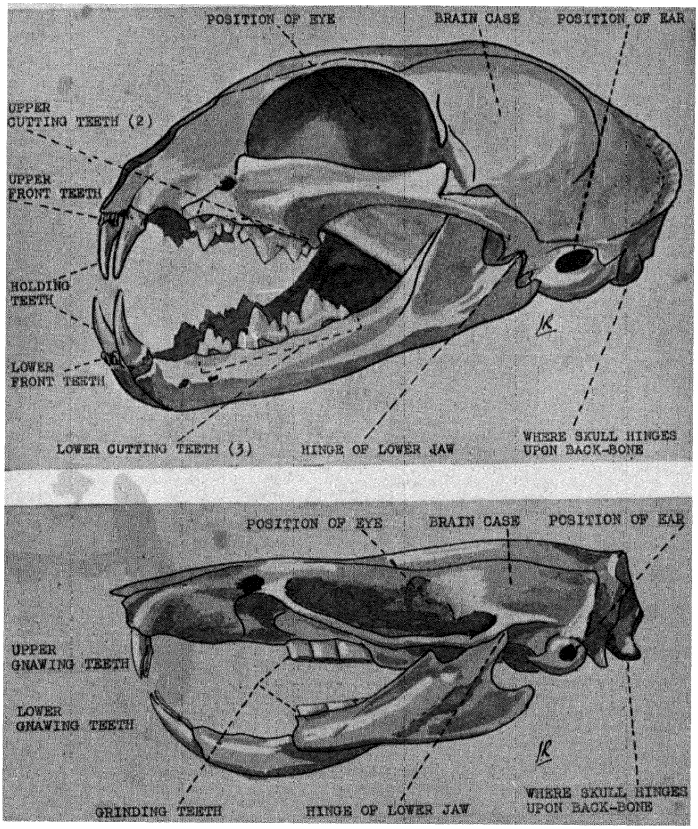
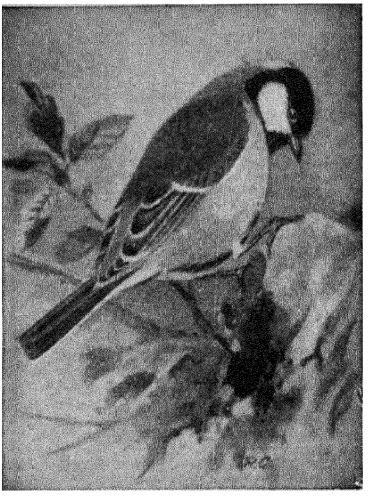


FIG. 43.

Skulls of a cat (a Carnivore), and a rat (a Herbivore known as a Rodent because the dentition makes it able to gnaw tough bark and roots); it has no " holding teeth ", unlike the cat.

(By courtesy of Prof. James Ritchie)



FOOD OF THE GREAT TIT

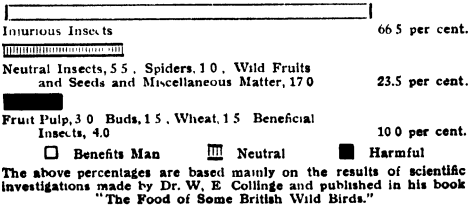


FIG. 44A.

(By courtesy of Mr. Roland Green and the Royal Society for the Protection of Birds)

warm-blooded animals, we find many which depend chiefly on a vegetable diet, e.g. House Sparrow, while others feed only on insects, e.g. Swallow, and still others favour a mixed diet, for example, Song Thrush. Fig. 44A gives details of the largest of our tits.

Feeding the Young

Turn now to the *young* of all these mammals and birds. How are they fed? The young of these four and all other *mammals* are provided with *milk and nothing but milk* for weeks or months, while most young birds are fed on animal food of some sort, whether small grubs, flies or

M. Munro

FIG. 44B.
SARUS CRANES AT WHIPSNADE
The parent knows best.

other kinds, rich in animal protein which is very nourishing and easily digested and assimilated.

Think now about some of the lower cold-blooded animals, for example, trout among *fish*, frogs among *amphibians*, and lizards representing *reptiles*. We find for all of these that an egg containing yolk is laid in water or on land and that the yolk, which is rich in animal protein

and in fat, supplies the nourishment needed by the young creature for its development. Refer to page 150.

Uses of Food

Next compare the chief uses to which a green land plant and a land animal put the energy tied up in their food when they digest and assimilate this food.

Perennial Plant	Animal
Growth and some repair.	Growth and much repair.
Food reserves, often in large quantity.	Movement.
	Food reserves in small quantity.

The plant, for example an oak tree, remains rooted in the ground and does not spend energy in movement apart from growth; the wind is always bringing fresh supplies of air and the soil is always being renewed by the autumnal leaf carpet and the crumbling of rocks.

The animal, for example, the hare or the badger must cover many miles to gain enough food of the right kind and in travelling it uses up much energy, and only lays down a limited reserve, chiefly in the form of fat.

Digestion

In their bodies, animals, like plants, make substances which we can refer to as digestive juices; these juices are poured out into different parts of the food passage in animals and their meals are acted on in different ways at different points. Take a few definite examples: the

starchy bread which we chew with our teeth is altered before we swallow it by the juice called *saliva* which is poured into our mouths just when it is needed. This saliva can change the starch into what tastes sweet and is, in fact, sugar in part before it goes lower down the food passage.

But the meat which a dog devours is often bolted and quite properly since the juices which can act on the meat are poured out in the stomach. This, however, is no argument for human beings bolting their meals. Unless we *masticate* our food we swallow it in pieces so large that the total food surface on which the stomach juices and other juices can act is too small; further we give our jaw muscles too little work to do and the saliva no time to function.

FIG. 45.

A Frog with its tongue in three successive positions during its swift catching of a fly. (The position of the ear-drum is shown only in the top figure.)

Many animals, such as the common frog, require different kinds of food at different stages in their lives. When you have studied frog spawn, frog tadpoles, small tail-less frogs and older frogs you will be able to complete the following table by filling in actual dates, and making

sketches about twice natural size. The rate of development depends largely on temperature; if possible, divide the spawn into two masses; keeping one in a cool place and the other where it is warmer.

Kind of food	Appearance of animal	Length of time since spawn was laid in days	Actual dates
Yolk (white part of egg).			
Green water plants.			
Animal flesh, or one another.			
Moving animals of very small size, e.g. green fly.			
Moving animals of larger size, e.g. flies, earth-worms, slugs.			

You all know what corrugated card is and can understand that if you take a rectangular strip twice as long as this page and roll it to make a cylinder with the smooth side out, the inner folded surface will be about three times as extensive as the outer surface. Similarly with an animal's intestine: but it is not only folded in one direction or another; each fold is itself prolonged into countless finger-like points so that its total surface is enormous.

In a butcher's shop you can often see a particularly

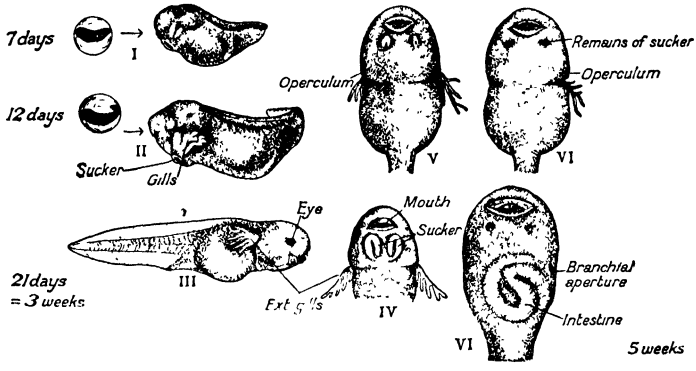


FIG. 46.

TADPOLES

I. Before hatching. II. Ready to hatch. III. Young tadpole with external gills. IV. Under side of head of the same tadpole. V. and VI. Under surface of older tadpole, showing disappearance of external gills and the gill cover (*operculum*) beginning to grow out. VII. External gills have gone, and the gill cover is complete, except for a hole marked 'branchial aperture'.

From Dakin: Elements of General Zoology, by courtesy of the Clarendon Press

clean looking, very pale yellow tissue taken from a calf's stomach. The surface is folded in a neat but somewhat irregular honeycomb pattern. This is tripe; it is very rich in juices which in life would aid the animal's digestion. It is also readily digested by human beings if it is properly cooked.

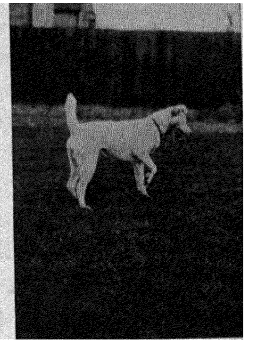
Study worm casts to gain some idea of the length and form of the food passage of the animal. On looking closely at several you will see that they are always solid, cylindrical and of about the same diameter. Worms extract plant food in the form of humus from the soil as they pass it through their bodies by

muscular movements and you will decide that their food tube must be a long hollow cylinder about as wide as a coil of the casting. Try to examine a rather small worm in a moist, white, glazed dish for a few minutes. You can see a long red line, the chief blood vessel, near the upper side because the skin and muscles of its body wall are semi-transparent. Turn it over gently and you may be able to see the dark contents of its long food tube. The inner wall is much folded lengthways, so giving an extensive surface. Replace the worm below some *damp soil* without delay.

The complete food tube in any animal is often called the *alimentary* canal. It may include mouth, gullet, stomach, small intestine which is long and narrow, large intestine which is short but wide, and the back passage. But it may be much simpler, or very different, as in the earthworm where there is no stomach but a tough-walled gizzard, and one very long intestine.

Study the profiles of a terrier which is very like that of a wolf, and a Welsh pony. What do you notice about the depth of the chest and the depth of the *abdomen* behind the chest? Clearly the abdomen is much deeper in the herbivore (Fig. 47). Can you suggest any explanation of this striking contrast between two very swift animals? The herbivore needs a bulky plant diet which requires a very long intestine and abundant juices to digest it, while the carnivore requires only a short intestine in which to complete the digestion of its occasional flesh meal. In the wild, a wolf may have only a few meals in a week. At any zoo you visit you should notice what kinds of food the keepers take to the various animals and whether there is a block of rock salt, perhaps with iodine and liquorice

M. Munro



R. C. Munro

FIG. 47.

Welsh ponies, Pennard, September, 1938. Fox terrier at play.

added for them to lick. Look also at their appearance in side view; contrast, for example, a Reindeer and a Tiger —when possible look closely at their teeth, which give a good clue to an animal's natural diet.

You may like to use a pocket lens and make out the changes which occur in the length of its food passage while the frog tadpole is developing.

From the under or *ventral* side you will notice the coiling which allows a very long tube to be packed in a very small space. What is the diet of the frog tadpole when its intestine is long and coiled ?

Distribution of Food

To be assimilated, the digested food must circulate throughout the body of the tadpole in the blood stream, as in all animals which have blood vessels. These include

a muscular pump called the *heart* and a series of very narrow tubes called *capillaries*; their walls are so thin that dissolved, digested food can *diffuse* into them and then the blood carries this food to every part: head, trunk, limbs and tail. The muscles give up to the bloodstream certain waste products and receive something from the bloodstream which helps them to carry on their work of shortening and lengthening, shortening and lengthening, and so propelling the animal through the water. If you watch very carefully a tadpole at rest you may be able to count the rate of throbbing of its heart. In a young trout it is very easy to do this.

Respiration

You have already taken your own pulse rate in connexion with your study of respiration and will remember that you were then concerned with the taking in to the bloodstream of oxygen and the giving out of carbon dioxide from the bloodstream into the lungs.

It is that same oxygen which makes possible the process of *slow combustion* in our muscles and other tissues as in those of bird, frog tadpole, adult frog and indeed, every animal which exists. This *slow combustion releases some energy in the form of heat while some energy is used up in movement.* The muscles, nerves and other parts must be built up afresh day by day; therefore we must not merely take suitable food daily ourselves but supply to animals in our care what they need. Then repair and growth continue satisfactorily.

Plants use up almost everything they take in through their root-hairs and their leaves except for an excess of water and you know how to prove that this escapes into

the air. Land animals too, have to get rid of a great deal of excess water, some by way of the skin and some by way of the kidneys and bladder, but the water which passes through our skin into the air and is called *perspiration* or sweat, is not pure; it contains impurities in small quantity.

The water which passes out of our bodies by way of the *kidneys* and *bladder* contains waste products which have been filtered out of the blood by the kidneys and give it a yellow colour. It is called *urine*. In a sense it is not correct to speak about excess water because the body can only deal with very dilute solutions. Very sweet syrup or over-salted soup makes us thirsty for plain water.

Energy is needed to change water from the liquid to the gaseous state. This energy, in the form of heat, is supplied by the animal's body, and its skin carries out the very important work of heat regulation, if it is warm-blooded, or better, let us say, if its blood is of even temperature no matter what the temperature of the air or water around it. Our body temperature is 98·4 ° F., and you can test this by asking someone to let you put a perfectly clean *clinical* thermometer in your mouth for a minute or two and then reading it. Not all mammals which have an even body temperature keep to this one of 98·4 ° F. Birds are much warmer and at the higher temperature (104 ° F.—112 ° F.) all the chemical changes which take place in their bodies proceed at a correspondingly swifter pace; they digest their food more rapidly and need to eat much more frequently. To obtain enough food of suitable kinds they must travel to and fro from morning until evening except for an afternoon rest.

Whenever you have the chance make a point of watching House-martins, Swallows or other birds taking succulent grubs to their young, and make a timed record with the date, hour of observation, number of journeys and exact locality, whether near a pond or stream.

BIRDS	near	**JULY 29, 1934**
	BAMBURGH	1.30—2 p.m.

House Martins

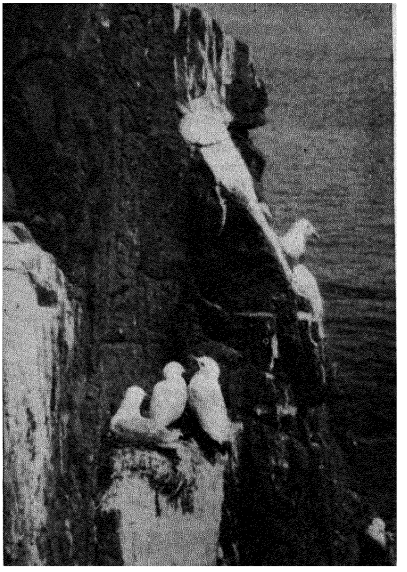
Watched two parents feeding nestlings whose mouths were seen above rim of nest under eaves of a mill-house. Food was brought once a minute almost precisely. Only a momentary pause separated the flights of the parents.

Getting Rid of Waste Products

All these animals which we have been considering have to get rid of solid waste matter as well as liquid waste. Among herbivores such as cattle, sheep and horses the amount is great, but though we speak of waste from the point of view of the animal, the farmer calls it manure and values it highly. Much of what has been taken from the soil by grasses and other green herbs is returned to it though in a different form, by all kinds of grazing animals whether domesticated or not.

The undigested residues left over from the food which birds consume represent a very small proportion of the whole but these residues in places where big *gregarious* sea birds gather in vast numbers are of great commercial value (Fig. 48). You have probably heard of the export of *guano*, which is very rich in phosphates and ammonium salts from South America. It comes from islands off the coast of Peru where the rainfall is extremely slight.

So you see in the general scheme of things in Nature nothing is lost or wasted in the long run. You have now thought a little about (1) the circulation of water ; (2) the circulation of carbon ; and (3) the circulation of nitrogen.



D. V. C. Jack

FIG. 48.

Kittiwake Gulls nesting on precipitous cliffs. Farne Islands, June, 1937. In a drier climate much more guano would accumulate.

But there is no limit to the number of diagrams you could work out for the circulation of different substances : you may like to think about calcium in this connexion, or about a calcium salt, namely, the carbonate which in one form is chalk, and in another the shell substance of marine

animals such as whelks, cockles and corals. It is present in hard water and forms a deposit inside kettles and boilers. Possibly you will prefer to think out what may happen to the calcium phosphate which was present in the bony part of the last chop you had for dinner. Try to put your ideas on paper.

In this present century there are few parts of the world remaining in an entirely natural state for with our new and rapid methods of transport it has been easy to introduce new types of crop and new kinds of domestic animals into distant countries. Further, through *irrigation* great wastes and semi-desert regions have been made productive. Unfortunately many plants and animals have been introduced in a heedless, haphazard way with disastrous results. A plant which thrives in spite of its natural enemies in Great Britain, when introduced to New Zealand may be so successful as to crowd out native plants and cause endless trouble and loss. New laws have been made to check this kind of thing, but such laws cannot cure troubles which already exist.

Following years of patient research, larvæ of the insects which are natural enemies in this country of the Ragwort are bred here and shipped to New Zealand where this plant was unfortunately introduced about seventy years ago.

SUMMARY OF THE CHAPTER

Things to Note

1. The food requirements of animals of different kinds and different ages.
2. Feeding, digestion and assimilation.
3. The disposing of excess water and other waste.

CHAPTER 7

REPRODUCTION IN ANIMALS AND PLANTS

ONE of the most arresting things about all living plants and animals is that they are able to produce new individuals of their own kind. A great number of them do this in two entirely different ways but some of the seed plants can only reproduce their kind by making seeds, and the great majority of animals, including all those which have backbones, must produce *eggs* for their kind to continue its existence. There is no space here to describe other methods whereby new individuals are made.

The Flower

You already know what must be provided for seeds to germinate and develop into new plants, but now you will learn how a seed comes into being and some experimental work will convince you of a few very important points; in advance you will need to study the flowers of a few weeds or garden plants. I suggest:

(1) Creeping Buttercup, Marsh Marigold or Japanese Anemone;
(2) Sweet Pea, Garden Pea or Clover;
(3) Primrose, Cowslip or Polyanthus;
(4) Bluebell, Tulip or Tiger Lily;
(5) Wallflower, Shepherd's Purse or Stock;
(6) Holly, Willow, Poplar, Yew or White Campion.

One example out of each group will suffice. This means that you can choose garden plants or wild plants of which some are common weeds. There is space in this chapter for directions about only five flowers but you will find these helpful for the others, whichever you may choose. Always try to have some old, slightly faded flowers as well as others which are younger and less developed (Fig. 49).

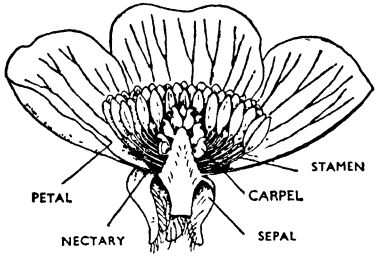


FIG. 49.
Flower of Bulbous Buttercup cut through the centre lengthways. × 3.
From Mackinnon: The Animals' World (G. Bell & Sons, Ltd.)

I will assume that everyone has three buttercups: a flower bud, a perfect open flower and one which is about to lose its gleaming yellow *petals*, for that is the name given to the large, spreading parts, and together they form the *corolla*. Outside this you will find generally five smaller, green, pointed parts called *sepals*, together making the *calyx*, while inside the petals are a great number of narrow stalks each bearing a double pollen bag, called an *anther*, though the anther and stalk together make a *stamen*. Inside all these parts, i.e., sepals, petals, and stamens, you find a central platform covered with small, tough, green, oval structures each with a little projecting part turned outwards. These are the *carpels*. Before you examine these fully, look at the flower bud. Can you see anything besides the five sepals? Gently part these, using a mounted needle or the point of a long pin. The

petals are beautifully packed inside, and on parting these you will find the stamens with plump anthers which when pricked are seen to be full of pollen, a mass of minute yellow grains. Notice the size of the smooth, green carpels all over the top of the central platform. Now turn to the open flower and look closely at the base of each petal for a neat little flat bag, possibly still containing a drop of a sweet fluid called nectar. Compare the sizes and conditions of sepals, petals, stamens and carpels in bud, open perfect flower, and faded flower. Then try to complete this summary :

Position on floral receptacle	Name of part	Numbers	Free or joined to one another	Work or function
Highest	Carpel	Many	Free	Production of
	Stamen			Production of
	Petal			Production of
				Attraction of
Lowest	Sepal		,,	Protection of

It is best whenever possible to study plants in their natural haunts, so if you can, go into the garden or a field and look for visitors to the flowers. You will probably

find a number of small insects. What are they seeking? Are many of them dusted with pollen? Are any of them going down to the nectaries? Have any of the carpels been dusted with pollen? Now turn to the oldest flowers you can find (Fig. 50). What remains? Just a cluster of brown carpels and of these some may fall at a touch while others will already have dropped to the ground. These large dry carpels which

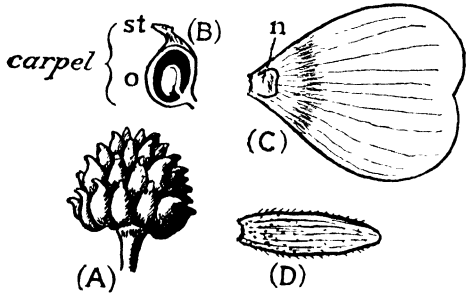


FIG. 50.
PARTS OF A BUTTERCUP FLOWER.
A. Group of Carpels.
B. One carpel cut open lengthways; *o*, ovary with one ovule *st*, stigma.
C. A single petal.
n. nectary.
D. A single sepal.
From Wyeth: Elementary General Biology (G. Bell & Sons, Ltd.)

are the parts of the buttercup fruit contain the seeds. Try to cut one. Can you take the seed out? It is so closely covered by the fruit wall that you cannot separate it. Cut across a carpel in the younger, perfect flower. Possibly here you will succeed in detaching the cover but are you sure that it is a *seed* inside and that if it were given sufficient time, warmth and

moisture it would germinate ? Examine the flower bud again. You can recognize the carpels, now small, green and soft. Do you think they already contain seed ? The answer is " No ". We must enquire :

(*a*) From what is the seed formed ?
(*b*) How is the seed formed ?

To (*a*), the answer is, " From an *ovule*, which arises as a little swelling on the inside of the carpel wall where it forms a case called the ovary (and below the parts called *style* and *stigma*). For (*b*) the answer cannot be given so briefly or simply and I shall postpone it until other flowers have been examined and described, but you can finish filling in the last column in the table set out on page 107. The chief work of a carpel is the production of one or more ovules.

The Sweet Pea clearly has five green sepals and five white or coloured petals but the latter are unequal. You will soon recognize the large standard, the two side wings, and the two small petals lightly joined together to form the keel. Gently press down the keel and observe the silky looking sheath made of nine stamen stalks and open along the upper border, since the tenth stamen is free. Within the sheath you will perhaps expect to find several carpels but there is only one and this is long and narrow tapering to an upturned narrow tip whose surface is sticky. Can you recognize the three parts of the carpel, namely, ovary, style and stigma ? Hold up against the light the one carpel of an old flower from which petals and stamens have fallen. Can you see a row of dark spots ? You will judge rightly that these are ovules. Watch for the growth and ripening of the sweet pea pods

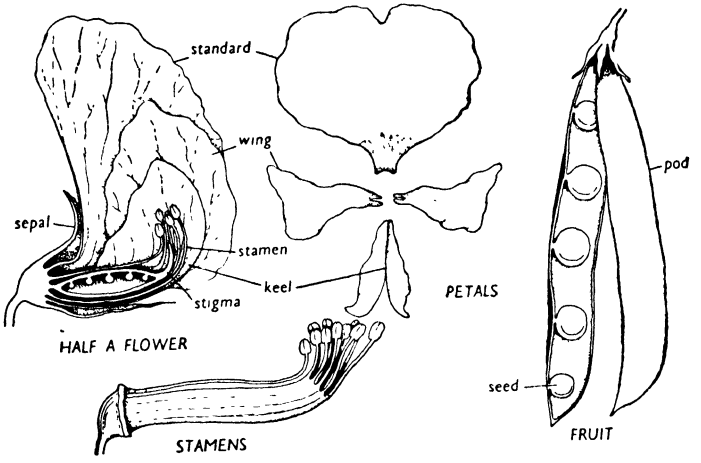


FIG. 51.
STRUCTURE OF SWEET PEA FLOWER AND FRUIT.

in the garden until some contain seeds as big as those which are bought for sowing.

Experiment 1

Meanwhile label on plants out of doors a few healthy looking sprays of unopened flowers, some *A* and others *B*. Leave *A* untouched. From each of the flowers in *B* remove all the stamens without damaging anything else. This requires delicate handling and a suitable instrument; a pair of fine forceps is best. You must be sure that you do not break the anthers. Have ready little bags made of muslin and tie these round the sprays of flowers, now incomplete. When the *A*'s have faded and show their lengthening pods, remove one of the bags and examine

one member of *B* group. A few days later look at the *A*'s again and examine a second member of *B* group. What conclusions can you draw? A simple table will show most clearly the results:

Dates	*A* with carpel (pod) and stamens undisturbed	*B* with carpel (pod) undisturbed but all stamens removed
1	Carpel small, green, with small ovules	Carpel small, green, with small ovules
2	Pod larger, green	,, ,, ,,
3	Pod still larger, and darker with large seeds, a ripening fruit	Pod still small with no seeds formed

This simple experiment seems to show the stamens contain something essential for the development of ovules into seeds and of a small ovary into a large ovary which is here a ripe pod. It is not difficult to prove that it is the anther, containing the pollen, which is the important part of the stamen, but what is it that the pollen does to the ovule? This question cannot be fully answered in a simple little book such as this. Each tiny pollen grain germinates when given the right conditions provided by the moist stigma in suitable weather. As it grows, it divides into several cells and one of these extremely small cells is able to cause a bigger cell in the unripe ovule inside the ovary to divide repeatedly to produce a small plant called the *embryo*; in time the pea embryo

FIG. 52.
CONTROLLED POLLINATION IN A LARGE NURSERY.
(By courtesy of Messrs. Sutton & Sons, Ltd.)

occupies all the space inside the protecting coat of what is no longer an ovule but a seed; the seed is capable of carrying on the sweet pea tradition by germinating, growing into a new plant, and so establishing a new generation. You may still be wondering why those muslin bags were put over the *B* flowers. On a sunny day try to spend a little time watching the insects which come and go in the garden borders or the hedges. You will soon realize that the hairy bodies of honey bees often carry much pollen from flower to flower and frequently some is deposited on a receptive stigma. When this transferring of pollen has occurred it is probable that the ovules will give place to seeds (Fig. 53).

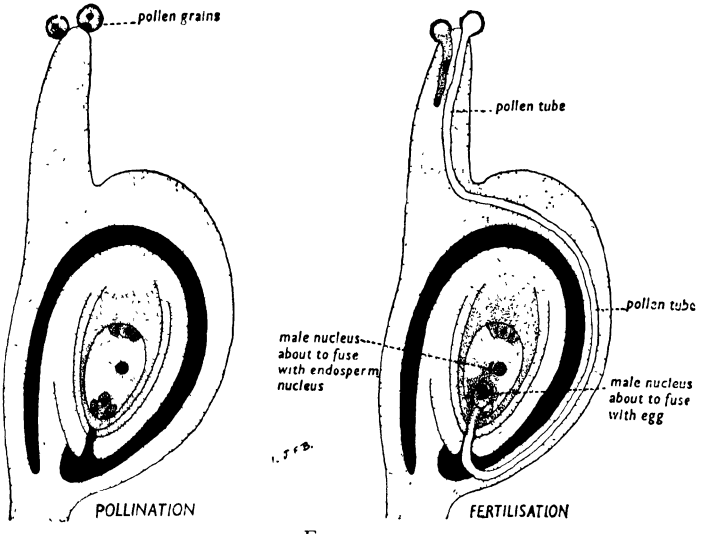


FIG. 53.

A carpel cut lengthways to show the ovary with one ovule. Above are the short style and the stigma.

When a male nucleus has fused with an egg nucleus a new plant begins to grow. The endosperm is a supply of food.

No names have yet been given to the all-important tiny cells which together are responsible for the building of the new embryo. The special cell contributed by the pollen grain is the smaller and more active of the two and is called the *male cell* or *sperm cell.* The special cell which lies waiting in the ovule is much larger though invisible without a microscope; it is passive (that is, it does not travel) and is called the *female cell* or *ovum.* For Primroses, Bluebell and Wallflower sketches must suffice to guide your observations (Figs. 54, 55 *A* and *B*). It is quite easy to raise new plants from seed in each instance; on the

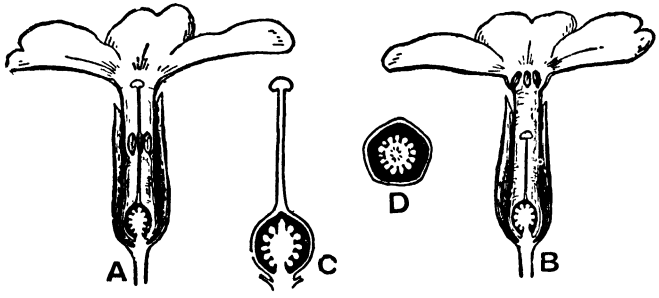


FIG. 54.

PRIMROSE FLOWERS.

A. Pin-eyed form cut lengthways, stigma high, stamens low.
B. Thrum-eyed form showing stamens high, stigma low.
C. Stigma, style and ovary cut open to show ovules.
D. Ovary cut across to show ovules.

From Yapp : Botany for Junior Schools (Cambridge Press)

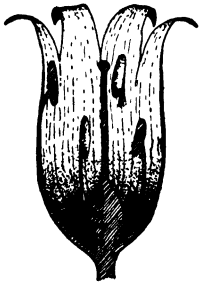


FIG. 55A.

One half of a single flower of Bluebell cut to show ovules in one of three chambers in the ovary, and four of the six stamens.

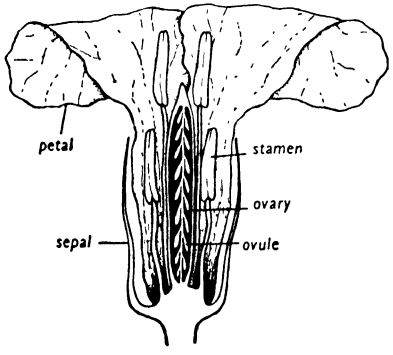


FIG. 55B.

Wallflower cut to show ovules in the two chambers of the ovary and two short stamens and two of the long stamens.

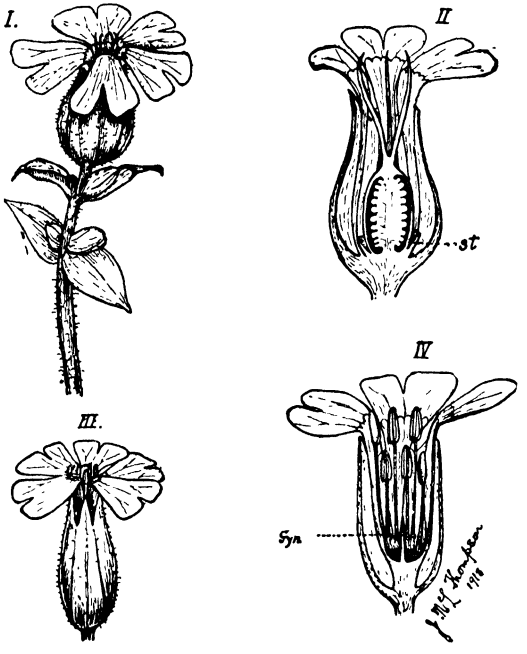


FIG. 56.

FLOWERS FROM THE TWO KINDS OF PLANTS KNOWN AS WHITE CAMPION.

I. Ovule-bearing or pistillate. III. Pollen-bearing or staminate.
II. The same in section. IV. The same in section.

field banks or in the woods one can often find great numbers of Bluebell seedlings and sometimes tiny Primrose plants, for in late summer ripe fruits yielded seeds.

We come now to group six, as listed on page 105. Many people complain in December that some of the Holly trees bear no berries, and it is perfectly true that about half of them are never brilliant with a burden of

fruit. In May or early June try to look at several trees while the twigs carry clusters of cream-coloured blossom. Are they all of one kind ? Do the flowers on all the trees possess stamens ? Do they all possess carpels ? Clearly the answer to the last question is " No, there are many trees whose flowers possess no carpels ". You will realize that these are the male trees and cannot carry fruit, while the flowers on the female trees will give place to small shiny green berries which change in colour through yellow to orange in early autumn and finally, towards Christmastide, to brightest red.

You can study other trees listed in a similar way and will realize that they too may be male or female. The contrast in April between male Yews with their thousands of tiny stamen flowers in clustered cones from which a cloud of pollen falls on the least disturbance by wind or hand and the female Yews with their tiny naked green ovules is most striking. Later on, in September, the Song Thrushes and Blackbirds seek eagerly on the female trees now laden with crimson-cupped seeds while the male trees are ignored since they yield no food at all. Like these trees, Dogs Mercury and White Campion (Fig 56) among wild herbs have two kinds of plants, and are therefore said to be *diœcious*; in bearing the male and female organs on separate individuals they remind us of the vast majority of the members of the Animal Kingdom which have the two sexes separate.

Reproduction in the Fish

It is convenient to consider first some common kind of fish, for example, Herrings. You probably know the expressions soft-roed and hard-roed. The long oval sac

called the hard roe is a very large ovary containing thousands of little round eggs, each of which is a single cell and a true *ovum*. The hard-roed herring is therefore the female. The soft-roe is the corresponding sac in the male herring and contains literally millions of almost unthinkably small sperm cells.

You may know the term *close season* as applied to various animals including fish. The spawning time for Herrings

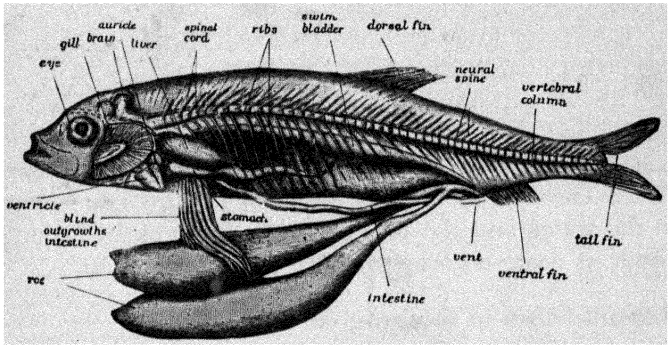


FIG. 57.

A BONY FISH DISSECTED TO SHOW THE CHIEF ORGANS.
The auricle and ventricle are the principal parts of the heart.

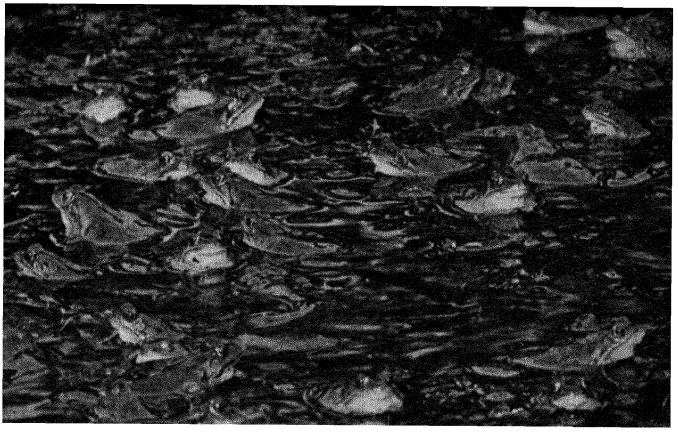
in the North Sea is early autumn off East Anglia; later the fishing boats follow the shoals and great numbers are caught and sent to market. The mesh of the nets is limited to a size which allows young fish to escape. If fishing were permitted earlier, year after year, the numbers would soon be seriously depleted, for though a female herring, like most fish, produces enormous numbers of young, these are sought by their natural enemies in the ocean as food, and do not survive to become adults and reproduce their kind (Fig. 57). The

female Herring at the right season and in the right place passes a vast number of egg cells from the ovary or hard-roe, out into the water. The male Herring at the same season and in the same place passes a still vaster number of minute sperm cells from the testis or soft-roe, out into the water. An actively swimming minute sperm cell is able to make a larger egg cell divide and grow, step by step into a tiny animal which in time comes to resemble its parents though it takes a few years for it to become an adult, whether a soft-roed male, or a hard-roed female fish.

This all-important process in which two tiny cells, unlike one another, come into contact and actually fuse or join to form one indivisible thing is called *fertilization.* In the Herring, as in other fish, this process takes place in the water and the tiny sperm cell swims by lashing about its relatively long tapering part in the water.

Reproduction in the Frog, an Amphibian

Let us turn our attention now to an animal which is very different in shape, in the character of its skin and in its way of life, the Common Frog. If you know where to look you may see this animal in almost every month of the year in the south of England but least often in January and the first three weeks of February. Towards the end of this second month you may hear the croaking of those male frogs which are about four years of age or older, near ponds and fresh water marshes. I know several ponds in Sussex where year after year on February 24th or a day or two later, large numbers of adult frogs congregated at the close of the *hibernating* period. First, on approaching silently and without casting any shadow over



Robert M. Adam

FIG. 58.
Frogs collecting in a pond after hibernation for the mating period.

the water, we can see some of them swimming about alone with long, vigorous leg-strokes. Then we notice just above water-level the bright eyes of a frog which is stationary (Fig. 58). Peering closely we see that these prominent eyes belong to a slim-bodied male with his arms clasped round the body of a female whose girth is much greater than his. In maintaining his hold the male takes advantage of the rough raised pads on his first fingers. (Frogs have four fingers and no thumb on either hand.) The pair remain together, swimming about in a leisurely way, or resting with their nostrils just above the surface of the water for several days or even for as long as three weeks. When startled they plunge down into the mud, out of view. They take no food all this time but seem to favour

sunny corners where the water is shallow and where there are plants such as rushes and Yellow Iris whose tall leaves have persisted during the winter. At length, late in February or early in March, we find a mass of spawn. The two frogs have parted and after a much-needed rest set out to break their long fast. The eggs or ova are not naked; each is surrounded by an envelope of clear jelly. The whole mass laid by one female frog soon occupies much more space because as you can readily see the jelly has swollen. You can divide a group of eggs into two parts, place each in water in a glass vessel, keep one indoors and one out-of-doors and note the rates of development, for just when the eggs of the female frog were passed out into the water, there escaped from the body of the male a stream of minute sperms in myriads. Each egg cell or ovum is fertilized by one of these actively swimming long-tailed sperms and then, and only then, in nature, there follows the development of a new individual; the early stages of its development take place within the envelope of jelly. You should keep a diary making two entries each day, Saturday included. One entry for the outdoor, one for the indoor mass. Here are some questions to guide your observation:

How soon does the little dark sphere take on the shape of a dumb-bell?

How soon does one end look different from the other?

How soon does this tiny creature within the jelly move?

How soon does this larva wriggle free and cling to a water weed?

For how many days does it cling there?

How soon can you see a little frill on each side of the head end of the tadpole?

How long do these frilly looking gills take to gain their greatest length ?

How soon does a mouth appear ?

What kind of food is eaten at first ?

By the end of March you may have to decide to return most of your frog tadpoles to a local pond but some of you may be able to take a few home, in water of course, and take care of them during the Easter holidays. You should continue to study them, for a few minutes each day will suffice ; you will have to provide raw worms or meat as food in place of green water weeds if you keep them longer. Early in June, if you have taken good care, you should have tiny frogs whose tails will soon be used up in nourishing their little bodies and limbs. It is not always easy to provide the right food ; soft-bodied greenfly from rose bushes and other plants are best of all probably, and it is fascinating to watch the quick flick of the tongue which conveys the insect to the back of the frog's mouth. Look back to page 95.

Do you suppose that in February next these same frogs will be ready to mate ? The answer is " No ", for they will still be much too young. Their parents were three or four years old at least ; indeed, they may have been five or six years or even older. These tiny frogs which leave the breeding ponds in June will have to fend for themselves till autumn, hibernate, come forth in the next year and survive two more winters before they can mate, become parents and so carry on the race.

Frogs and most other amphibians such as the Common Toad of Great Britain and the various kinds of newts which we have in this country exercise no parental care.

Reproduction in Reptiles

In the glossary you can find out what the word reptile means, but you need to remember that all reptiles have backbones and either four limbs, two, or none, and that many animals which creep have no backbones and a great many pairs of legs. Your list of British reptiles will probably include our one poisonous animal, the Adder, and in addition the harmless Grass Snake and the Common Lizard; all are land animals and breathe by lungs. More familiar than these to many city children are the tortoises which are imported from southern Europe in large numbers and sold as pets. The eggs of a reptile are not too numerous to be counted and each has a tough shell. Now the possession of a tough shell is a very significant or meaningful thing.

The soft eggs are produced by the female reptile inside the ovary in her body; they are large and rather few. Like the male fish and the male frogs and toads, the male snake produces a great number of minute sperm cells and these must work their way towards the egg cells before these are covered with a firm tough shell. In other words *fertilization must take place inside the body of the female reptile.* This is equally true of birds.

Birds: Parental Care

Several warm-blooded animals were introduced in the first chapter. There are two groups: (1) the birds which are all feathered as you know; and (2) mammals such as dog, horse, cattle and sheep among domesticated animals, together with Squirrel, Badger, Fox, Dormouse, and Mole among wild animals in Great Britain; these all agree in having hairy skins or fur coats. You know some-

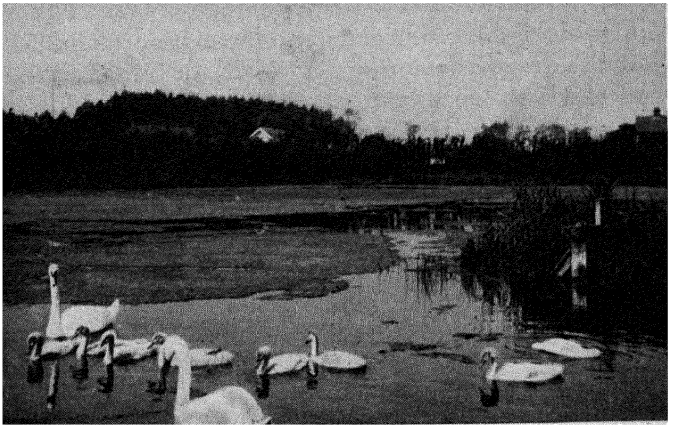


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FIG. 59.
A family of Mute Swans in late spring on a pond near Angmering, Sussex.

thing about the family life of birds and can probably answer these questions :

At what time of year can we see young birds in gardens, lanes or woods ?

How many are there in a clutch of (*a*) House Sparrows, (*b*) Chaffinches, (*c*) Mute Swans ?

Do both parents feed the young ?

What kind of food do they collect ?

How many days old are the nestlings before they can fly ?

Do they come back to the nest ?

How long did it take the parents to build the nest ? Did the cock and hen share the work equally ? Did they share the task of sitting and so keeping the eggs warm ? How many days did incubation last ?

When you have learned enough about those birds or others to answer these questions you may like to set things out in some kind of diary. If you have put out food and water regularly during the winter, the birds will allow you to watch them more closely than they would if you had not been caring for them in this very practical way. The birds, with very few exceptions, are among man's best friends. Indeed, without their constant help we should have our crops eaten up by those harmful insects which multiply at a great rate and are sought out by birds as food, not only for themselves but for their young ones. Many small birds, while they are rearing their young, make *a journey once a minute* for hours during the long early summer days, from morning till evening, and on every journey they collect a grub, a fly or some other small pest from the orchard or the field where food crops are being attacked.

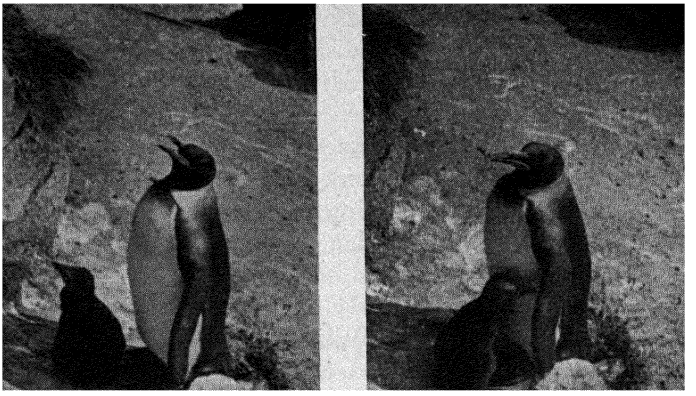
Those who watch birds in the open generally become keen to protect them from their enemies and they can learn what to do and what not to do by getting in touch with the Royal Society for Protection of Birds.* You may have to tell younger children who have not begun to think about these things, that we should never disturb a nest or even study it closely until the young have flown. Many a sitting bird after all her labours of building and incubating has been frightened so badly that she has deserted her nest and the helpless nestlings just starve and die. This is one reason why we must be very careful to guard bird tables and bird baths from cats which naturally prey on small birds, especially during the nesting season while they are fully occupied with the rearing of a family.

* 82 Victoria Street, London, S.W. 1.

There is certainly no question about birds showing parental care, though in emergencies they are quite unable to do what we should call " the sensible thing ". For example, very few birds will attempt to replace in the nest a young one which has wriggled out or fallen from it ; the Water-Rail is exceptional, and I have seen a film of this retiring, waterside bird in which the parent helped her nestlings back into the nest where she continued to care for them till they were fit to forage and fend for themselves.

A few birds actually carry their young while flying. The female Woodcock is a British example and she carries the little one between her feet, close under her warm body.

Before we leave this very short study of the family life of birds you will possibly be asking about the all-important process of fertilization. All mother birds, like the female reptiles, lay eggs with firm, protective shells ; the sperm cells of the father bird are as small as those of the cold-blooded vertebrates (i.e. fish, amphibians and reptiles) and he must introduce these into the body of the mother bird *before* the chalky shell has been added as a protective covering and before the eggs are laid in the nest. So the bird's egg which we speak of and may see in a nest is something more than an egg which has been made fertile ; indeed there is a protective chalky shell hiding from our sight the true fertilized egg with its reserve of yellow yolk, on which the developing chick depends for its nourishment. Warmth is needed for the wonderful changes which take place during the few weeks which elapse between egg-laying and hatching and this warmth is supplied by the parents sitting in turn or by one parent—generally the mother bird. The father bird or



M Munro

A *B*

FIG. 60.

A KING PENGUIN WITH HER SINGLE CHICK AT THE EDINBURGH ZOO ON A VERY HOT AUGUST DAY.

A. The mother bird with beak wide open was panting.
B. A half hour later after a cooling water spray had been turned on, the chick still in the shade had moved close to its mother's body.

cock may therefore have to collect food for his mate as well as himself, and then when her patient brooding has been rewarded, for the nestlings as well; so that the hours while daylight lasts are filled for him with journeys amounting to hundreds of miles between dawn and sunset.

Some birds have to protect their young from heavy rain and from the sunlight when it is too powerful and the nest is not shaded by trees or rocks (Fig. 60). Others have to spend much time in persuading their little brood to take to the water or to the air for a first flight.

Mammals : Parental Care

We must now turn our attention to the second and last group of warm-blooded animals, the hair-coated mammals. The hairs may be of two sorts and grow so closely that the fur is very dense as in a cat, or sheep ; but the hairs may be very few and widely spaced as in an elephant. Most monkeys have coats with far more hairs to the square inch than an elephant, but not nearly so many as a cat or a sheep. The skin of your own head bears a vast number of hairs whether short or long ; in addition you have eyebrows and eyelashes, hairs in your nostrils which help to filter the dust from the air you breathe in, and small numbers of short hairs even on the backs of your fingers and wrist as you can see by holding your hand against a dark background.

Let us now consider a second way in which all mammals resemble one another. This table will help you to realize that only one of the parents is able to feed the young and that one is the mother.

	Father	*Mother*	*Baby*
sheep	ram	ewe	lamb
cats	tom-cat	she-cat	kitten
cattle	bull	cow	calf
dogs	dog	bitch	puppy
lions	lion	lioness	cub

The ewe and the lioness, like every other mother among mammals, feeds her young with milk from her own breast. For human beings we use the words at the top of these columns, and the best way for a mother to feed her baby until it is nine or ten months old is with human milk from her own breast. It is possible to bring up a baby on cow's milk, or on goat's milk; but as you

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FIG. 61.
Ewes (Dorset Horns) with their lambs in a fold near Chichester in late spring.

can see from the simple comparative table in Chapter 11 the content is different and the baby often suffers severely in consequence. Each mother mammal produces the kind of milk which is exactly suited to the needs of her own babies, for example a ewe for her lamb (Fig. 61), a lioness for her cubs.

This breast-feeding of the young is then a second and most important character among mammals. It is continued for not less than several weeks, as in Rabbit, and in some animals such as the Indian Elephant it is continued for a whole year or longer. This is a great recommendation for milk as a food. A baby who weighs about 7 lb. at birth, often turns the scale at 21 lb. when it is eight

months old, and after feeding him on milk alone, his mother is thinking of weaning him, that is, giving him less milk each day, and introducing other food in small quantities so that he has variety, and something hard on which to bite.

During the long period of infancy, a young mammal is cared for by one or both parents in a number of ways which you can write down from your own observations on (*a*) domestic animals including pets, and (*b*) wild animals, e.g. Rabbit (though you should remember that this was introduced into Britain from Spain only some nine centuries ago), (*c*) animals in any zoo (Fig. 62).

For each animal give the average number of young ones born at a time, or in one litter. The smaller the size of the family, the greater is the care exercised by the parents, as a general rule, both before weaning and afterwards.

It is during the long period of dependence on its mother and father that a baby mammal has time to learn a number of things which will help it to take care of itself later on. In the wild it learns how to lie perfectly still or to bolt to its hole when danger threatens, how to find the right food, whether plant or animal, and sometimes happily, how to recognize and avoid snares and death traps. Its own instinct helps it too.

Grey Owl has given us a wonderfully fine account of Canadian Beavers at work and at play in the woods of eastern Canada, where they build the most remarkable homes and collect great stocks of food in advance of winter. It is not very long ago since the Beaver lived in our own country. Some of our place names remind us of

FIG. 62.
WALLABY AND YOUNG.
The baby is very small at birth ; it is carried in the mother's pouch till it is much bigger than the one shown here and able to get in and out.

its presence, e.g. Beverley Brook, a south bank tributary of the Thames within the Greater London area. Beavers have become extinct in our own country and the Canadian Beavers were threatened with extinction through heedless

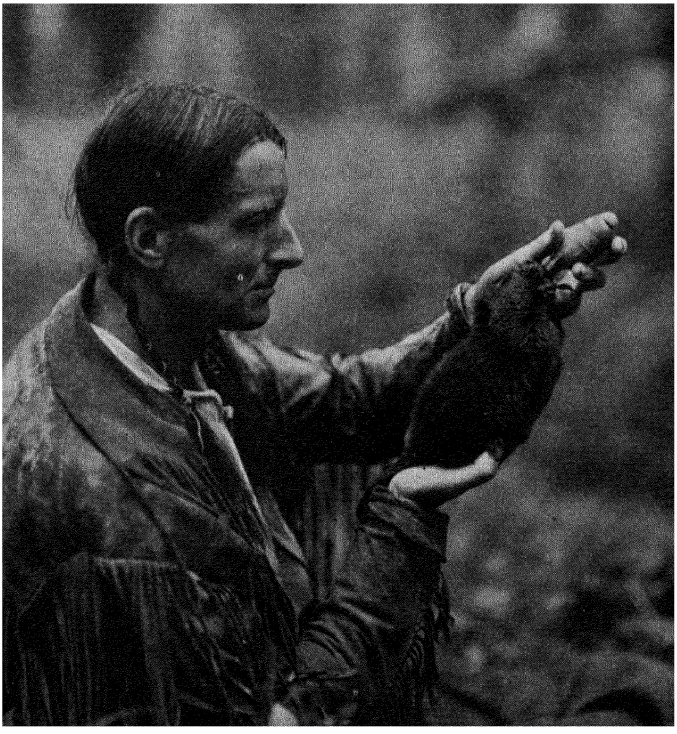

FIG. 63 (1).
GREY OWL FEEDING A VERY YOUNG CANADIAN BEAVER WITH MILK.
(By courtesy of the Canadian National Parks Bureau)

trapping for their valuable coats, till Grey Owl's wife made a strong protest to which, first Grey Owl, and then the Canadian people listened. It has now been resolved that wild mammals, like birds, need to be protected by

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FIG. 63 (2).
A WELL-GROWN BEAVER AT WHIPSNADE SHARPENING ITS FRONT TEETH.
Only part of the large flat tail is seen.

law so that in the breeding season, at least, they may be unmolested, in the interests of man himself, many kinds must be protected throughout the year.*

The breeding season begins much sooner than you might, at first, suppose. The eggs of mammals have very little yolk and are extremely small even in creatures much larger than ourselves.

These small eggs, once they have been fertilized by the still smaller sperms provided by the male parent, must be nourished in order to grow and develop into new

*Royal Society for Prevention of Cruelty to Animals, 105 Jermyn St., London, S.W. 1.

individuals, whether puppies, lambs, young elephants or any other kind. The mother provides the nourishment which makes this possible. Her blood carries all the food substances and all the oxygen which is required; further, her body affords precisely the right temperature for the young which she is carrying securely until the moment of birth. The period of development varies from three weeks in some very small mammals, such as mice, to about six months in sheep, and a year or more in the largest land mammals, namely the elephants.

SUMMARY OF THE CHAPTER

Things to Note

1. Reproduction of higher plants and higher animals by ova or eggs, and sperms.
2. Pollination of seed plants precedes fertilization.
3. Fertilization external in the fish and amphibians—but internal in reptiles, birds and mammals.
4. Shell added to egg of all reptiles and birds before it is laid.
5. Importance of close seasons.
6. Parental care exercised by animals.
7. Breast-feeding with milk, a rule without any exception among mammals in the wild.

CHAPTER 8

SOME LIFE-HISTORIES

In this chapter we are going to give our attention to a limited number of plants, namely, Crocus, Primrose, Ash; and a limited number of animals, namely, Garden Spider, River Trout, Crested Newt, Mallard Duck, Black-headed Gull, and Brown Hare.

The arrangement by months of suggestions for study together with definite observations, each bearing a date, will help you to see at a glance what you may hope to hear or see at any time of the year. But the statements in this chapter are of two kinds: (1) general notes in which likely haunts and average dates are given, whether merely for the month, or for the week; (2) particular notes in which the precise haunt and precise dates are given; on occasion, the time of day is added. In (2) notes on the weather at the place and time mentioned are often given too, since the weather frequently determines the position or activity of plants and animals.

The Weather

In our islands, as is well known, we experience extremely variable weather, and references may be found frequently in the daily papers especially after:

(1) a particularly sunny, hot, dry month or season, as in the summers of 1911, 1921, and March 1938;

(2) an unusually wet period. These we can readily recall.

(3) an exceptionally destructive gale, e.g. late October 1937; June 1, 1938; June 29 and 30, 1938 (see p. 54).

(4) a very severe late frost, e.g. May 16 1935 (see p. 23).

We need to remember, however, that such remarkable patches of weather may not affect the whole country. Sometimes indeed, it is much less cold in the S.W. of Scotland than in the S.E. of England, particularly during the winter; while a gale is raging at 75 miles or even 90 miles an hour in the south there may be no destructive winds in the north; a week of deluges of rain in the west may be contrasted with absence of rain in East Anglia.

You should consult in your atlas the maps which show for Great Britain the average rainfall (under which heading snow is included: 10 inches of snow being equal to about 1 inch of rain). There may be merely one map for the whole year, as on p. 19 maps for the winter and summer halves, or possibly four maps, one for each season.

Your study of the *weather* and *climate* will help you to be prepared for a great number of surprises. Some plants and certain animals are particularly responsive to the influences of temperature and moisture in soil and air. Other plants and animals are much more regular in their seasonal activities.

You will notice that for some months there is only very brief mention of certain plants and animals. By close watching or careful delving you will almost certainly be able to add something of interest in your own notebook to what is given in this chapter.

In your particular part of the country a few of the

animals and plants introduced in this chapter may not be common. This absence may serve as a challenge to you to study some different but related kind. For example, instead of the Mallard you may choose the Eider if you live in a northern county and near the sea, and instead of the Primrose, you may choose Cowslip, or the garden plant, Polyanthus.

Differences in Plants and in Animals

As you have already learned, the raw materials required for food-making by all green plants are the same in general: they are water containing mineral salts and carbon dioxide. Though they all require certain salts, the *proportions* of these vary as do the *strengths* of the solutions which the different plants can tolerate. It is important, therefore, to notice in what *kinds of soil* the plants you study are growing, and whether they seem to be stunted or in a flourishing condition. The low stature of trees and their unequal development on two sides is often caused by violent winds blowing frequently from one direction, as shown on page 32.

Green plants, for the reason given, will appear in the food-chains merely as fodder for animals; it is true to say of many animals, whether small insects such as butterflies, or larger but cold-blooded and with four limbs, like newts, or feathered and warm-blooded, namely, birds, that their *appetites vary according* to their *age* and the *season* of the year. But full information is not easily found for some of them, and there are gaps which, by careful watching, you may be able to fill in. Some creatures perish if they are unable to find exactly what they are accustomed to.

Some adult insects eat nothing whatever; indeed they

have no mouth parts developed, e.g. the silk moth. Others, for example the Herring Gulls, have *changed* their *feeding habits* in the most surprising way in recent years. They now compete with Rooks far inland, feeding in part on grain in the late summer. I have watched them in an oat field in Roxburghshire, and seen that the undigested husks are rejected (by way of the mouth) in their *pellets*. Great Tits in London and other cities have learned to take advantage of the bottling of milk; there are now many records of these bold small birds pecking through the card caps and helping themselves to the cream.

Other changes may fitly be introduced in this chapter. Several plants, for example some orchids, and several animals, for example the Osprey, have become very rare, or entirely extinct in this country during the present century. Heedless collecting, drainage of marshes and other causes are responsible for some such losses. There are additions to be noted too. For example, the Little Owl is now common in England and has appeared in Scotland. It is very risky to introduce new animals or plants. They are liable to multiply too rapidly in the absence of their natural enemies and immense damage may be done. After full inquiry the Little Owl has been accepted as not harmful in *our* country. It feeds chiefly on beetles, mice and other small mammals.

Some years ago a few pairs of the Musk Rat were introduced into this country. They were bred for their *pelts*. Through carelessness, a few escaped from the places where they were reared and multiplied rapidly. Untold damage to river and canal banks followed. After an intensive campaign lasting several years and costing vast

sums of money, the menace has been overcome. In 1938 it is said that the country was free from this pest.

The life-history of the Annual Meadow Grass and many other weeds, together with some small animals, e.g. the Common House Fly, occupies only a few weeks in warm weather. Consequently many generations are produced within the year. When such plants and animals are harmful, methods of control have to be used to keep the numbers down.

Life-Histories of Plants and Animals

A chapter on the life of many a creature you might choose to think of would require three hundred and sixty-five pages to include an account of all its activities, unless it happened to be one that is dormant during the winter months or one which breeds very rapidly. Though our days are too much occupied for any such chapter to be written, on certain days a fairly full diary may be compiled, for example, for one kind of bird. If you draw two circles having a common centre but of different diameter, subdivide the space between them into eight, and write in these your observations about

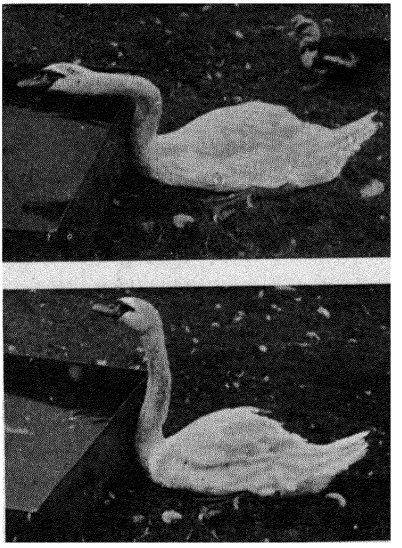
morning { feeding, drinking, bathing

afternoon { preening, resting

evening { feeding, drinking and

night sleeping

including always the time of day, you will begin to realize the *rhythm* of the bird's life more clearly. These things are done every day and your diagram will resemble a clock face of the continental type in which twenty-four hours are shown.



M. Munro

FIG. 64.

To swallow liquid a bird must raise its head. Mute Swan, during moult—Early August—Edinburgh Zoo.

At certain seasons special duties are carried out by the parent birds and at other seasons, the birds, whether immature or not, must moult. On any *preening* ground, day by day, large numbers of feathers are shed. By collecting all of these in a definite area on two successive days you can learn something about the progress of the

moult. Often one kind of bird keeps to one particular place for preening, e.g. Green Plover (or Lapwing or Peewit), and Blackheaded Gull in pastures, near water. Wood Pigeons congregate in selected lofty, wide-spreading trees; so, too, do Starlings.

Like the hours of the day, the months of the year are best arranged on a circular plan, so that by adding notes in rings outside that representing the first year of life, the further history of a long-lived plant or animal is conveniently traced.

No one person can hope to investigate the complete life-history of even one of our great forest trees, e.g. the oak, the life of which spans many centuries. Some of our largest sea birds have been ringed while young and are known to need six years to become adult and to reach or pass the age of fifty years. Their yearly migrations and long daily journeys are becoming better known through combined effort among bird watchers. The ring is fixed round the ankle.

Examples of Plant Life-Histories

PRIMROSE

Perennial. Dimorphic, that is, two forms: one called *pin-eyed* has style long, with stigma visible in tube of corolla and stamens lower down, the other called *thrum-eyed* with stamens visible in corolla tube, and the stigma lower down on the short style. This plant grows well on clays and loams. Flowers are shown on page 114.

January-February.—Last year's leaves have not yet withered completely. A few fruits may still be found here and there.

March.—New foliage showing on old plants. Leaves short, erect and not yet unfolded, 1 in. to 3 in. high in most places. A few flower buds just visible on some plants ; other plants starred with flowers.

April.—Seeds of previous year germinating ; two small leaves, or three on some plants. One year old plants bear several leaves and a very few flowers. On the old plants leaves lengthening and unfolding; flower stalks longer and nearly all flowers wide open. Especially forward are plants on southerly banks. Many insect visitors active now. Some flowers nibbled by snails and slugs. New plants show a few more leaves late in the month.

May.—Flowers seen in diminishing numbers this month except on northerly slopes and in shady places. Corollas withering and much fruit setting within the shelter of the calyx tubes. Flower stalks bend over. Leaves very large and wide-spreading now.

June.—Many of the new plants well established but overshadowed by their larger neighbours. The former show no flower buds this year.

July.—Fruits of old plants begin to open though still within the shelter of the calyx tube. Leaves in part brown and shrivelled.

August.—Brown capsules open and half empty. Many seeds scattered. Old foliage probably no longer active.

September.—This year's new plants more conspicuous.

October, November, December.—Many plants of all ages, obscured by taller herbs and fallen leaves from trees and shrubs. Seeds are buried now, in part through the work of earthworms.

CROCUS

(*extracts from personal diary*)

January.—Not observed. New corms were planted in loam in a London garden four months ago at a depth of about 3 in.

February.—A few plants showing about half an inch of growth above the soil. An external sheath protects everything within from the weather.

March (*Early*).—Flower buds visible within the white papery *bract*, some yellow, some purple. The leaves are very short.

March (*Later*).—Many flowers out now and widely open in the sun. Bees visiting and collecting the yellow pollen. On the large frilled orange-coloured stigmas much pollen is clinging. Leaves still short. Cock House Sparrows have taken shreds from the yellow flowers, as usual.

April (*Early*).—Flowers nearly all over. The leaves have lengthened remarkably and lie along the ground.

April (*Later*).—All the flowers have shrivelled. The leaves look very untidy.

May 1.—Fruits, green in colour at present, are just showing at soil level.

May 15.—A few of the fruits are now 1 in. above ground and turning white.

May 24.—While some of the later formed seed boxes are only at soil level, others are now lifted up 3 in. on their pale three-sided stalks.

June.—All the foliage is withered to a pale fawn colour and looks like untidy string. The fruits are nearly all 3 to 6 in. above the ground. Some of the capsules

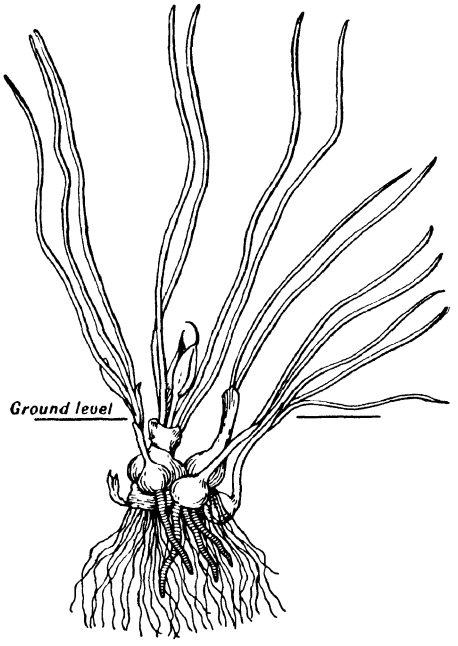


FIG. 65A (×⅓).

Crocus plant lifted in June, 1938. The shrunken corm planted in the previous autumn is partly hidden by five new corms of which one bears a fruit. Five contractile roots had begun to draw them downwards.

have split, showing the three carpels and a number of large rounded brown seeds. Old corms are shrunken to a very small size. New corms above them are already large. Contractile roots are 1½ in. to 2½ in. long and much wrinkled. Fibrous roots are 4 in. to 6 in. long and very numerous (Fig. 65A).

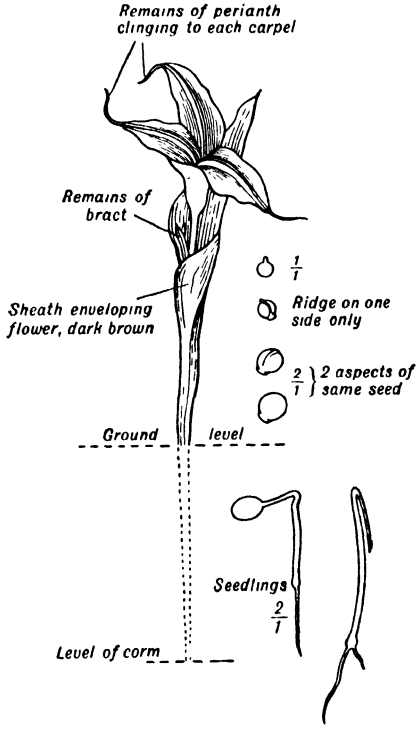


FIG. 65B.

Crocus fruit and seeds collected in a London garden in June, 1937. Lower right: Seedlings from a Jedburgh garden, October, 1938.

July.—Nearly all the seeds have been scattered. Several of the old corms have given place to five and six new ones.

August.—No observations made.

September (*Late*).—A few seedlings found, each with one green leaf about 2 in. long.

Previous October.—Root development had begun.

Previous November.—Roots were much longer and more numerous.

Previous December.—No further observations made.

THE ASH

A tree which favours soils on chalk and other limestones. Trees are shown on pp. 32, 54.

The complete life-history from seed, through seedling and sapling stages to seed-bearing occupies many years. Stamens and pistil are borne by the same or separate flowers; as a rule both kinds, but on occasion one only, may be found on the same tree.

January, February.—Remains of the clusters of old dry brown "Keys" still hang from the branches of the older trees. These keys are winged fruits (Fig. 66).

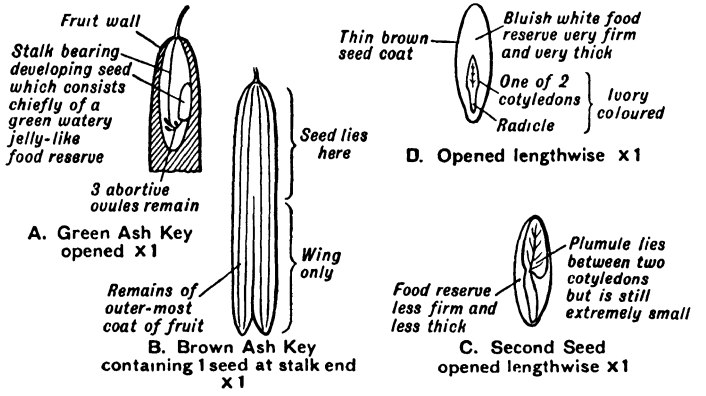


FIG. 66.

Fruits of 1938 (A), and 1937 (B, C, D), examined in late July, 1938. Chapel-le-Dale, Yorkshire.

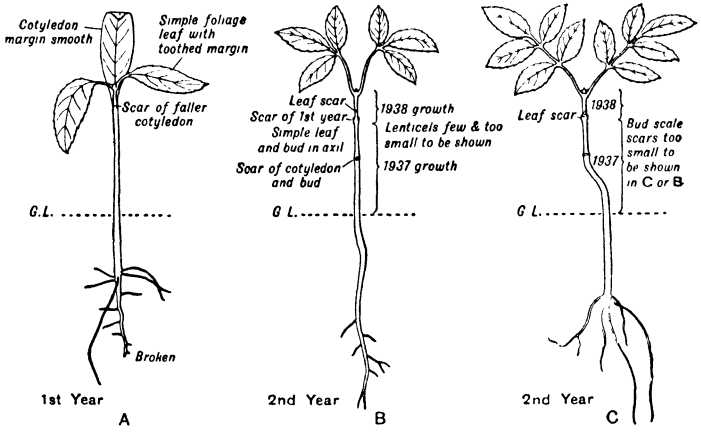


FIG. 67 (×½).

Ash seedlings and two older plants from a mixed wood on South Downs, May, 1938.

March.—Flower buds swelling on the older trees. Flowers with dark purple stamens, may open out in this month.

April.—In a favourable season in the woods and under hedges seedlings may be found. A few still bear aloft the dry brown oval wall of the " Key " shed by the parent tree, but others have pushed this off.

May.—The black leaf buds of the older trees swell and begin to open. Second year plants may abound locally. Their leaves springing from a pale green stem consist of only three or at most five leaflets (Fig. 67, C).

June.—Third year plants are generally less numerous and not much taller than those of two years growth. Their leaves are made up of five or seven leaflets as a rule. The colour is a light green. In some woods

where there is abundant light, tall saplings flourish. The bark is pale grey and very smooth. The leaflets are more numerous than on the younger plants' leaves. No flowers or fruits occur. The still loftier, older trees with many branches now have all their leaves outspread but not full grown. The leaflets number eleven or thirteen, rarely fewer or more.

July, August, September.—The branches of saplings and true trees are much obscured by their load of dark green leaves. Each leaflet may be 3 in. long.

October.—The foliage is turning a paler green and late in the month a clear, cool yellow.

November.—After a sharp frost some of the trees stand stripped, the ground below being thickly covered by the fallen load.

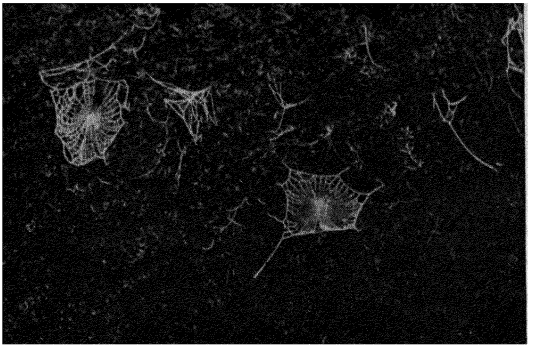
December.—Once more the tree's shape is fully revealed. The young plants have shed their few small leaves and stand straight and slim.

CROSS SPIDER or GARDEN SPIDER

The male of the species does not make a large orb web for catching insects and is small but the paired pedipalps in front of the four pairs of limbs bear conspicuous knobs at their tips. The female of the species is very familiar, through her large web with its many radiating spokes and the pattern on the upper side of her *abdomen.*

January, February.—Very few spiders or webs are seen (Fig. 68, A, B).

March.—Late in the month hundreds of young spiders may emerge from their silken cocoon in warm sheltered places, e.g. a sunny greenhouse or hedge.



M. Munro

FIG. 68A.
WEBS OF FEMALE GARDEN SPIDER.
Early January, 1932. Amberly, Sussex.

April.—This is the more usual month for the appearance of the young ones out of doors. They may scatter and gather together again several times before taking long journeys in different directions. Much *cannibalism* occurs. See p. 184.

May.—Many small fine webs are made in bushes and hedges. Diameter only about 3 in. The young female spider is seen either at the centre or at the far end of the line which leads from the centre to a retreat in the foliage.

June, July, August.—The average size of the spiders and their webs is much larger and the silk is heavier, week by week. Several times the old skin is shed and the soft new one which allows for growth, hardens.

September, October.—Webs of large size abound, especially

on Gorse, Bramble, and bridges near shallow water where small soft-bodied insects abound. A few build indoors. Many large spiders are active in web-making by day; most webs are made at night, however, the majority of these nets are nearly vertical.

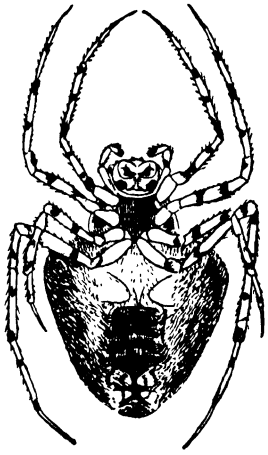


FIG. 68B.
CROSS SPIDER.
Female, from below.

November, December (*Early*).—Females spin each a silken cocoon. They deposit in the lower saucer-shaped part a large number of apricot-coloured eggs before making the upper lid-like part and binding the two together. This activity generally takes place at night.

December (*Late*).—Many spiders die, but a few hibernate. In frosty weather webs in sheltered places are conspicuous.

RIVER TROUT

(*extracts from personal diary*)

Reared indoors

January.—Earlier in the winter eggs were laid in great numbers by female fish in clear water. These eggs are fertilized by the microscopic sperms produced in vast numbers by the male fish. Each egg is about $\frac{1}{8}$ in. or $\frac{1}{6}$ in. in diameter. That development has

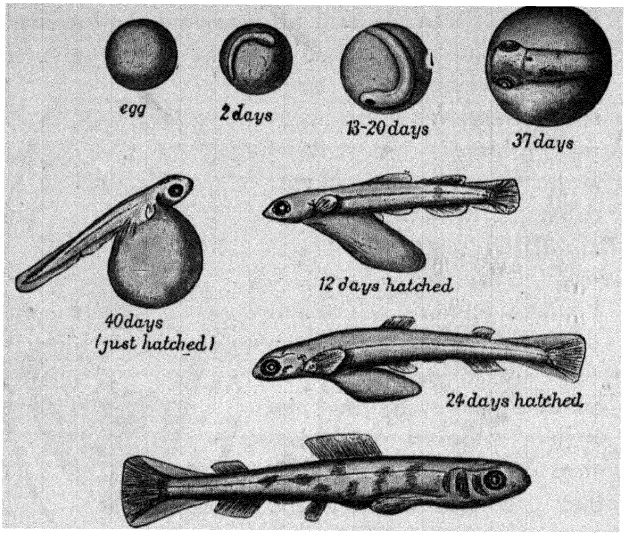


FIG. 69.

TROUT; STAGES OF DEVELOPMENT.

The only food is its own yolk for ten weeks or longer.

begun is clearly shown by the two large black eyes visible through the transparent egg shell (Fig. 69).

February (*first week*).—These "eyed eggs" travel well in damp moss. In *clean constantly flowing cool water* development continues satisfactorily. By much effort after the outer cover has given way at the nose end, out wriggles a small *alevin*, the name of the young trout, now about half an inch in length. The pectoral fins just behind and below the head can be seen. The *yolk sac* is the most obvious feature. It changes in shape to a longer, narrower oval within

a day. The little red heart pumps regularly. With a lens to help a count can be made, day by day. The transparent tail fin is visible.

February (*second week*).—The alevin is about 1 in. long. A rear pair of fins, called pelvic, can be made out. Oil globules are recognized in the yolk sac which is already much smaller. The blood vessels can be traced towards the heart.

February (*third week*).—The backbone is seen as a moderately dark line along the length of the body. Below it the food passage can be traced before the skin becomes speckled. An unpaired fin is seen some distance behind the head. The yolk sac is still smaller. The rhythmic pumping of the heart can still be counted.

February (*fourth week*).—The alevin moves more rapidly through the water; it spends much time quite still except for its breathing movements of mouth and gill cover, which is a flap opening just behind the head. There is much more pigment in the skin.

March (*second week*).—Fish now called *parr* are nearly $1\frac{1}{4}$ in. long. No yolk can be seen. The yolk has served as the only source of food for six weeks. A small quantity of Spratt's "Zeke," prepared as prescribed, is given once a day. An alternative is a minute quantity of ox, calf or sheep liver.

April.—It is best to place the young trout in a clear stream or in an aquarium which is *constantly aerated* and in charge of some person who understands the needs of the fish. They require several years to reach their full size when they can breed, as did their parents.

July (*Late*).—Observed trout of different ages at the hatchery and in the local streams at Stockbridge, Hampshire. In one of the five chief streams of the braided River Test, each day and all day a very fine large trout with correspondingly large speckles in its skin poised itself in the clear shallow water over one particular patch of gravel which it matched perfectly. Elsewhere in this reach of the stream the gravel was much finer and against that as background this trout would have been much more clearly evident to its enemies. Here was a good example of *camouflage*.

CRESTED NEWT

The life-history of the common Smooth Newt is very similar to that of the larger Crested Newt.

January, *February*.—Most newts hibernate.

March.—Many newts already in ponds. In the spring the males develop a prominent crest.

April.—Adults 3 to 4 years old travel to ponds. Courtship and pairing takes place. The male passes out one or more tiny packets of sperms. The female takes them into her body.

May.—Eggs in large numbers, already fertilized, are laid by the female, one by one on the leaves of water plants. Rather long leaves are used. A leaf is folded over each egg and clings to it. In about a fortnight the small semi-transparent tadpoles hatch out. They cling with their thread-like feelers to the plants and breathe with external gills. Within a

month from the time the eggs were laid eyes and mouth are well formed.

June.—The fore limbs of the tadpoles are very slim but easily seen. The four fingers appear in turn.

June 5.—Many adult Crested Newts and adult Smooth Newts in deep pond full of the plant *Chara*, near Saffron Walden, Essex, 1938.

July.—Within the second month the hind limbs appear. Five toes grow. The external gills are still in use at

FIG. 70.
CRESTED NEWTS, A PAIR.

the end of the third month. The body is much longer and plumper, the tail much more powerful and the skin darker.

August, September.—In the fourth month after the eggs were laid the external gills of the tadpoles disappear, for the lungs have formed and the newts come to the surface to breathe. They generally leave the water late in the summer and live on land during the autumn months, in damp, cool places, feeding on insects, worms and snails.

October, November.—A few young newts may remain in

the pond till spring. These still retain gills. If they are frozen in ice in cold weather they may be none the worse when a thaw sets them free.

December.—Newts hibernate in damp holes in the ground. Often there are many close together. This clustering helps them to keep moist. The skin aids in respiration. The newts show little activity during the winter.

MALLARD DUCK (the common Wild Duck)

(extracts from personal diary)

23 in. long. Resident throughout the British Isles, but also an abundant migrant. Many arrive in autumn to stay the winter, but some birds bred in our country go south in the autumn (Fig. 71).

January.—Very large numbers in London Parks every year.

February.—Many birds seen in vigorous flight in groups of two and three. 1937 1939

March.—Most of the drakes seem to have found mates early in the month. 1937 1939

Many pairs rest on bank.

April, 15.—Three families have reared ducklings already in St. James's Park. 1939

May (*first Saturday*).—Salt Marsh, Shellness, Sheppey, Kent. Duck rose from nest and disclosed eggs. The shell of one cracked and the duckling emerged. 1934

May 8.—Kew Gardens Lake at Richmond end. One duck with eight young; three light and five dark. Only a few days old. 1938

May 29.—Saw the same family intact at Kew.

May 21.—Six families seen at Hampton Court: One duck with six ducklings, one with four, three with three, and one with a single duckling. Some adults were flying strongly; drakes pursued one another or a duck on the wing. Very young birds caught flies successfully. 1938

M. Munro

FIG. 71.

MALLARD: TWO DRAKES AND ONE DUCK.
Wandsworth Common. Early December, 1938.

June.—Late in the month at St. James's Park the ducks with their second brood are spending much of the day on the water. At a very few days the ducklings dive frequently. The drakes' plumage is already heavily mottled with brown. 1938

July 3 *and July* 10.—Scores of flight feathers moulted by the drakes litter the grass near the lakeside at St. James's Park. They appear to be worn very little. 1938

July 18.—Broomfield Park, North London. Mallard drakes in eclipse seen on the pond. For detail see below. 1937

July 20.—St. James's Park. The *ducks* appear to have their flight feathers intact and still fly vigorously. The *drakes* are more or less completely in *eclipse* plumage. Many of them have *moulted all* their *secondary* and *primary feathers from their wings*. (Some dozens were collected from the lawns bordering the lake.) When the birds unfolded their wings the new flight feathers were seen to be all equally short. Only about ¼″ of the vane was showing beyond the sheath. A few drakes had lost some tail feathers. 1937 A fine evening

August 29.—Powfoot, Dumfries, "The Lakes". Three small families. The young birds are nearly full length and very like their mothers. 1937

September 2.—St. James's Park. Many drakes not yet in breeding plumage. 1934

November and *December*.—Very large numbers in London Parks every winter.

BLACK-HEADED GULL

Especially for London Area, except in breeding season.

April.—Most breeding grounds are in marshes, often in upland country and often far from sea. Eggs laid from middle of April to May. Nest on islet in a pool or on ground among grasses, etc., or, less often, on rocks.

May.—Twentieth to twenty-first day after egg-laying

A. H. Willford

FIG. 72.
Black-headed Gull in breeding plumage alighting on nest on an islet in a marshy area.

chicks are hatched. Down moist. Speckled pattern soon very variable. Down dries. Chicks fed by parent. After a few days they drink water and bathe.

June.—True feathers appear and gradually replace down.

July.—Associate in pairs when only a few weeks old.

August.—A few birds are back in the cities after the close of breeding season towards end of this month (or even late in July).

September.—At three and a half months old, plumage typically that of a full-sized but immature bird, with brown mottling and black lower border on tail.

October.—Young birds congregate in cities together with adult birds, especially on *large* ponds, e.g. St. James's

Park, in increasingly large numbers. Seen only during daylight. Many spend night on reservoirs west of London.

November.—Very eager for food, especially bacon rind and fish, but take much bread too. At dusk fly west from London. Bathe, preen and roost on reservoirs, e.g. at Staines. Smaller ponds now tenanted by gulls. e.g. those of the commons of S.W. London.

December.—Vast flocks remain in cities by day. Feed on ground when it is soft. In country follow the plough and eat great numbers of harmful insects in grub stage.

January.—Daily, large flocks come back to cities from their roosts, remaining only until dusk.

February.—Daily the gulls circle widely a few times over the water as in other months before leaving the city parks for their night quarters.

March.—As a rule very few birds remain in cities late in this month. Assemble in breeding grounds. May travel thirty or forty miles to good feeding grounds daily. Those in London rest much of the time.

BROWN HARE

A very lonely animal which never goes underground and generally keeps to open meadows and arable land. It prefers low rolling ground. It feeds mainly at night and is wholly vegetarian, the diet consisting chiefly of grasses and roots. The natural enemies of the Brown Hare include Stoat and Fox (Fig. 73).

January.—Seldom seen by me during day except after very wet nights.

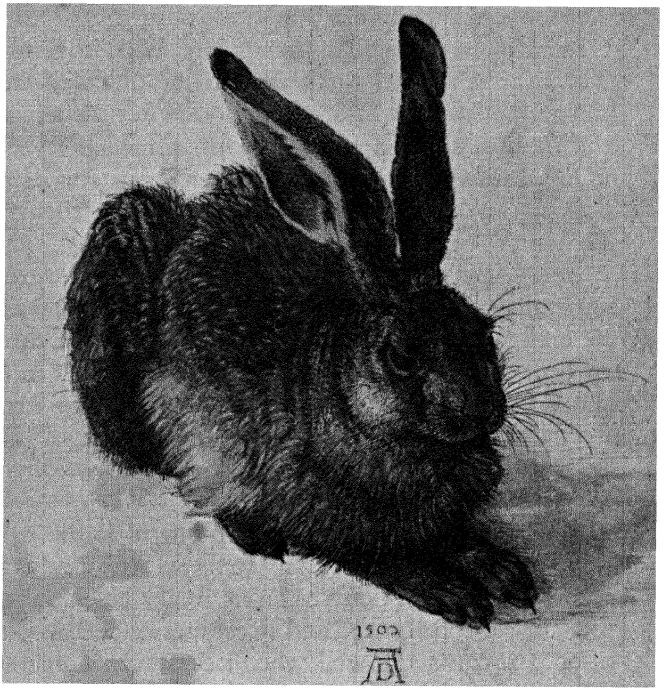


FIG. 73. A BROWN HARE.
Copyright: The Medici Society, Ltd., England.
A. D. are the initials of Albrecht Dürer, the famous artist.

February, March.—Courtship season begins now. They are seen boxing and careering about at all hours of the day.

April, May.—The youngest mothers are about one year old. After the mating of doe and buck, a month passes before the young are born, in April (or later

in the spring, in summer or even in the autumn). The nest is merely a slight hollow in the ground. Generally two to five *leverets* are born together. Their fur is already thick and on the first day they can see and walk a little way. Soon after their birth the mother seeks a separate form for each leveret unless it has found a spot and made one for itself. She carries them in her mouth and visits them at night to suckle them with milk.

May, June.—After the age of one month the leverets generally feed and fend for themselves, each taking its own way. Occasionally a family group of three or four is seen in the day-time. The toilet is most thorough and the hare's method of washing itself very like that of a cat, oddly enough.

July, August, September, October, November, December.—Hares are seldom seen by day.

"When leaving the form or returning to it the hare takes two very long leaps (some 15 ft.) to baffle scent." The hare doubles on its tracks when travelling almost at full speed and so escapes its enemy very often. It can swim well when necessary. Leverets are easily reared from about the fourth day by hand, on milk for two weeks or three and later on a mixed vegetable diet.

SUMMARY OF THE CHAPTER

Things to Note

1. Weather and climate influence the lives of plants and animals.
2. Habits of some native birds are changing.

3. Grave risks attend the introduction of alien animals or plants.

4. Control of pests.

5. Recording observations : common plants and their development ; daily and yearly rhythms in the lives of familiar animals.

CHAPTER 9

MOVEMENT IN A FEW FAMILIAR ANIMALS

In these days of mechanical toys, and the varied machines which they resemble in some degree, an increasing number of people take a keen interest in the build and mode of working of these man-made things, wonderful in design, in construction and in achievement. As we all know, methods of travelling and transport are still being speeded up but you are too young to remember a time when motor transport was rare and aeroplanes were never seen. The wonder for you is less than for those whose memories are longer.

Each year new words (*a*) appear in our standard dictionaries and other words (*b*) come to have additional new meanings. For example, (*a*) monoplane, hydroplane, aerodrome and (*b*) streamlined, submarine (Fig 74). Through countless ages, perfectly streamlined fish have peopled the waters while perfectly streamlined birds have traversed the air, travelling great distances at high speed. Looking back through the last few decades it is astonishing to see how slow most designers of land vehicles seem to have been, in beginning to try to copy these wonderfully fast creatures, while canoes, kyaks and other water-craft seem to have been streamlined from prehistoric times; the air offers less resistance than does water to craft which is propelled through it and herein lies part of the explanation. The earliest heavy-wheeled vehicles were probably drawn

by animals and men, and the very earliest trains were provided with engines to supply the energy which was needed.

In recent years, however, animals have been closely studied in the hope that some of the secrets of their success may be mastered and applied.

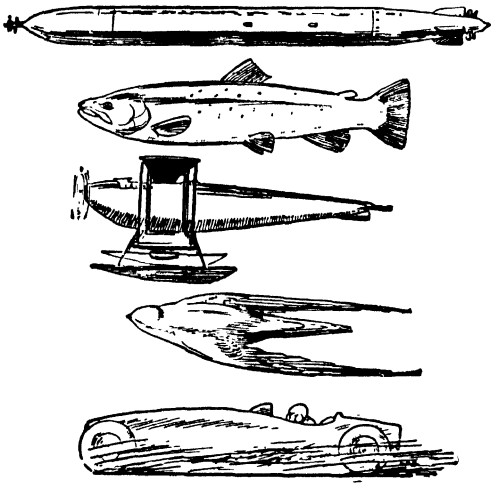


FIG. 74.
STREAM-LINED ANIMALS AND MACHINES.
The fish is a Salmon, the bird is a Swift.
From Andrade & Huxley: Science and Life (Blackwell).

Some fifteen years ago, when a few people were watching intently the *humming birds* from South America in a glass-fronted aviary at the London Zoo, a keeper said that experts at the Admiralty had recently sent photographers to make a film of these tiny birds as they hovered while sipping nectar from long tubular flowers.

The film was to be shown to the experts—in slow motion,

of course—in order to reveal what the unaided eye fails to see. How much help such analysis gave I do not know, but we now have planes called *autogyros* which after rising maintain a stationary position; while observations are then made at leisure—a very great achievement. As early as 1926 a rotating-wing aircraft was made according

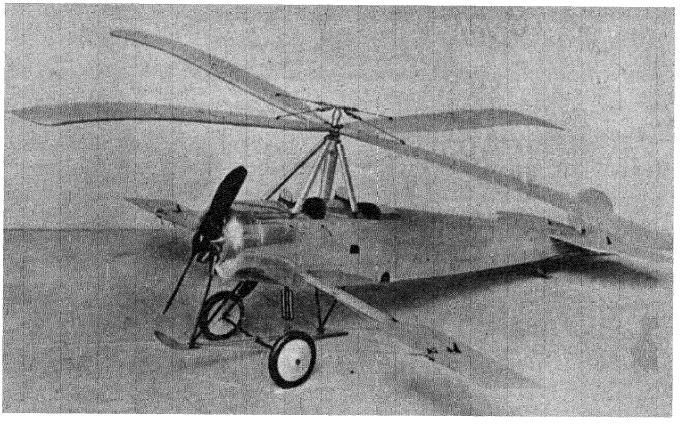


FIG. 75A.
AN AUTOGYRO DESIGNED BY CIERVA.
From a model in the Science Museum, S. Kensington, London.

to the design of a Spaniard, Señor Don Juan de la Cierva. There is an example in the Science Museum, London. (Fig. 75A). In it a vertical ascent or descent can be made safely. Clearly it is of great advantage to a pilot as to a bird to be able to take off and land without circling round while gaining or losing height.

In most news programmes at cinemas we are able to watch in slow motion as well as at their normal rates

famous cricketers bowling, divers taking off at great heights, picked teams sculling on the river, skating or

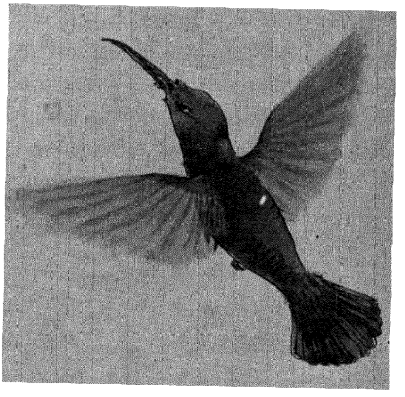


FIG. 75B.
GREEN-BREASTED HUMMING BIRD JUST BEGINNING AN ASCENT.
* *London Zoo. Autumn* 1938.

playing hockey on ice, and most exciting of all perhaps, ski-ing and gliding. Nearly every week new national or international records are announced.

Movement in Animals

We are able to appreciate when watching slow-motion pictures of animals how much happens in movements, which in life appear quite simple; we then begin to realize how extremely difficult it is to *describe* these movements. Yet it soon becomes evident that we can at least *group* them under a small number of headings though the name of any one animal which we can watch frequently may reappear in several lists: many birds are

fully at home not only in the air but also in the water and on land, for example, gulls ; moreover, birds show their mastery of the air in taking advantage of the varying conditions they meet there ; most often we watch gulls either at rest on the water or at one of their preening grounds, or else in true flight through the air when their wings work vigorously all the time ; but these same gulls soar and glide with great success in certain kinds of weather (Fig. 76). They make persistent efforts to hover when food is thrown up into the air. When fish or bacon parings are offered, their excitement and endeavour reach a maximum for this food resembles their normal diet much more closely than such starchy things as bread which most people provide.

M. Munro

FIG. 76.

A Herring Gull soaring while following a steamer, late August, 1935, along the Caledonian Canal.

The moult of large flight feathers had begun in the wrist region.

You will need to consult a dictionary for *definitions* of these words :

biped	walk	amble	trot, canter, gallop.
quadruped	climb	waddle	crawl, wriggle, burrow.
step	run	skip	hop, leap.
stride	jump	dive	float.
	swim	soar	hover.
	glide		
	fly		

If you have not time to study all of these, study those in the first and second columns, starting on the left. You will find it very helpful to use the dictionary for these terms too :

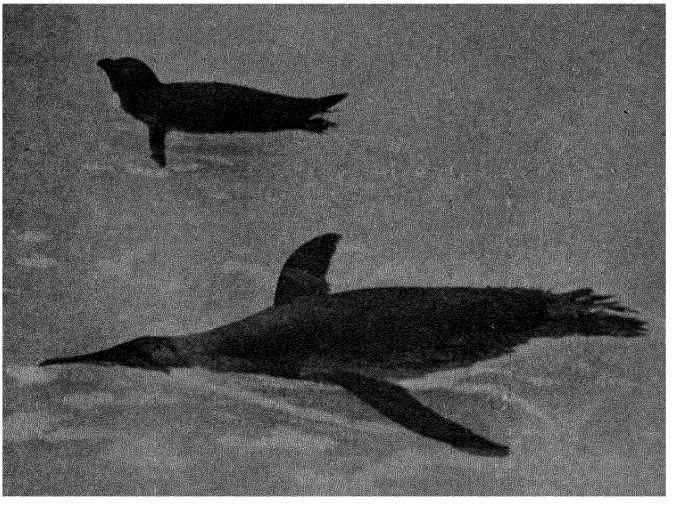
Pulling—with a boat hook	Bows
Punting	Stern
Sculling	Oar
Rowing	Lever
Yachting	Rudder

At the first opportunity watch someone in a boat on a pond, that is, on water free from marked currents or other movements due to stream or tide, and choose a day when there is little wind. You may be fortunate enough to see (*a*) a boatman reaching forward from where he stands in the boat with a metal hook mounted on a long pole and hitching it on to some firmly fixed tree-root or block of concrete in the bank, as he *pulls* the boat forward. (*b*) The boatman standing up and pressing a pole against the bed of the pond, which in a park is often made of concrete and offers a good resistance. The boatman in doing this is using the pole as a lever and thereby *pushes* the boat forward. He lifts the pole at the right moment, and repeats the pushing. In this way he *punts*. You will notice that the boat in use is broad at both ends. (*c*) The boatman seated or standing in the *stern*, using only one oar with which he pushes away a mass of water, first to the right, and then to the left. In this way he *sculls* as the boat goes forward. Similarly he may paddle a canoe using a very short oar and seated low in the boat. (*d*) The boatman using a pair of oars of the same length, weight and shape at the same time, one on the right and one on the left. He forces away two equal masses of water at the same time. In this way he *rows* as the boat goes forward.

Thinking now of the water in the pond as something through which a boat may be made to move, try to compare it with :

(1) loose sand
(2) crumbly soil
(3) air.

The same kind of movements as you watched the boatman make can be made by certain animals in these three



K. Hubschmann

FIG. 77.
Above. A small Penguin showing left wing in use and left foot trailing.
Below. A King Penguin speeding through water, the wings being used equally for progress in a straight line.

other substances. The air, when still, offers much less resistance to a given push than does an equal mass of water. The loose sand and the crumbly soil offer a greater resistance to the same given push than does an equal mass of water.

In connection with :

(*a*) pulling, try to watch a leech in water in a glass jar. Remember it is a blood-sucking animal and keep it alone with a well-secured lid.

(*b*) punting, try to watch a crab walking (sideways) over firm rocks or damp sand, or a friend walking quickly on a paved surface.

(*c*) sculling, try to watch a goldfish or other similar fish in a large tank or pond when it is moving straight forward. Watch the rear part of its body closely.

(*d*) rowing, try to watch a turtle in a large aquarium, a large bird whose wing beats can be counted; Rooks, gulls and Wood Pigeons are all suitable, so too are King Penguins when in water (Fig. 77).

Movement in Snakes

Some kinds of animals move forward in ways which are much more difficult to understand, for example, Earthworms, Eels, the limbless lizards, which are unfortunately called Slow Worms, and snakes.

It may be helpful at this point to recall the efforts of beginners who were trying to steer a straight course through the water in a boat using one oar first on one side and then on the other.

Experiment 1

Take a four-yard or greater length of skipping rope which is about $\frac{1}{3}$ in. thick and not new. Better still you could perhaps use at school a length of wire-covered flex as supplied for leading gas to a movable heating stove. On the floor practise making the rope perform snake-like

movements. You will soon find that you succeed when you give a swing to the rear part from a position to the left (or the right) of the remainder of the rope, but also in other ways. Notice the effect of a smooth linoleum in contrast to rougher surfaces.

Rudolf Zimmermann

FIG. 78.
A MALE VIPER, OR ADDER, READY TO GLIDE FORWARD.

The snake, like the Eel, has a great number of similar blocks of muscle throughout the length of its body on both sides and each block of muscle can contract more or less than neighbouring blocks of muscle whether on the left side of the body or on the right (Fig. 78). Opposite any group of contracted muscles on the left, there is at any one moment a corresponding stretching of the group of muscle on the right. But as you can observe when you

watch closely, in a wave-like effect, the *position* of the group of contracted muscles on the left passes forward, as those which were first contracted become stretched while the muscles corresponding to them on the right become contracted. The body is thrown into a series of reverse curves. There is progression in a straight line, yet we can appreciate the swinging from side to side of the outer curves; but to draw any one series of curves as seen at any one moment we must rely on *memory* for the animal moves continuously whether on land or through water. The part played by bones and scales has been omitted, like much else, through lack of space.

In watching and still more in handling a living animal we realize the *energy* output of living muscles, whether reptilian, or of any other kind. How do they accomplish their work hour by hour and year after year?

Muscular Movement

Experiment 2

Sit in a chair, roll up your sleeves and rest the whole of your left upper arm (between elbow and shoulder) on a table or on the arm of the chair if it is rigid and in a suitable position. (*a*) Then raise and lower the rest of your left arm while grasping the big muscle above the elbow with your right hand. What do you notice? There is a regular *changing of shape* of this big biceps muscle and you soon become aware of *heat being produced.* (*b*) Now take a large flat pebble in your left hand and repeat the movements. Is more effort required than

in (*a*)? (*c*) Next place the pebble mid-way between your elbow and wrist, fix it with tape or a couple of rubber bands, and repeat the movements once more. Do these demand as much effort as was required in (*b*)? (Fig. 79).

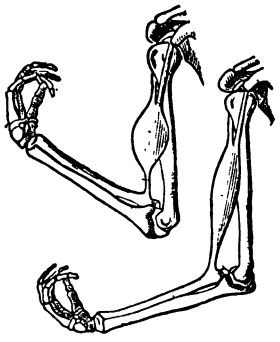
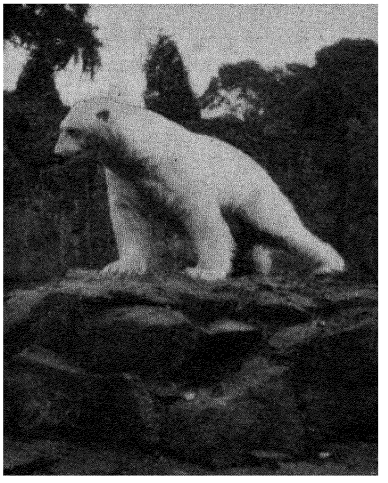


FIG. 79.
HUMAN BICEPS MUSCLE CONTRACTED AND RELAXED

You have been performing tests with a *lever*, one of many levers which you use every day. A lever is by comparison with most kinds of *machine* very simple. With a finger of your right hand press hard on the inside of your left elbow joint while working the lower part of your arm up and down as before. You readily find the tough *tendon* which joins the lower end of the biceps muscle to the arm bone beyond the elbow and on the thumb side. It is more difficult to find the two tendons at the shoulder end of the same big muscle.

When this or any other *voluntary muscle* works, it changes its shape; it often contracts as in this instance. All *work* requires *energy* and this is supplied by *fuel* in the form of *sugar* which is brought by the *blood* always circulating through the innumerable blood vessels of the body. The blood also carries *oxygen*. You will recall that sugar consists of carbon, oxygen and hydrogen. In the living muscles sugar is broken down to make *lactic acid* which, in turn, is oxidized to *carbon dioxide*, two waste substances. (Fig. 80.)



M. Munro

FIG. 80.
A Polar Bear has just pushed off with left rear leg.
Early August, 1938. Edinburgh Zoo.

You can understand now why these muscles have been compared with steam-engines; sugar, like coal, is rich in carbon, and *combustion*, or burning, may be slow as in our bodies or rapid as in the furnace. Compare the two performances in another way:

	Engine of Locomotive	*Human Muscle*
% Energy in form of heat.	Extremely high	Much less high
% Energy in form of mechanical work.	12-15	about 25

You will gain a good idea of the way in which a particular form of energy, called mechanical, is converted into another kind of energy, called heat, by rubbing an embossed metal article such as a penny with a piece of some woollen fabric.

Some animals are much more efficient than we are in muscular work. To realize this watch ants carrying bits of twigs and even stones much larger than their own bodies up steep inclines for the building of the colony mound. On dumping their loads they immediately set out on fresh journeys of a few yards, or many, and such journeying is continued for hours.

Movement in Fishes

You will probably enjoy making a fuller study of the locomotion of fish since some kinds can be kept throughout the year in school aquaria. Let us consider a goldfish. The specific gravity is closely similar to that of the water in which it lives, thanks to the air-bladder inside its body. The shape is excellently streamlined and the surface very smooth; all the overlapping scales are arranged so that when the fish moves forward they offer very little resistance (Fig. 81). Picture the goldfish at rest with the body axis in a straight line, as shown in Fig. 82. A short swing of the head places the rear end of the body in a position for a long vigorous stroke. As the body moves forward the point x, which may be described as the *pivot* for the moment of time in question, moves backward so that as the end of the stroke is approached it is closer to the tail than the head. The broad head end moves much less vigorously than the tapering rear end of the body. The path of the fish through the water is in a true straight line.

Its forward progress is assisted by the *expulsion of* used *water* backwards from under the gill covers, which is called *jet propulsion.*

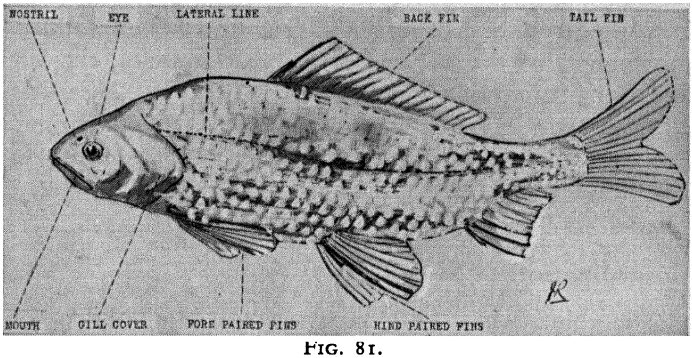


FIG. 81.
A CARP.
A bony fish, seen from the left. (XI)
(By courtesy of Prof. James Ritchie)

In looking down on a goldfish from above you will see these movements most satisfactorily. You should make a few very simple, very quick sketches when you have observed the regular rhythm of the movements which together make up swimming. Among them you will have noted the action of the fins ; the two sets of paired fins are clearly used for balancing while the fish is at rest but they may be used to assist it to rise, or descend through the water or to go forward when it is travelling slowly. The unpaired tail fin, as you will have realized, adds to the effectiveness of the strokes made by the rear end of the muscular body in forward swimming. Because of

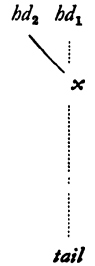


FIG. 82.

its position *far* from the pivot the tail fin is very important. The unpaired fins in the middle line above and below the body show wave-like movements which seem to assist in balance and in forward progress especially when the fish is turning round. Then is the time to watch the *unequal* movements of the left and right body muscles, the left and right paired fins and the two gill covers. By using all of these in the right way the fish turns in a short time, in a small space and with a minimum of work. Moreover it appears graceful in its turning.

Co-ordination of Movement

The goldfish is as perfectly successful in a pond as the Swallow in the air above when it circles time after time now high, taking insects on the wing, now low, taking water as it flies with little reduction in speed. These two animals, like hosts of others, indeed nearly all that we can name, show a remarkable *co-ordination* of movements whatever they may be doing. So too, do you, though all unconsciously, whether you are walking, running, swimming, climbing, playing cricket or any other game. You may just remember how difficult you found it was to learn to bowl successfully or to swim, especially if you were not provided with a pair of floats. Almost certainly you will have forgotten entirely how difficult it was to learn to stand and, a little later, to walk. When you watch a small child trying to do these things you will realize that though it may be able to use each limb in the right way it cannot use *both* legs in the right way and quickly enough to achieve success. It is very hard for the young toddler to stand upright for long. Its many muscles

have to be trained to work together ; it loses its balance frequently meantime and moves awkwardly.

Most kinds of locomotion with which you are familiar are made possible by the many muscles of the animal's body working harmoniously in relation to one another

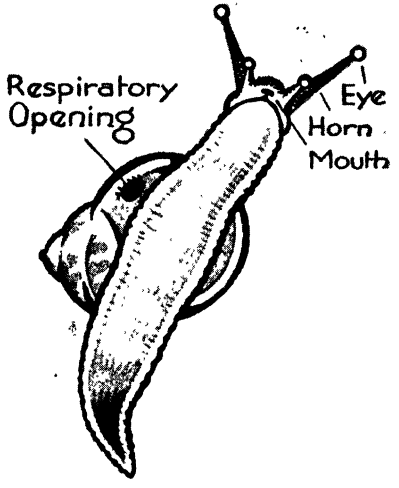


FIG. 83.
A Garden Snail shows, through a sheet of glass, lighter and darker bands in its muscular foot.

and to the bony skeleton within, or tough outer cover as in crabs and mollusces. One of the best close-up views you can have is in observing with the help of a lens a water snail or a land snail through a strip of clear glass (Fig. 83). *Suction* enters into the story, and to understand how powerful this may be, try to detach some Limpets (another

mollusc) from rocks where they are exposed at low tide.

In watching the snail you see a wave-like effect of dark and light along its so-called foot. The long muscle of which it is made is shortened in transverse strips alternating at any one moment with strips not so shortened and appearing different in colour in consequence; the latter are much lighter. This gives you some idea of the *rhythm of work and rest* which *is Nature's rule*. In your biceps not all the muscles, fibres or strands work at once; similarly, throughout your body there is a provision for working in shifts so that undue fatigue is prevented. This helps to explain the remarkable endurance of migratory birds, and also butterflies, in traversing the ocean.

With the aid of a watch and neat paper strips fixed to the outside of an aquarium you can work out average and individual rates of gliding for the different snails, on dull days and bright ones, when the water temperature is low, and when it is much higher; note whether they are travelling vertically upwards, downwards, horizontally or obliquely in your records and whether they were feeding or not. One July afternoon twelve timings for six snails all travelling with the foot uppermost in a long stone garden tank at Ingleton, Yorkshire, averaged eight minutes for about fifteen inches.

On occasion try to work out their rate of progress when the snails are moving along the surface of the water. Notice also how swiftly an ascent or descent can be made at a distance from the containing walls by a different method altogether. When it is at the top of the water the snail may suddenly force out the air from its lung while withdrawing into its shell, and sink rapidly. It

must then climb up again to take in a fresh supply. When, however, the snail is low in the water with a large quantity of air in its lung, it may, on occasion, release its hold of the wall or other solid object and rise rapidly to the top, without obvious effort, because of its *buoyancy*.

Movement in Birds

Now turn to a very different problem, crudely presented in the question : Which weighs more, a pound of feathers

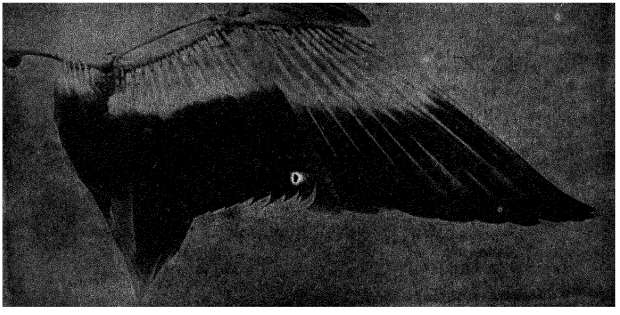


FIG. 84A.
Bones and large flight feathers of Wild Duck (Mallard).
From Lankester : Extinct Animals (Constable)

or a pound of lead ? We all know the answer, but we also know for how long a time a feather may travel on air currents before it comes to rest. Failing feathers we can use thin oval leaves or strips of paper to remind ourselves that in general the greater the surface in proportion to the bulk the more likely is the object to float in air as on water.

Floating and gliding do not carry a bird far. It must flap its wings or use its feet. Fig. 84A helps you to see

what to look for in a poulterer's shop, also in the skeletons of birds either in a museum or in the kitchen at home. (Compare Fig. 86A.)

The prominent keel on the breast bone provides large areas for the attachment of enormous muscles; these taper towards tough tendons which fix them to the upper arm bone at points near the shoulder joint, for the bird's

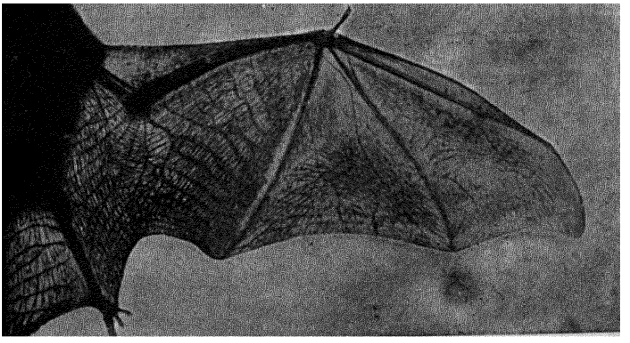


FIG. 84B.
PART OF BODY OF BRITISH BAT WITH WING EXTENDED.
The short hooked thumb, four very long fingers, and three of the five toes are clearly shown.

wings correspond to our arms and hands. Some of these muscles are concerned in depressing the wing, others in raising it. As you know, birds fold their wings when stationary; the many movements required for unfolding them, taking off from the ground or from water, rising, flying, slowing down and alighting can only be followed in detail with the aid of slow-motion pictures. Even then the bird's performance leaves one full of questions and admiration.

Turn now to a few feathers such as you can collect in

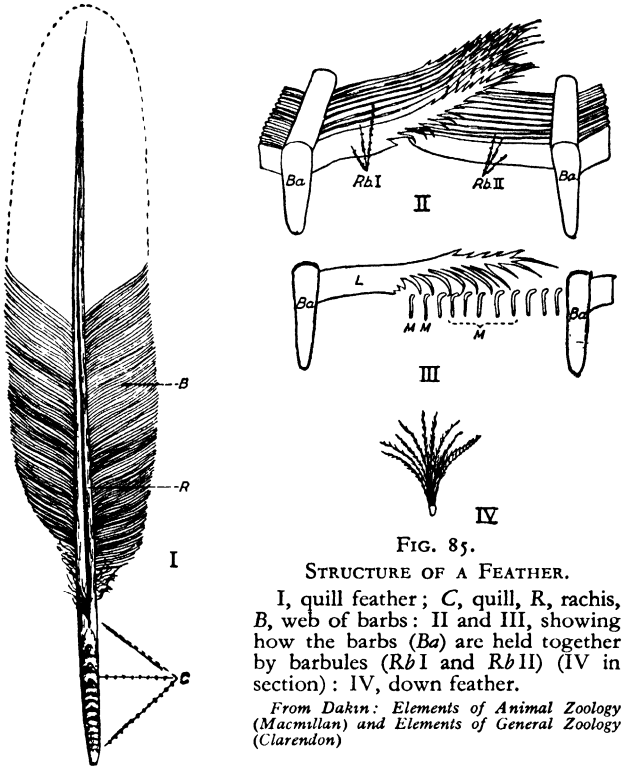


FIG. 85.

STRUCTURE OF A FEATHER.

I, quill feather; *C*, quill, R, rachis, *B*, web of barbs: II and III, showing how the barbs (*Ba*) are held together by barbules (*Rb* I and *Rb* II) (IV in section): IV, down feather.

From Dakin: Elements of Animal Zoology (Macmillan) and Elements of General Zoology (Clarendon)

quantity in summer and early autumn which is a season of moulting, on the seashore, in woods or any place where birds gather in flocks to feed, to rest, or to preen themselves in preparation for their next flight. The feathers of the domestic fowl will serve but since its flight is very restricted they are not quite satisfactory. Incidentally the pale colour of the breast and wing muscles in contrast

with the dark leg muscles is explained by the same restricted flight. The former do little work.

Make out the different parts in a *flight feather* and a *covert*. Use a lens in order to see the way in which neighbouring

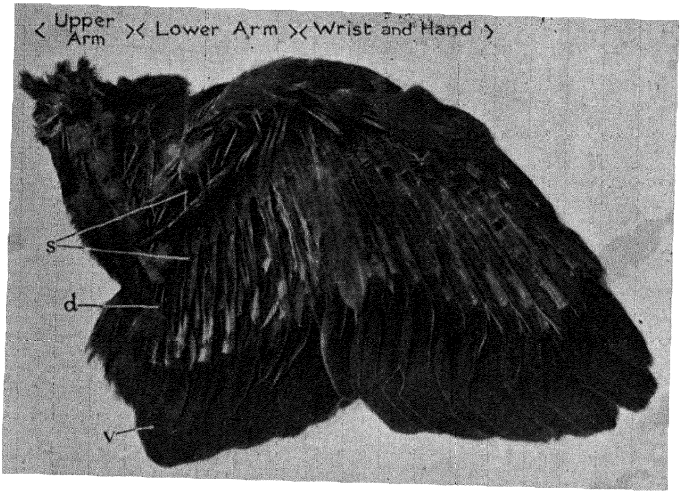


FIG. 86A.

LEFT WING OF YOUNG WOOD PIGEON SEEN FROM BELOW. × ½.

s. Horny sheath of small and large feathers not yet fully grown.
v. Vane of flight feather.
d. Down still attached to feather (Fig. 86c).

barbs of the flight feather are interlocked, while you hold the feather against the light or against a contrasting dull background. Then hold the vane (or web) on one side of the central axis or shaft at two points separated by about an inch using thumb and first finger of each hand, thumbs below and fingers above the vane. Now pull your hands

apart very slowly till the distance is greater by nearly an inch, perhaps. What has happened? The interlocking

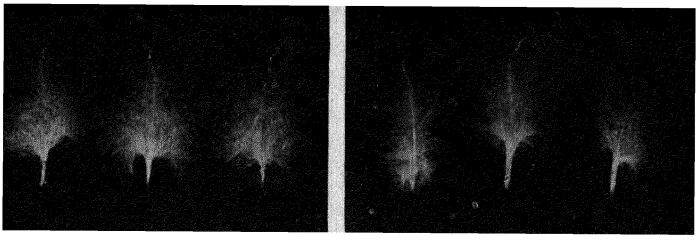


FIG. 86B.
Original down of nestling attached to down feathers and to small covert feathers. × 1.

arrangement between two neighbouring barbs has given way, but only after a considerable pull had been applied in two opposite directions. You can stroke the vane so that the barbs go back into position for they, with their two kinds of barbules, are remarkably springy, yet firm. A bird when preening itself, spends much time in making the barbs of its feathers interlock in preparation for flight.

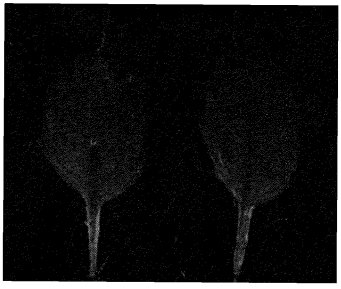


FIG. 86C.
Original down of nestling attached to tip of vane of covert feathers. × 1.

In a bird's wing, which you should try to study while it is flexible, you find many layers of feathers arranged in series and overlapping one another closely, but capable

of being twisted during life so that air can pass between. The wing feathers all together weigh remarkably little but when in close contact as they are during the downbeat they form an *impervious* sheet and air is forced to move. (Fig. 86A.)

In *steering*, wings, tail and head are used together or separately.

Movement in Spiders

Late summer and early autumn are undoubtedly the best times to watch the travelling of a Garden Spider in the construction of her web. Here is a most remarkable kind of locomotion along silken threads of her own making. Most often, probably, the spinning of this orb, a wonderful piece of workmanship, is carried out at night but certainly in some districts, London included, the web-making may be watched during all the daylight hours.

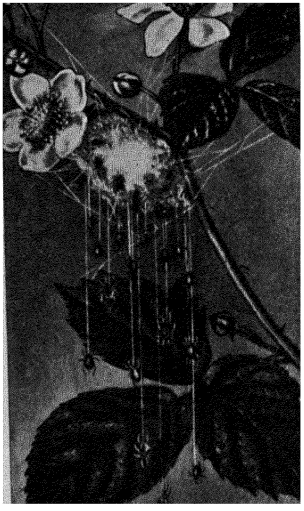


FIG. 87.

A swarm of young Garden Spiders dropping from a cocoon on their silken lines. About natural size.

Spiders are liable to be particularly busy in making their food-catching nets after very rough weather which has kept a great number of small flies in retreat and destroyed others. The spiders are then particularly hungry

and in their haste may spin only half the usual number of turns in the final *viscous* spiral of their webs. Earlier in the year you should seek an opportunity of observing the way in which the very small young Garden Spiders, and other kinds too, depend on air currents to carry them on their invisibly fine silken lines to points of vantage. The adult in laying down the first few long lines of the framework also depends on a breeze for transport (Fig. 87).

Flight

The birds remain the outstanding masters of the air. It is true that in the last few years their greatest recorded speeds have been outstripped by aviators, but they were in machines equipped with powerful engines and a number of ingeniously designed instruments ; these give information of critical importance to the intrepid man or woman pilot who may be travelling alone to or from the antipodes with a minimum number of stops. So astoundingly rapid has been the progress of aviation in the last forty years as your teachers and parents can realize, that one hesitates to suggest what may be the limits of progress even in the next ten years. Yet there are limits to the rapidity with which the human eye can adjust itself to changing scenes, as to rapidly moving indicators the pointers of which cannot be disregarded if disaster is to be avoided. It is worth while remembering how much assistance of one kind or another an aviator needs at the times of taking off and landing, and how he is beset with limitations in travelling on water and on land.

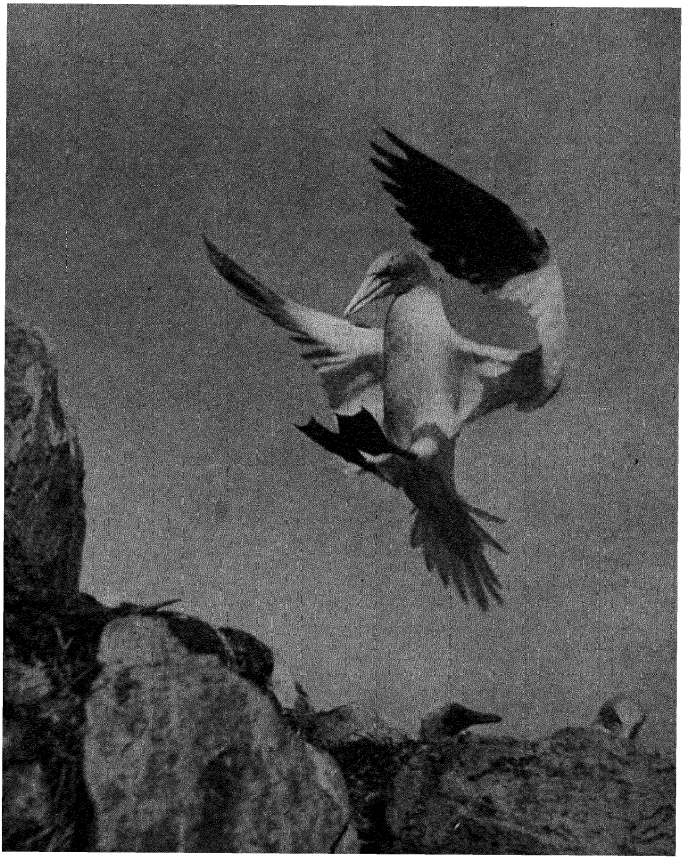
Many kinds of birds, including the Black-headed Gull, can fly, soar and glide, alight on land or on water, perch on buildings or branches, dive for food, and rest either

on water or on the land. Will there ever come a time when a man-made machine will make possible such a range of activities linked by quick, smooth, safe transitions ?

The gull moults and renews its plumage regularly every year, receives no overhauling, has no instruments nor maps to guide it, and furthermore, when it has grown up it rears a family which carries on in the unwritten traditional ways of the Black-headed Gull. Some kinds of birds have to urge their young to leave the security of the nest and take the first plunge through the air or make a first acquaintance with the water. The time when the young birds begin to feed themselves may come soon or late, but to find food they must travel.

The only animals besides birds which are capable of true flight are the bats (which have hairy skins and feed their young on milk like other mammals), and insects. It is true that some kinds of insects cannot fly and indeed the little springtails and certain other groups have no wings with which to lift themselves. It is equally true that some birds cannot fly since their wings are not nearly large enough in proportion to their bodies and legs, e.g. the Emu and Ostrich. Penguins cannot fly through the air but their rate of swimming in which they depend principally on rapid wing strokes is extremely fast.

In many books one reads of flying fish, but it seems probable that those fish which have very large paired fins, looking like wings near the front of the body, can only *leap* out of the water and *glide* down. One reads, too, of flying squirrels and flying lizards but the progress of these land animals through the air is always from a point of vantage, for example, a branch high in a tree which has



Niall Rankin

FIG. 88.

A parent Gannet putting on all its brakes when about to land at its nest on a steep sea cliff. It descends almost vertically in safety.

been reached by ordinary climbing, which is really walking up a steep slope, no more. These animals by unfolding a large flap on each side of the body which is then stretched out horizontally, kite-wise, can glide downwards to some lower perch.

Birds, in addition to flying through still or moving air, can glide, taking advantage of air currents as you know from the evidence of your own eyes. Besides this apparently effortless means of travel, many of the larger birds with broad wings such as hawks, Ravens, gulls and buzzards circle up and up on motionless wings. This kind of locomotion is called soaring. Are we able to watch birds soaring in *any* kind of weather? Try to recall the last occasion when you saw a big bird pursuing an invisible spiral course. What was the appearance of the sky? Many of you will agree that it was in fine, warm weather when the sky was blue except for billowy white clouds and when a breeze was blowing fallen leaves or bits of straw directly *upwards*. We read that "birds soar in circles to keep within an ascending column of air. If they fall over the edge of the column they flap their wings in order to get back."

Most large birds glide when they approach either a perch or the ground. Watch closely to see the *braking* which is carried out by sea-birds in the spreading wide of the webbed toes as well as by the action of tail, wings and body (Fig. 88). Soaring is only possible when the air is moving and on still days we rarely see Ravens or Common Buzzards in mid-air. Their haunts are far from woods though they may sail high above them. Most often they nest near the summits of steep rocky cliffs and command wide open prospects whether inland or near the sea.

Compare these speeds given in miles per hour :

In Air : Swift, 60 to 200.	Starling, 30 to 40.
In Water : Trout, 23.	Man, about 3 (but only for 1 mile).
	Woman, $2\frac{2}{3}$ (but only for 1 mile).
On Land : Greyhound, 35 (but only for 525 yd.).	Man, 3 to 12 *for a short time* only.
Giraffe, 40.	
Cheetah, 60.	

The speeds for men and women apply to *record-making amateurs* only ; the speeds given for animals in the wild are maintained for long distances, except for the maximum quoted for the Swift, probably the fastest of all known animals.

SUMMARY OF THE CHAPTER

Things to Note

1. Locomotion : Study limited here to work of muscles linked with bones and external hard parts.
2. The role of fuel foods in supplying energy.
3. Feathers : structure and moulting.
4. Birds, bats and insects. True flight, gliding, soaring, steering and braking.
5. Snakes compared with eels.
6. Bony fish with fins : swimming movements.
7. Spiders : travel on silk lines of their own making.

CHAPTER 10

ANIMALS IN CAPTIVITY

THOSE who cannot go into the country as often as they wish and at times when conditions favour close study of the lives of small animals, naturally collect them and take them home. Unfortunately, it often happens that no provision has been made and the hapless creatures die, but not before they have suffered serious discomfort or worse.

We are going to consider this housing-problem and the provision of suitable food with a view to the well-being of plants and animals in the school-room.

The Aquarium

We will concentrate first on a few of the inhabitants of a small shallow pond and their requirements. We must begin by studying their native haunts, the places where in Nature they flourish from year to year.

(1) A shallow pond presents to the air a surface wide in proportion to its depth and volume.

(2) It is lighted only from above.

(3) It is floored with sand, clay, silt and slowly decaying leaves.

(4) It is exposed to the wind and the rain so that dust and other things which fall on to it do not remain on the surface.

(5) There are many green plants in the pond :

(*a*) some floating ;
(*b*) some rooted but submerged ;
(*c*) some rooted but with leaves (and flowers in the summer) exposed at the surface or well above it. These provide shade for everything below.

(6) There are a few animals of different shapes and sizes and showing different habits in moving and feeding.

What kind of vessel shall we choose for use in the class-room ? Where shall we obtain the water ? Shall we need any screens, for example, against light or dust, or both ? How shall we decide which kinds of plants and animals are to be introduced and how many ? Is there a wide sill or bench where the vessel which is to house them can remain undisturbed, at a suitable temperature, and where it can be easily inspected—preferably by several members of the class at one time ?

In aiming at setting up a *balanced aquarium* we want to ensure (1) that the green plants will be adequate to the needs of the animals, (2) that both plants and animals will have enough air, water, food and light, but no excess of any of these things, and (3) that the temperature of the water will not be much higher than that in the pond itself on a summer afternoon. A much lower temperature, say 50° F., is far better than a much higher one, say 70° F.

A diagram together with two lists will indicate clearly the answers to most of the questions about which you have been thinking (Fig. 89).

A large jam jar or small fish kettle serves for collecting from the pond the following :

Plants recommended :

(1) *Rooted and submerged.*

Canadian Pond Weed with new shoots and some white roots.

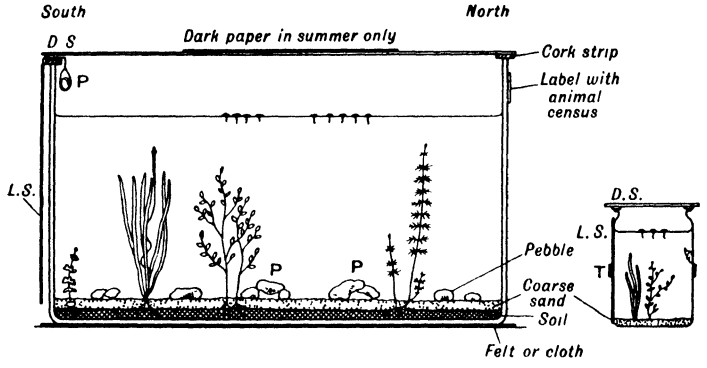


FIG. 89.

The water moss, *Fontinalis*, generally found attached to the submerged roots of trees, for example, willows.

(2) *Submerged and anchored by special stems.*

Hornwort.

(3) *Floating.*

Duckweeds—there are three kinds.

Many other attractive plants will be seen in ponds ; but most of them do not last long and when they decay everything becomes foul.

Animals recommended :

(1) *Plant feeders.*

Water snails of many kinds but especially the Common Pond Snail and the Ram's-horn Snail.

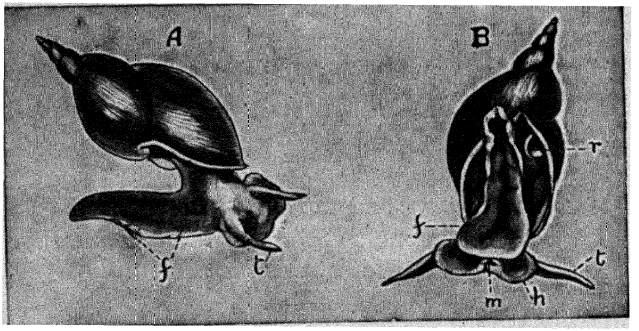
(2) *Scavengers.*

Water fleas, for example, *Daphnia* and *Cyclops* ; water slaters, *Asellus*, which looks rather like a Wood louse, but cannot roll up.

Carefully avoid leeches no matter how small, and all flesh-eaters including certain beetles and the larvae of dragon flies.

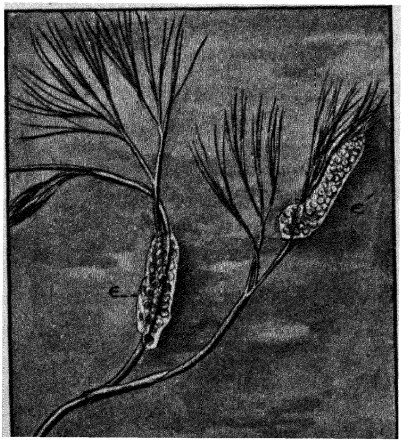
Let tap-water stand in a wide vessel overnight in contact with the air though screened from dust. A large watering can is suitable. Wash the larger plants thoroughly in a big bowl under a tap for two reasons : (1) to free them of excess numbers of minute green plants which cling to them and are likely to multiply much too rapidly in a small aquarium especially on its walls, where they soon form a continuous green film which checks observation ; (2) to get rid of most of the innumerable bacteria which thrive in the black mud clinging to their roots. These would multiply very rapidly in the aquarium and especially in a warm room ; the probable result would be the fouling of the water and complete failure.

Now put all the plants in a jar of clean water. Thoroughly wash some coarse silver sand and also some fine gravel. Place these at the bottom of the aquarium, sand below and gravel above ; unless the aquarium is really large, it is better not to put any soil under the sand.



THE COMMON POND SNAIL. × 1.

A. Seen from the right side. B. Seen from below. t, tentacle; f, foot; h, head; m, mouth; r, respiratory opening.



Two masses of eggs attached to Water Crowfoot stem and leaves. × 1.

FIG. 90.

Next, tie those plants, already washed, which were rooted in the bottom of the pond, to large pebbles, using strong cotton. Place these in the sand and gravel. Now pour in the water, which has been waiting overnight, very slowly to avoid stirring up the sand. You can pour it over a sheet of glass held at an angle of about 45° to a

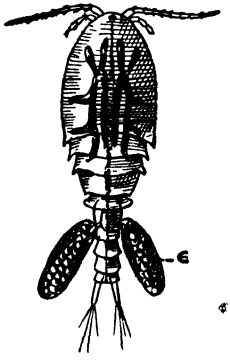


FIG. 91 (1).
A FEMALE CYCLOPS.
× 20. e, egg-bag.

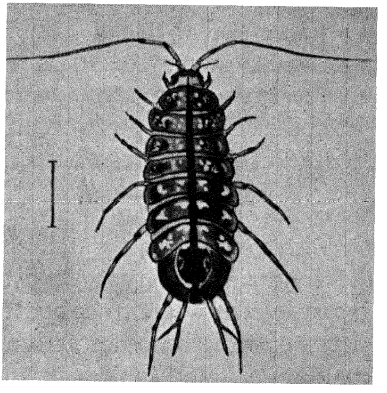


FIG. 91 (2).
ASELLUS, A WATER SLATER.
Actual size is shown by line on left.

side wall of the aquarium, or pour it through two layers of perforated zinc. The rooted plants will take up fairly natural positions in the water; then put in the floating plants, and lastly the animals which have been waiting in the collecting jar. They will soon explore their new surroundings.

Now there are still three very important things to be done:

(1) Make a census of the animals on a rather small label

bearing the date and fix this on the aquarium. A new census should be made at intervals, perhaps each month.

(2) Place the dust screen in position. A sheet of glass supported on two strips of wood or in some other way is good. In a very sunny place, however, a sheet of paper may be needed above the glass for part of the day.

(3) Place the light screen in position. A sheet of brown paper tied with tape suffices but much better is a strip of dark green cotton fabric with four or more weights in little bags sewn to the upper border. These will hold the screen in position on one, two or three sides and any adjustment takes only a moment.

For close observation of any individual animal lift it gently with a small net, a watch glass, a spoon or a pipette of the fountain-filler type, transfer it to a saucer containing sufficient water to cover it fully. It may be some minutes before it becomes active; this is the best time for making a sketch (unless it is a snail which has withdrawn into its shell). Use a magnifying glass and make notes on what you have only now been able to see clearly, for example, feelers, eyes, mouth, limbs, gills.

Be careful to keep the water deep enough and to replace the animal in the aquarium as soon as possible; light and dust screens must be replaced too.

As the water-level sinks in the aquarium replenish with clean rain-water or tap-water from a can with a fine sprinkler in order to introduce as much air as possible.

In winter it is a very good thing to add a few small, unbruised *outer* lettuce leaves which are really green. These will float on the surface and provide attractive food for the water snails.

The Canadian Pond Weed will then persist with its new leaf shoots intact until rapid growth is stimulated by brighter and more continuous daylight in the spring. At this season you will notice steady ascending streams of tiny bubbles of gas very rich in oxygen which give proof that food-making is going on rapidly once more and at the same time, growth. Lettuce will be needed no longer for there will be plenty of new leaves, as well as green algae on the sides of the aquarium, for the snails to feed on. If they cannot keep pace with the formation of this green film add one or two more snails to assist and cut down the lighting. In any case, watch closely the mouth parts of the snails as they glide over the glass. Notice, too, the kind of track they make. Does it show any definite pattern ?

Early in March in a small aquarium you can often count all the duckweed plants. With the help of a sheet of glass and a sheet of finely squared paper you can calculate roughly the area they occupy and replace them in the water. At the end of March and late in April by repeating this process you will realize how much growth has occurred.

Very full instructions have been given for the setting up of an aquarium, and if followed they generally bring success. A two-lb. size jam jar set up and cared for in the way suggested and with no addition except for water a few times in summer weather proved to be a very satisfactory aquarium for more than two years. There was a good balance as between green plants and animals, moderate lighting, sufficient air and scarcely any dust.

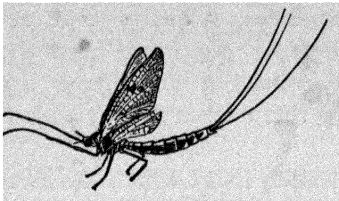
It often happens in a warm room that a thin film appears on top of the water and literally covers it. In

some lights it appears *iridescent*; it consists of a continuous raft made by innumerable bacteria and prevents all the aquarium inmates from getting enough oxygen. This film can be removed on a sheet of good white paper or thin white card. A lowered temperature will help to check its formation.

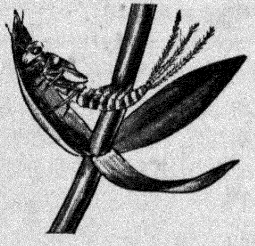
When you have succeeded with the few animals referred to on page 193, you will probably wish to introduce others including some small goldfish or a pair of Minnows. These should be bought at a reliable shop or obtained from a wholesome looking pond. Often it is best to keep fish separate from other animals in a tank of their own.

Fish need plenty of water so the tank must be large for it is natural to them to swim very rapidly at times and they require well-aerated water. You should introduce air daily by filling a small watering can with aquarium water and letting this fall as a spray. Once or twice a week remove about a tenth part of the water, throw it away and put in a rather greater quantity of fresh clean water. It is not good to subject fish suddenly to water of an entirely different quality. It is most important to offer only as much food as will be eaten. There are several kinds of dried fish-food on the market, one of the commonest being the pupae of ants, misnamed ants' eggs on the packets. These float at the surface and are snapped up eagerly by the fish when they are hungry. One meal a day, and this a very small one, suffices.

Many people have no plants in their fish tanks, but they provide large clean pebbles to make retreats above the clean gravel floor. Remember that fish cannot close their eyes even when they sleep, for they have no eyelids, and they suffer badly from excessive light. See page 175.

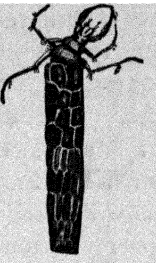


Adult.

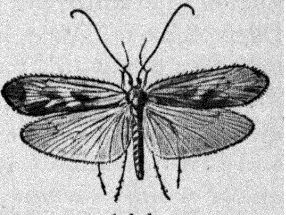


Larva of the common May-fly, resting on a piece of Canadian Water-Weed. × 2.

FIG. 92.
MAYFLY (× 1).



A Caddis larva in the case it has made of pieces of green leaf (× 1).



Adult.

FIG. 93.
AN ADULT CADDIS-FLY (× 1).

On occasion you may like to introduce into your aquaria animals which in nature, after a long existence in a pond, escape and pursue their activities in the air. For such animals whether insects or amphibians some special provision must be made at the right time of year.

The larvae of the mayfly and caddis will need a tall smooth slender twig up which they can climb to complete the transformation which precedes their first flight (Fig. 92 and Fig. 93). You will be very fortunate if you are able to witness this.

You may be eager to study dragonflies; their *metamorphosis* is remarkably impressive; anyone who has

watched it will recall the experience vividly. But, remember, the larval stage is long continued and the larvae are not only carnivorous but also have big appetites. You need to keep them apart from all plant feeders.

Other native amphibians besides frogs which lay their eggs in water are the toads and three kinds of newts. Whenever you raise tadpoles from eggs of these several kinds you must make provision after a number of weeks, the exact time depending on the season and the temperature of the aquarium water, for a *terrestrial* existence. Deep moist soil, moss and shallow dark saucers of water in a deep box with a really well-fitting lid are needed for the small four-legged amphibians which no longer have gills but breathe with lungs. They will climb, escape and perish miserably in dark, dry corners of the room unless your vivarium is properly closed. Air can be admitted through two small grids of perforated zinc. Ideally the aquarium is sunk in a big vivarium so that as soon as they are ready the lung breathers can crawl on to the land.

Many of you will know the aquarium house of the London Zoo, one of the most successful in the world. There is also a tidal pool where you can watch the behaviour of many of our common sea-shore animals ; but the tide is made to rise and fall only once in the twenty-four hours instead of twice. In the larger hall there are freshwater and marine tanks, for animals of temperate waters and a tropical hall for fish and other animals accustomed to higher temperatures. You can scarcely fail to notice the excellent arrangements for forcing streams of air bubbles into the water. But for the constant aeration

most of the occupants would very soon die, oxygen being of vital importance as you have learned.

Feeding days for the larger fish and other big animals in this famous aquarium come only once a week. The eagerness with which these creatures dart and seize the cubes of cod or other food shows that they are really hungry; seldom is any food left over; the attendants remove all scraps for otherwise the water would be fouled by its decomposing; the expense of renewing the water in the marine tanks is very great, but with proper care there is no need to do so more than once a year.

At Monaco on the French Riviera there is another excellent aquarium, but it is exclusively marine. Fresh water from the Mediterranean Sea is continually pumped up a few hundred feet to the tanks, where it is constantly aerated, and a great variety of small animals flourish throughout the year. Their beauty of colour, form and movement must be seen to be believed.

In Liverpool, Plymouth and elsewhere in Great Britain there are aquaria devoted specially to marine animals of our home waters. At some of these trained biologists study the development and feeding habits of fish in order to be in a position to give sound advice about our fisheries in different seasons and different localities.

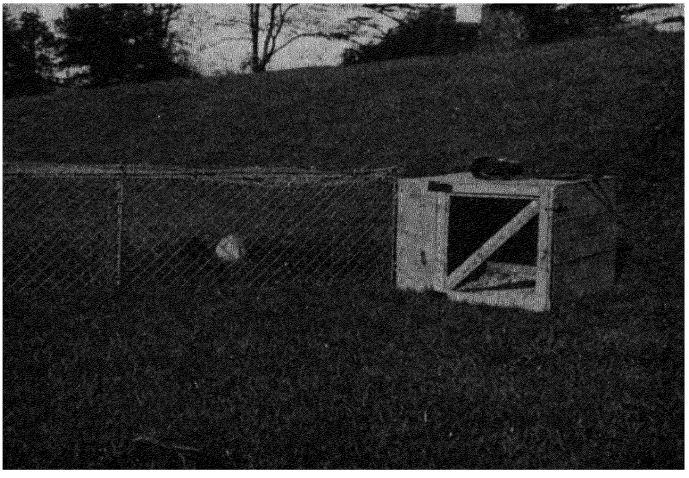
Those who live near the sea may like to set up an aquarium for marine animals but without continuous aeration no attempt is likely to be successful for more than a few days; you should try to realize that before an animal succumbs to the effects of wrong conditions it must experience great discomfort, or real pain. If you can collect from tidal pools in the morning, study your catch in a large vessel of fresh sea-water in a cool shady room,

and place your catch the same evening in the same or a nearby pool on the seashore, no harm will be done though the animals may have been hungry.

Protection of Animals

It comes to this : before we can take care of the humblest creatures we need to know a good deal about their haunts and ways of life. Fortunately many good books are now available to help us though often there are gaps in the information, for example, as to the right kind of food !

A number of large stores now have a zoological



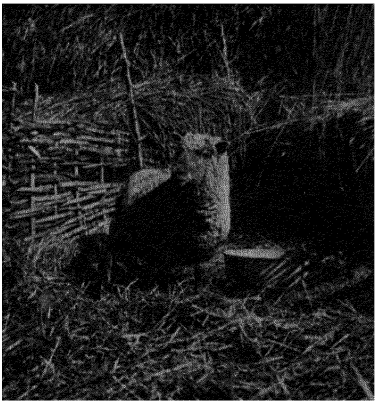
M Munro

FIG. 94.

Two Guinea Pigs enjoying the grass in a collapsible run with two compartments and gates. Their hutch is kept in the Animal House. Furzedown Training College, 1938.

department and issue valuable catalogues. There are, too, a great number of pet stores, reflecting the growing interest in the keeping of animals of all kinds. It is best to go to places with a reputation based on long experience, where you can rely on the advice of the salesmen.

Very valuable leaflets are published by the Royal Society for the Prevention of Cruelty to Animals and by



M. Munro

FIG. 95.

A South Down Ewe with her new-born lamb in a straw-thatched pen on a farm near Chichester.

the Royal Society for the Protection of Birds. In recent years a new society has been formed; it is known as the Universities Federation for Animal Welfare.* These are long titles so one refers to them by their initials, as the R.S.P.C.A., the R.S.P.B., and U.F.A.W. All three societies are doing extremely interesting and valuable work, in part by lantern lectures and films.

* 29 Gordon Square, W.C. 1.

Zoological Gardens

There are many zoological gardens now in which we can observe the paddocks, cages and tanks of a great variety of animals. Most of the animals are wild, but generally some space is devoted to domestic animals : for example, there are Guinea Pigs kept in the Zoological Gardens, in London.

If you are able to pay more than one visit to a zoo it is a good plan to use part of the time in studying the " house " and diet of two or three favourite animals in some detail. Here are some suggestions :

Name ; numbers ; ages ; native country ;

Length and height of adult ;

Length, breadth and height of house ; general aspect and building materials of walls, floor and roof ;

Lighting, natural and artificial ;

Heating, ventilation, actual temperature ;

Water for drinking and for bathing ;

Food containers ; food, kinds and amount (a salt block is often provided for herbivores to lick).

Exercising ground ; extent ; grass, gravel or other surface ; litter for bedding. (Note the separate sleeping quarters if provided) ;

Entrances and exits for animals and keepers.

You may be able to watch the cleaning of the " house " and the grooming of the inmates. Are any disinfectants used ? Feeding times may be announced. Most of the animals are really hungry at meal times and may be watching or listening intently for the keeper's arrival.

Other things affecting the health and comfort of the animals are the stores department, arrangement for dis-

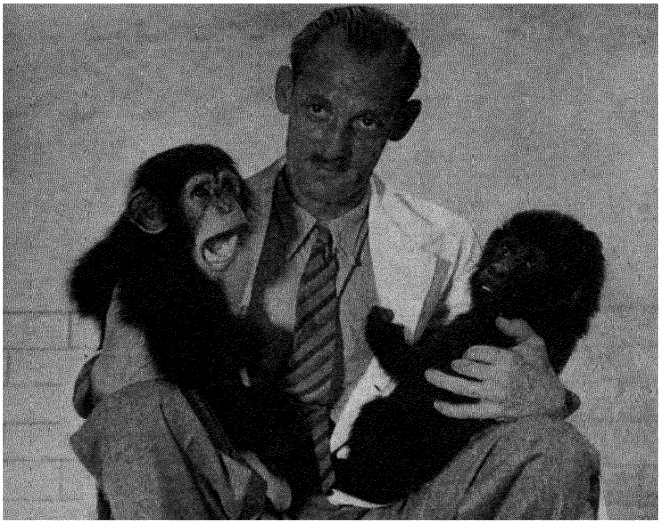
M. Munro

FIG. 96.

Three of the four King Penguins which laid an egg and reared a chick in the Edinburgh Zoo, in August, 1938. One chick and one egg visible.

posal of refuse, isolation quarters and sanatorium; but these all lie behind closed doors.

When you notice the advanced age which many of the animals reach in captivity you begin to realize how much care and thought has been given to them. Those that rear families in captivity give proof that they are in excellent condition. In recent years, through better provision for out-door exercise, vita-glass roofs and windows, special lamps to give ultra-violet light on dull days, and better diets, many animals which had never succeeded before have had young and reared them. Everyone is familiar now with the name and engaging manners of 'Jubilee', the Chimpanzee born in London in 1935;



Daily Herald

FIG. 97.

Keeper Shelley at the London Zoo with 'Jacqueline' and 'Meng'. The Chimpanzee was deserted by her mother when only a few weeks old, and the Gorilla was found alone at the age of a few months in an African forest. Photographed when about nine months and twelve months old.

she is one of several healthy and extremely playful young chimpanzees born in Great Britain. As a special precaution, the house where 'Jubilee' and her mother lived is a real house with its own kitchen, and detached from all other buildings. No visitors were allowed for many weeks and then for many months only during certain hours. This programme allowed for long hours of undisturbed rest and sleep during the day. The same keepers were always in attendance. Heavy plate glass

Mondiale

FIG. 98.
BADGERS NEAR THEIR EARTH.

separates the public from the chimpanzees here and in the large monkey house to prevent infection by disease germs.

On December 26, 1937 a baby giraffe named 'Boxer' was born at Whipsnade where the parents have a splendid large house. This is another real achievement in the proper care of animals whose native haunts are extremely different from any that our country can provide.

Without being over-ambitious and without heavy expense a number of colleges and schools have advanced

from the keeping of a few pets to the starting of small zoos in sheds or special rooms set aside for the purpose.

Still more attractive and instructive than any zoo, no matter how richly stocked and well organized, are Sanctuaries and National Parks and their number grows apace. Happily, many a large well-wooded garden is a veritable sanctuary for birds which become remarkably trustful and even inquisitive when there is nothing to fear.

Thanks to the National Trust and the Society for the Promotion of Nature Reserves we can count on being able to study in the open a good variety of our native birds. Of the few British mammals which still exist many, like the Badger, are nocturnal and exceedingly shy. Opportunities for watching them are therefore few.

SUMMARY OF THE CHAPTER

Things to Note

1. The care of animals in captivity based on the study of the same or similar animals in their natural haunts.
2. A simple well-balanced aquarium. Provision for metamorphosis.
3. Zoos large and small. National Parks.
4. Protection of animals by Societies.

CHAPTER 11

OUR OWN HOMES AND FOOD

In the British Isles most people have to spend many hours out of the twenty-four, even in summer time, indoors. Fortunately doors, like windows deserving the name, are made to open so that a house, no matter what its size, may be a very airy place, and, as we all know, when the wind blows from a cold quarter there may be too much air passing through a room and no real comfort. Probably none of you can choose either the town, the village, the house, or the flat where you live ; but very often by common-sense methods you can make small improvements in a room through which everyone who uses it benefits.

Buildings and Sites

In Chapter 2, you were offered a few ideas on the aspects of buildings in relation to the sun, and those of you who have spent one year in a sunny class-room and another year in one facing north will realize, how important aspect is. Some people are wise enough to make what was a sunny first-floor bedroom into a living room and what was an almost sunless living room into a bedroom even though that room was on the ground-floor. But stairs which may be narrow and steep and add to the labours of a mother who is already too busy, or the excessive noise of railway or road traffic preventing some

of the family from having enough sleep might determine that the sunniest room in the house had to remain a bedroom.

It is good to see a growing number of people alert to learn about ideal sites, ideal houses and better fittings of all kinds, but most of us need to be alert to learn how to adapt, at slight expense, what is inconvenient or unhygienic so that some of the family benefit.

Hygiene in the Home

Many people cannot afford refrigerators (Fig. 99). It may be that the larder is not cool enough nor even fly-proof. Some simple device which maintains the evaporation of water will use up heat and thereby reduce the temperature so that milk and butter will keep sweet; some perforated zinc and tacks may be all that is needed to keep out those loathsome insects, the House-Flies and

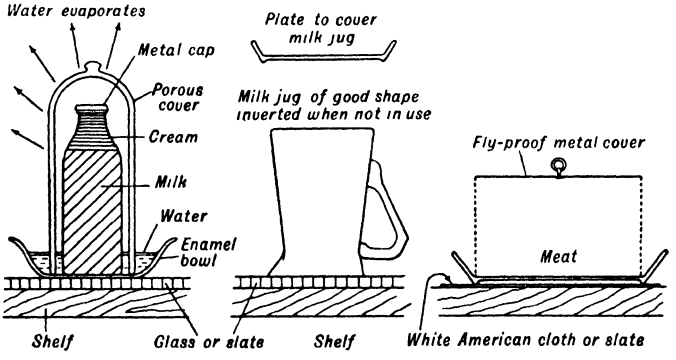


FIG. 99.
For those who have no refrigerator.

blue-bottles; but, of course, we need to do all we can to prevent them from ever coming into the house. Here are some rules which, if adopted, generally solve the problem.

(1) After each meal clear the table promptly.

(2) Keep all food in the store cupboard or larder and make this fly-proof. Cover separately all food either closely, e.g. jam and sugar, or use a perforated cover, e.g. for fish and meat.

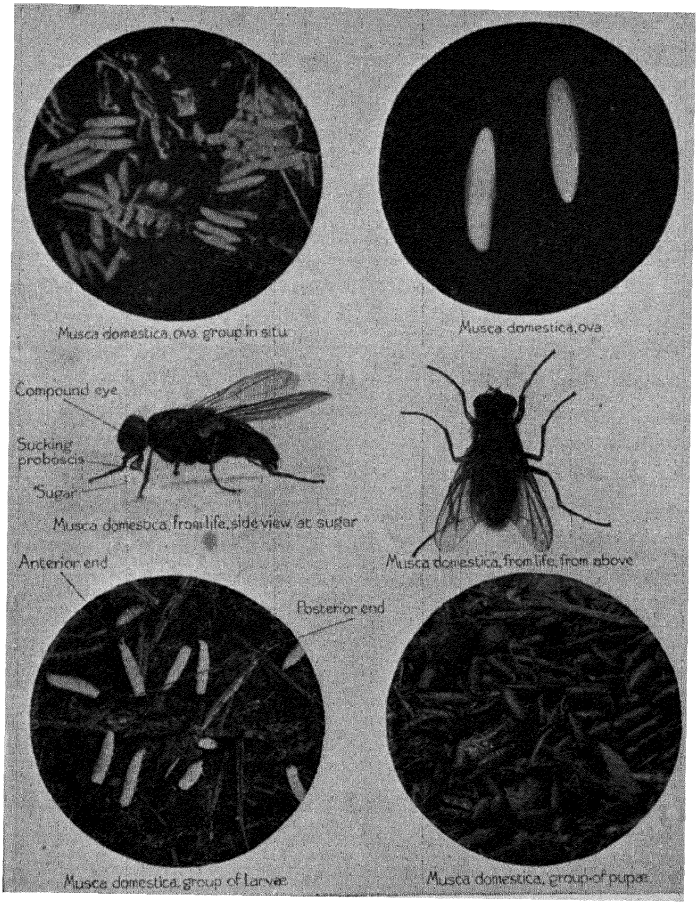
(3) Wrap up all pieces of waste in newspaper before putting it in the waste-bin. Put the lid on securely.

(4) Wash up dishes and all else without delay, or, if this is impossible, wash knives, spoons and forks, wipe plates and dishes clear with paper and fill used saucepans with water, there will then be very little to bring flies which, as you know, are attracted not only to wholesome food but also to all manner of filth. They convey great numbers of minute disease germs to whatever they touch.

If we have definite ideas, we can generally improve things. During the Great War, thousands of women students and school girls who were old enough were eager to work on the land wherever help was needed and spent several weeks each summer on farms of different kinds. The second farm on which I worked was in a famous fruit-growing area in Worcestershire. There were twelve of us housed in a two-roomed school; there was one gas ring on the floor and one very small oil stove for all cooking. We worked in two gangs. Water for washing had to be carried by hand from a well about an eighth of a mile distant, while water for drinking

was brought only three times a week in a tiny barrel and we never had enough of either kind of water. We took turns in the cooking of the mid-day meal and the cook for the day left the plum orchard only half-an-hour ahead of her gang. By chance, I was cook on my first day and was instructed to stuff a marrow with meat and mushrooms and cook it in the fish kettle over the gas. (Besides this utensil we had only a tin tea kettle and one saucepan). We had no cupboard and, of course, no larder. I noticed that the mushrooms were too old and riddled with small white grubs ; much more serious, on the meat, which was uncovered, there were clusters of eggs and I knew them to be those of the loathsome House-Fly (Fig. 100). The gang was disappointed in having plain marrow for dinner ; we had started work at 6 a.m. when it was scarcely light, for it was mid-September, and breakfast was a small and hurried meal. The gang leader kept an account of all expenses which were not to exceed our wages, namely, fourteen shillings per week. The newcomer hesitates to offer advice, but after a few days I suggested a levy of 3*d.* per head, and with this 1*s.* 6*d.* we bought at the town only 2 miles away, a yard of stiff book muslin which frustrated all flies approaching the one food-shelf, and a galvanized zinc pail to replace the leaky wooden box which had served as a refuse bin. The 1*s.* 6*d.* was less than the cost of the tainted food which no one wished to risk eating.

For the time being this old-fashioned school-building was our home just as a tent in a camp, a caravan by the wayside, or a punt on the river may be home for a time. Wherever we are we may be slovenly through lack of imagination or a little effort, but the worst kind of



Flatters & Garnett, Ltd.

FIG. 100.

THE LIFE OF THE HOUSE-FLY.

Eggs (ova), larvae and pupae and adults.

slovenliness is that which does hurt to our neighbours : one uncovered rubbish bin in a street is a case in point ; banana skins and orange peel in a playground or in the street are both a danger, especially in wet weather, and always an eyesore.

Lighting

Though in recent years the number of children afflicted with blindness has been greatly reduced by treatment on the very first day of their lives, the number of people needing spectacles to remedy defects of vision and the number of grown-ups with very poor sight has increased. Among the causes of eye-strain are (1) the habit of reading print which is not very large or well-spaced in rapidly moving buses, trams and trains where the motion is unsteady ; (2) the amount of time we spend indoors and in the streets where it is impossible to look at things at a comfortable distance, that is, at a distance of twenty feet or more, when our eyes can focus without any strain. (3) The brilliant lights of shops and signs together with advertisements, many of them attractive as single items, but together, preventing our eyes from having any repose. Further, all the people who have to drive through city streets must be ever watchful for traffic signals.

For all these reasons and many others we need to arrange the lighting in our homes so that close work, leisure reading, sewing and all the other things we do in the evenings impose no undue strain. Often a different bulb, or a different placing of the points will give us at least twice the value for the electric current we consume. Similarly with gas, and oil lamps, or even candles, by

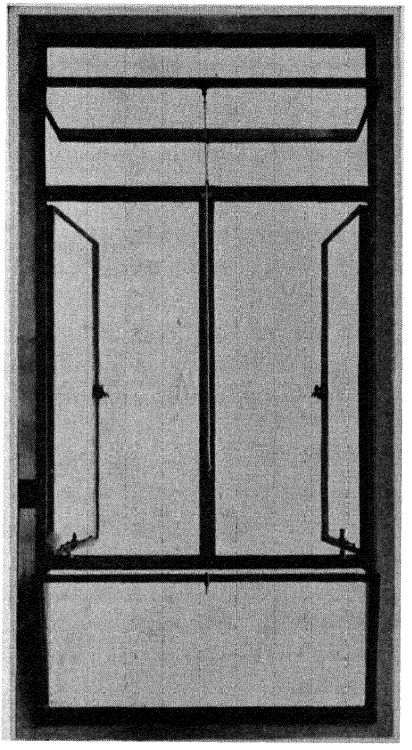


FIG. 101.
One of the best kinds of window for schools.
(By courtesy of Messrs. Henry Hope & Sons, Ltd.)

planning rather than by merely spending money, we improve the lighting; we also keep our eyes in good working order provided other things are right: for example, our eyes suffer quite definitely in any place which is over-heated, or stuffy. Dark walls, floors,

ceilings and curtains absorb a very large proportion of the light available. Pale yellows, greys, cream and other delicate shades are now in vogue.

Diet

You have learnt many things about the food requirements of green plants and animals. The green plant has the truly marvellous power of using some of the sun's rays and simple substances from the air and the soil for the making of extremely complex substances including sugars of many kinds, starches and cellulose, all of which, for convenience, are often called *carbohydrates*, and also oils and proteins.

These substances, of its own manufacture, the plant either uses up as food in growing or holds in reserve. When held in reserve they are concentrated stores of energy. When used as food by the plant much of this energy which was locked up is released and in consequence the plant is both able to grow and keep its temperature a little higher than it would be otherwise, and thereby escape damage.

On page 13, for Rabbits I suggested oats, crusts of wholemeal bread, hay, cabbage, dandelion leaves, carrots, swedes, together with water as a suitable diet.

All these things, except water, are even more complex than carbohydrates, oils and proteins. In the table provided in Fig. 102, you can see, in part, what the chemists have found out by careful analysis for most of them. We need to remember that the *mineral salts* present in all these things which a rabbit eats are very valuable. Further, all these things contain in still smaller quantities

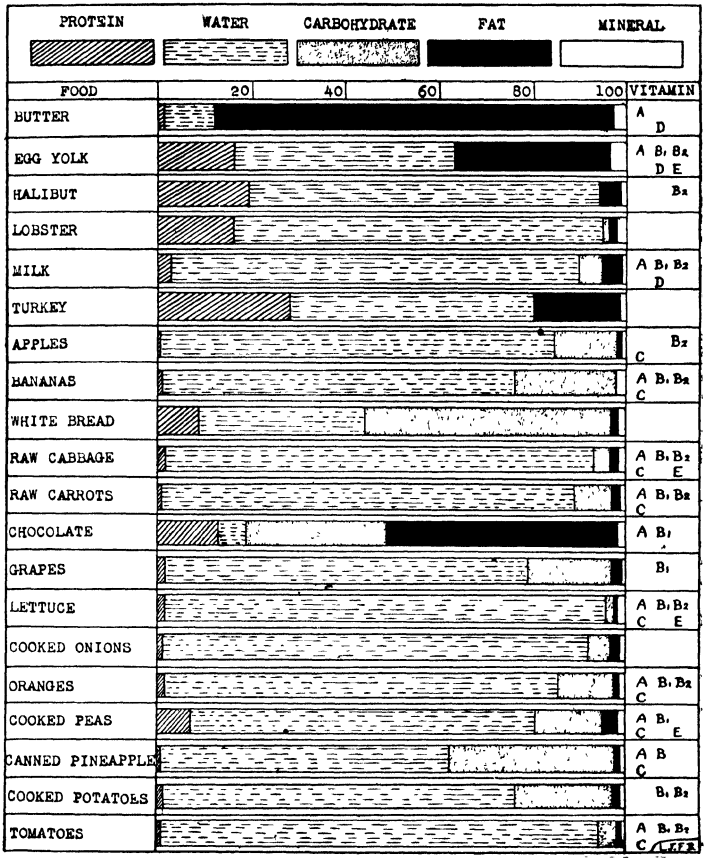


FIG. 102.

substances called *vitamins*. Mineral salts and vitamins are essential for the health of all animals and man is no exception. It is impossible nowadays to fail to see

advertisements for foods rich in one or more of these vitamins. Our grandparents and earlier ancestors had never heard of them, but they used to eat all of them nevertheless, in any good mixed diet. But what do we mean by a good mixed diet for ourselves? Neither the rabbit's diet nor the cat's would suit us; but if we combine the two, make a few additions, e.g. butter, eggs, fruit and potatoes, omit the hay, and allow for the cooking of the oats, we have a very good variety, for some days at least (see p. 13).

There is no space to discuss the reasons for rabbits, cats and men favouring a wholly vegetable, a wholly animal, and a mixed diet, but in passing we may notice that the *teeth* are very different and so, too, are the digestive passages and juices, in these three types. We have touched the fringe of a very big subject; try to find answers to such questions as these: Is a purely vegetarian diet the best possible for the natives of the Ganges plain? Is a purely animal diet the best possible for the Esquimaux of Greenland?

This will set you thinking about the way in which we modify our own meals on very hot summer days, during the coldest parts of the winter and when we are in camp or having extra outdoor physical exercise. The great thing is to be able to have more food than usual when we are more hungry than usual. If you store more than you need in your bodies (e.g. as fat), unlike the trees and most of the lesser plants, you have to carry it wherever you go. On the other hand, if you eat less than you need the reserves that you had in your bodies are used up and though you may grow taller you become thinner than you should be and less robust.

Milk

In Chapter 7 you learned a little about the needs of the young of those warm-blooded animals which, whether only hairy or actually bearing a fur coat, are called

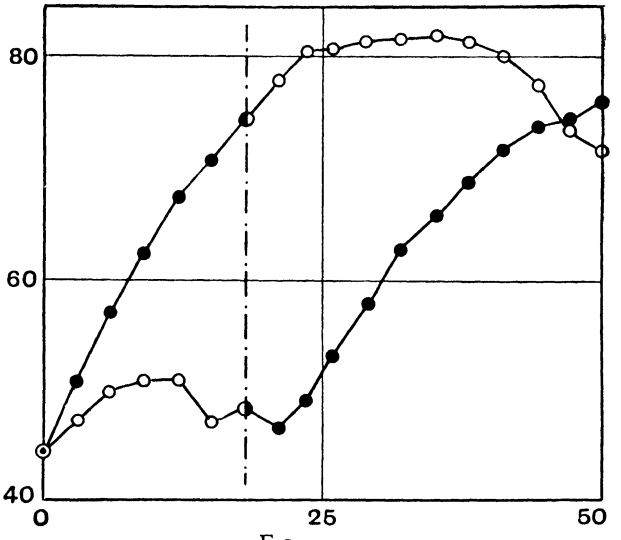


FIG. 103.

FEEDING EXPERIMENTS ON RATS.

Read time in days from left to right and average weight in grammes from below upwards.

The lower curve (up to 18th day), 8 male rats fed on pure dietary.

The upper curve, 8 similar rats on same diet with added milk. The diets were reversed on the 18th day.

The pure dietary contained chemically pure fat, carbohydrates, protein, water and mineral salts but no vitamins.

mammals because the mothers in every kind or species produce milk and suckle their babies for the first few weeks or the first few months of their lives (Fig. 103). The milk of cows and goats, to name two domesticated

mammals, is not identical as you probably know. Indeed, each kind of mammal produces a particular kind of milk which is *perfectly* suited to the young of that species, alone; differences are in detail and there are marked likenesses in the composition of all types of milk as this table shows:

	% water	Fat	Protein	Carbo-hydrate in form of milk sugar	Mineral salts of	Vitamins
Human	88	2·0	3·5	6·5	Calcium	A,D,B,C
Cow	about 88	3·5 to 3·7	3·3 to 3·7	4·5 to 4·9	Phosphorus and Iron	A,D,B,C
Goat						A,D,B,C
Lion, Cat and Dog	75	10	10	3·0		A,D,B,C

It is not surprising to find that *in milk, and only in milk, are found all the different kinds of food substances*, best called food constituents, namely, water, fat, protein, carbohydrate, mineral salts and vitamins, for on milk alone a human baby is reared for nine months and its weight is often trebled. But notice that all of the four chief vitamins are present in milk if it is fresh, that is, neither pasteurized nor boiled, and if it has come from pasture-fed cattle. The herbs of the meadow yield what the hay and cattle-cake diet of a stall-fed cow cannot provide so that the milk of the latter lacks vitamin D. You know how butter is made from milk and this explains why it is worth while in

M. Munro

FIG. 104.

A five-day Highland calf being fed with a favourite grass, Cock's Foot, just beyond its reach. (In the same vast paddock were its own parents, the bull and the cow.) Edinburgh Zoo. Early August, 1938.

winter to buy the best New Zealand butter; while our days are short and the grass has ceased growing so that the farmer cannot let the cattle graze in the fields, New Zealand, in the Antipodes, is enjoying high summer, and vast herds of cattle graze at large in the pastures. So wonderful and potent are the sun's rays that since their value has come to be understood more fully, some dairy produce, after manufacture, is subjected to ultra-violet rays though only for a very short time, and thereby gains an added value as an article of diet. Many herbivores while depending on milk seek a little vegetable food rich in vitamins (Fig. 104).

You can learn a great deal more by reading the printed leaflets which lie on the counter in many of our modern dairies about the different kinds of milk ; some of these differences are due to the breed, for example, Jersey and Guernsey cattle yield far more cream than other breeds and the cost of the milk is rather higher ; other differences are due to the way in which the milk has been treated before and after bottling. Most of us drink *pasteurized* milk in this country, as you can see by looking at the caps on your $\frac{1}{3}$ of a pint bottles at school, or on the larger sized bottles at home. This term *pasteurize* is to be found only in modern dictionaries and it is a lasting memorial to the great Frenchman, Louis Pasteur. If you have the opportunity of seeing the film which bears his name, you will certainly wish to read more about this man to whose vision, courage and work we owe more than we can ever realize. Briefly, milk which is pasteurized is heated to a temperature lower than boiling point and generally to 165° F., held at that temperature for half an hour and then cooled rapidly to 45° F.

School children and grown-ups, unlike babies, must have a mixed diet. Milk alone would be much too bulky and it would not give our jaw-muscles and gums enough activity. Our teeth as they emerge need to be given work to aid them in their development ; of solid food a good proportion should be tough or crisp so that we chew it thoroughly and so stimulate the flow of a colourless juice called saliva into the mouth and mix it with the food. This saliva contains an enzyme which digests cooked starch, e.g. in bread, potato or rice ; and if we have given it a chance to get thoroughly mixed with these foods before we swallow them, enzyme action continues in the stomach

which like other parts of the food passage makes juices containing other enzymes, some for the digestion of proteins in egg, lean meat and cheese, and others for the digestion of fats.

Real wholemeal bread contains a very good proportion of protein, mineral salts and vitamin A, and is a most valuable food. Wheat germ (the tiny embryo) is included and this is the chief source of vitamin E.

Rest

Fortunately, as long as we keep fit, we need never think about all that is happening, but to keep fit we do need to be sensible over meals, fresh air, work, play and rest. After a large meal we need a rest because it is then that the food passage makes big demands on the blood which carries the oxygen collected by it when flowing through the tiny capillaries in the lungs; consequently after a large meal we often feel sleepy for a little while because the brain has to carry on with rather less blood than usual. In playing a strenuous game of net-ball or any other game *immediately* after dinner we make our muscles demand extra large supplies of blood and thereby reduce the amount reaching the food passage. "After dinner rest awhile", is an old saying, founded on experience and commonsense. At night we need to rest in the most complete way possible by lying down, relaxing and sleeping for many hours on end so that every part and therefore the whole may recover after the varied demands of the day and be equal to the challenge of the morrow. We are fortunate if, while we are in bed we have warmth, fresh air and quietness.

Noise Abatement

By the use of rubber, asbestos and other substances, and by improved designs in machinery, instruments and buildings as in many other ways, needless noise is being reduced.

Trolley-buses are rapidly replacing trams. Tube trains and tracks have been greatly improved in the last two years in London to reduce the noise. Road drills of the latest patterns are not seriously disturbing. Older ones are fitted with silencers. In hospitals and hotels bells are now often replaced by a system of lights, and in the former the up-to-date lifts have self-closing silent doors worked by machinery so exquisitely made that it is almost silent and wears for a correspondingly long time. The law of 1935 prohibiting the use of motor horns after 11 p.m. has proved an immense boon to millions of people and especially the sick. Now in 1939 the Noise Abatement League has prepared a measure for presentation to Parliament which seeks to make it an offence, on pain of suspension of radio-licence, to use a loud speaker loud enough to disturb neighbours. In time, we may have more sleep and sounder sleep, the need for which is very clear.

SUMMARY OF THE CHAPTER

Things to Note

1. Our Homes. Buildings and their sites—Windows and artificial lighting ; larders.
2. Milk—a balanced food. Our diet.
3. Vitamins and mineral salts.
4. Rest and sleep. Noise abatement.

CHAPTER 12

SOME PLANT AND ANIMAL COMMUNITIES

In a country like ours with moderate rainfall and temperature in each season of the year an old stone wall is a good place for the study of a plant and animal community. It is after a severe winter with hard frosts that angular blocks in great numbers are split off from exposed rocks in which there are well-marked joints and cracks. The farmer's work is seriously impeded by scattered blocks and boulders so these are collected into large piles or used in making walls; there is seldom any cement used and one speaks of dry stone walls. It is astonishing to find how long many of them have stood, thanks to the skill of the men who built them, whether on gently undulating ground or very steep hillsides.

Here are a number of suggestions which will help you to study a dry stone wall wherever you may find one:

(1) The county and latitude.

(2) Altitude above sea-level.

(3) Age, if this can be ascertained.

(4) Chief kinds of rock, for example, limestone, sandstone or grit, granite, basalt.

(5) Sources of blocks: for example, from newly worked or old quarries; from inland crags; from the open hillside; from a river bed.

(6) Direction of wall, for example, E. and W. or N. and S.

(7) Height and thickness in feet.

(8) Prevailing winds and average rainfall.

(9) General character of area, for example, pasture, open woodland, mixed farming, partly industrial.

The three aspects of the wall will probably merit separate descriptions. If it extends in an E.–W. direction, it will have a sunny south side and a shaded north side, while if it extends in a N.–S. direction it will almost certainly have a wetter west side and a drier east side. The third aspect is, of course, on the top. For simplicity, we will suppose that the wall chosen for study is never overshadowed by buildings or big trees. Even so, according to the general features of the landscape it may or may not receive the maximum sunlight possible in the particular latitude (Fig 105).

So far there has been no naming of plants or animals but only of some of the many conditions of their existence. Many features of the climate and some of the raw materials of soil will be clearly indicated in the notes you make under the headings given on page 225.

The blocks of rock will now be examined more closely. You may find that without exception they are entirely covered by a curious kind of plant mosaic composed of several sorts of *lichen*; or you may find that what you recognize to be blocks long exposed to the weather are so covered, while others used for repair or coming from a different source, e.g. a nearby newly dug road-cutting are naked; but in time these raw rock surfaces will be mellowed by the slow growth of lichens (Fig. 106). It is

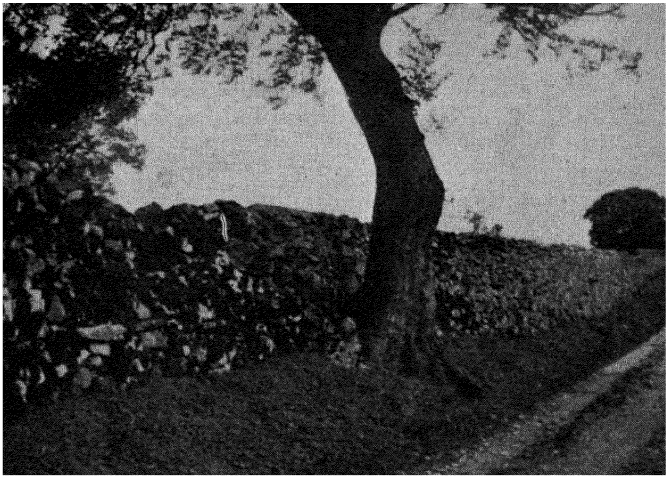


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FIG. 105.

A dry limestone wall, Chapel-le-Dale, Yorks, half covered with green mosses under the Ash but free from mosses elsewhere. July, 1938.

recorded that some of the close-clinging encrusting kinds require at least a century to cover a patch of limestone the size of a penny. These strange plant growths prepare the way for others; in decaying they provide a little humus, and dust lodged in the crevices and cracks together with wind-borne fragments of fallen leaves help to build up a soil; in this some of the countless minute spores of mosses carried by air currents germinate when the moisture content of these small pockets of soil is adequate.

Later, the tiny spores of ferns in a soil to which the mosses in their turn have added humus, germinate and in time give rise to some of the most familiar of our stone-

wall plants. The lichens and mosses can tolerate in a most remarkable way dry winds and scorching sun and yet revive and carry on their life and growth time after time when the moisture of the soil is again sufficient. We find these lowly plants therefore in the most exposed positions while the ferns generally begin life in deep recesses and only when their roots are well established there do they develop fronds which reach out to the full light of the sun. You would find it interesting to take temperature readings within such cool recesses and just outside on a summer day and you could readily gain some idea of the differences in atmospheric humidity by noticing how many minutes were needed for the drying of strips of coloured blotting paper saturated with water, in the two positions.

On the shady side of a stone wall you may find very few seed plants, that is, of course, plants capable of bearing flowers; there may well be quantities of ivy actually binding the wall together, for its numerous *adventitious* roots gain a secure hold, and afford a deep shade and full shelter from wind and frost to the many plants and small creatures, hidden from sight within the wall (Fig. 106).

On the sunny side of such a wall you may find a wealth of herbs, some making it gay with flowers in the early spring while others add richer colours as the months pass. Among these you will often note Ivy-leaved Toadflax, Primroses, Lesser Periwinkle and Herb Robert; the last affords rich colour in its crimson leaf rosette long before the pink flowers are opened; it is a plant which tolerates extreme exposure to the sun even on glaring white chalk slopes or grey limestone scars.

Often on the top of a stone wall you will come across several kinds of stone-crop whose power to store water against the dry days is recognized by the simple tubby form and close crowding of the smooth shiny leaves.

(1)

(2)

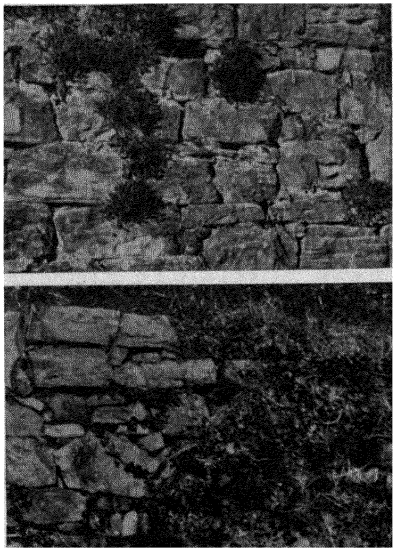

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FIG. 106.

Two dry stone walls less than half a mile apart: 1. South aspect; the only plants are succulent Sedums. Lizards abounded. 2. Westerly aspect, receiving the maximum amount of rain and supporting a wealth of vegetation on the right. On the left the wall had recently been rebuilt.

Monte Bré, above Lugano, Late March, 1938.

Thus far, not one animal has been introduced, but you will recall that a soil worthy the name contains invisible animals; and visible animals are generally present too. An old stone wall is not exceptional, where the soil

pockets are deep and moist you find earthworms, especially between the big blocks just above the ground. You will often notice in spring and summer nests of ants of certain kinds when their activity is at its height. During wet or foggy days the land snails, which have been in hiding, emerge and make long excursions, especially after dusk and their journeys can be tracked by the shiny trail which is left by each. There may be lizards, too, in number, but they will emerge only on sunny days during the middle months of the year and until you have learned to be wary you may never see one but only hear the rustle of dry leaves and the fall of dry soil and crumbling rock, as they swiftly seek and reach safe hiding.

Lizards, together with various spiders, beetles, centipedes and the common wood-lice, are true wall *denizens*. Each finds food and shelter within or on the wall. Some may search for food beyond its confines according to appetite, supplies and weather.

In addition, there are a host of *visitors* at different seasons of the year. Some, like butterflies, hive bees and certain hover-flies come in search of nectar or pollen or both ; it is fascinating to watch the movements of tongue, feelers, wings and feet but very hard to give any description because of their rapidity. It is interesting to note what flowers are visited, whether there is a definite selection or what appears to be random choice on any one journey.

Other visitors to the wall are birds in search of insects and other small creatures, particularly in late spring when hungry nestlings are gaping in readiness for succulent dainties.

Ian M. Thomson

FIG. 107.

A dry stone wall showing a great variety of lichens and a Blue Tit in the act of taking succulent grubs to her hungry nestlings.

There are several familiar birds including Blue Tits and Great Tits, which roost in the crevices of walls and old tree trunks; these as well as many others often build their nests in well concealed places such as a bushy clump of ivy springing from some old wall.

In autumn old nests in such sites as these may be relined and used as larders by harvest mice and dormice. They make little hoards of fruit and seeds. Perhaps they choose more often old birds' nests in hedges; certainly they are more readily noticed in such positions. On a

bitterly cold January day when a sou'wester was blowing hard, the only patch of bright colour in a mile-long hedge of hazel, hawthorn and bramble whose shelter I sought, was the crimson of haws in a neat round bird's nest about four feet from the ground; it had been re-lined with moss by some small mammal.

Many a stone wall is continuous with a hedge though both kinds of boundary are giving place in several counties to concrete or wooden posts supporting endless lines of uninteresting wire which serves for perching but never for nesting or even for roosting. Birds seek shelter elsewhere, insects increase and the crops suffer.

Any old brick walls, especially those bordering a garden or an orchard, are likely to prove full of interest. Some of the cement may have crumbled so that there are recesses and tunnels giving shelter to a variety of creatures both foes and friends of the gardener, and places where shade-loving plants can grow. Very commonly on an old brick wall the Ivy-leaved Toadflax, Wall Pellitory, Snapdragon, Valerian and Wallflower find a secure footing. It is astonishing to see how small a quantity of soil suffices while their roots are undisturbed.

Brick walls, like stone walls, are generally vertical so even at mid-day in late June, when the sun is at its highest, its rays cannot strike with full effect. For many plants this is an advantage. When you visit a rock-garden you will find that many of the slopes have been built with the view of giving the plants the maximum benefit from the sun in early spring which is their flowering season, when a beautiful display is obtained. Among these are many which have large reserves of food materials underground in bulbs, corms or rhizomes.

Colonizing New Soil

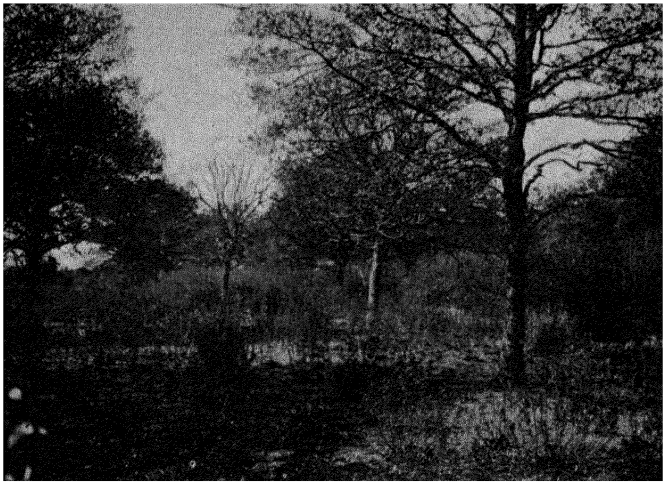
Let us turn now to an entirely different kind of setting, one in which we can watch the colonization of a new land surface, very possibly in a town area. Wherever gravel deposits are being worked we are likely to find a sifting apparatus at work ; this grades the material according to the ways in which it will be used, whether for building, for gravel paths or any other purpose. A constant stream of water is played on the finer sediment often rich in iron oxide and chalk and this is directed to a part of the pit where no further excavation is likely to be made. This raw sediment settles and is drained. It now offers an entirely new surface, devoid of any plants except perhaps some invisibly small ones which were present in the water. This local desert, a desert in the truest sense for a short time, is soon invaded : minute air-borne spores of lowly green and blue green plants, known as *algae*, are likely to germinate on settling, and in a few weeks we may find all the shallow pockets in this biscuit-coloured sediment coated thinly with a weft of fine green threads. A few weeks later, if the weather has been favourable, we are likely to come across the small star-like forms of certain *mosses*. Now, or later, various *lichens* appear. The growth and decay of these lowly plants yields humus, so that soon there is a soil extremely thin but affording all that is needed for the germination of such *seed plants* as grasses, Tormentil, certain speedwells, Coltsfoot and thistles ; several of these herbs have seeds well adapted for air transport. Their growth and decay yield more humus and the soil becomes deeper and more stable through the binding action of roots. By now it will

certainly be peopled by invisibly small animals and possibly by insect larvae and others which we can recognize. Birds, for example Goldfinches, will delight in the thistle heads. Other bird visitors may drop the undigested seeds of Hawthorn and the first tree seedlings with well established roots, far longer than the shoot, may be seen within two years of the foundation of this new colony.

In time, if there is no interference, the vegetation will become completely *closed* and a veritable thicket in which Hawthorn, Dog-rose and Bramble combine to give shade to the lesser plants as well as food and safe hiding to a variety of creatures both residents and visitors, will mark the site of the particular patch of gravel washing with which we started. Fifteen or twenty years will certainly suffice. Often, however, at the end of such a period when the deposit has settled and become stable enough with the help of the now deeply rooted shrubs and trees, the site may be offered in plots for building. The record then comes to an end.

Woods

Yet it gives a very clear notion of the *succession of plants* beginning with the lowliest in structure as in stature and ending with a diversity of plants most of which are seed-bearing ; among these some will have reached tree height. When you next walk through a wood or a true forest where towering trees dwarf all the lesser plants, and where last autumn's rustling leaves cover a deep leaf mould always moist, think back a hundred years or more to a time when these same trees were seedlings. There has been a remarkable sequence or succession of events



M. Munro

FIG. 108.

A Coppice on a lower slope of the South Downs near Goodwood. The trees are Oaks. The Hazel had been coppiced in the previous year; there is light enough for herbs to flower.

whether it began with grassland a century back or in far more distant pre-historic times.

There remains in Gloucestershire to this day the truly ancient Forest of Dean with oaks in magnificent condition. In turn some of these great trees in their prime must be marked by the forester, sold and felled; the bark will go to a tannery and the timber to a yard where in time it will become fully seasoned and ready for use. It is a strange and searching experience to watch the preparations for felling a great tree, to see its fall and hear the crash of the branches and the tearing of a fraction of the trunk near its base. Felling and bark-stripping are

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FIG. 109.

A well grown Oak felled while the sap was rising rapidly, in May. Tan (bark) flawing is in progress. A copse near Chichester.

generally done in May, when the sap is ascending rapidly and when saplings, held back till then by shade, take advantage of the clearing (Fig. 109). In them lies the promise of the completion of another chapter in the history of the Forest.

In a large *coppice*, for example one of a hundred acres, each year a fraction of the whole may be cut. The woody plants such as Hazel, Ash, Silver Birch and Sweet Chestnut are cut back once in ten or fifteen years, generally before they have reached tree-height, that is, twenty feet. After each cutting or coppicing, a many-branched stump is left. These stumps, which are known as stools, reveal clearly in their *annual rings* of wood the age of the branches

when the woodman cut them down with a keen-edged implement which leaves the section smooth.

You can imagine the contrast between two successive springs, one preceding and one following the autumn coppicing. Flowering herbs such as Wood Anemone, Primrose, Bugle and Dog Violets, which for some nine to fourteen years had been deprived of full lighting are suddenly treated to all the sun there is. Herbs which for several years had developed foliage only, and that of a quality suited to deep shade, may develop flowers in abundance. Once more the floor of the coppice has a gaily chequered carpet. The flowers attract insects, pollination is achieved, seed is set and scattered and in the next spring, before the woody plants with their vigorous new growth come into leaf, there may be a carpet still more gay as in the scene depicted on p. 235.

It will be many years before this particular fraction of the coppice, a few acres in extent, is so colourful again if the general rule as to the interval of years between one coppicing and the next is kept.

You can, of course, study in any one year different areas of the same coppice which are in different phases, for example, one year, two years, four years and eight years after the last coppicing, and tabulate your findings.

Many changes besides those referred to above would come to light, some involving lower plants, especially mosses and fungi, others involving animal life. The Hazels for instance might produce nuts, attracting certain birds such as Nut Hatch, also Red Squirrels and Dormice some nine or ten years after the last coppicing ; these animals will have sought food elsewhere while these particular hazels were not bearing fruit.

Much time and fairly fine weather are needed for outdoor studies such as those suggested in this chapter, for newly floored corners of gravel pits and for coppices. But failing a gravel pit, a gravel path even if it is well weeded, is worth study; equally, a small lawn or a

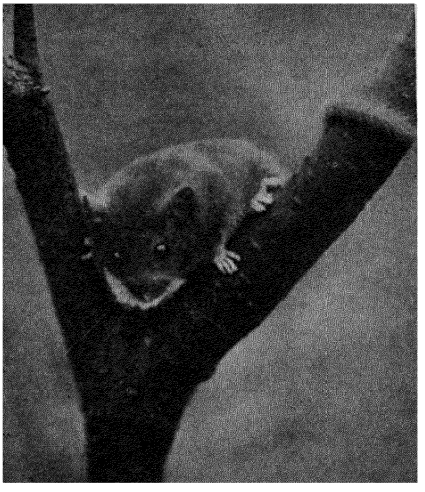


FIG. 110.
A DORMOUSE.
The hairy tail is seen on the right.

solitary tree will prove interesting to watch, and the older these are the better.

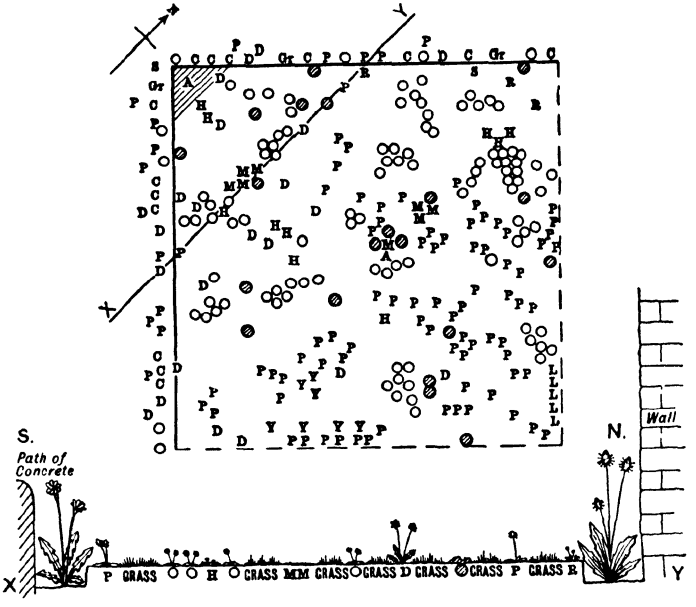
Lawns

The ideal lawn results from the healthy development of absolutely reliable lawn seed sown thickly in thoroughly prepared soil at the right time of year. If you watch

the making of a bowling-green you gain some idea of the time and care that is given to ensure a dense, even growth of grass which may be likened to velvet, with good drainage and entirely free from weeds. Similar care is devoted to tennis lawns and golf courses, though some are made of selected sods of turf taken from the Downs where sheep have grazed for ages. According to the weather there must be watering, mowing, rolling, sanding; on occasion, finely sifted nutritious fertilizers are spread as evenly as possible. Some people employ Guinea Pigs instead of mowing machines on their lawns and thereby avoid all ruts; they serve as measuring agents too.

Among the loveliest lawns to be seen are those in the gardens of many of the old Colleges in Oxford and Cambridge. It is reported that a visitor, from a country where the winters are so severe that no lawn can survive them, asked a gardener how these wonderful lawns were made. This was his answer: "You just rolls and mows and waters." The visitor asked if that were all. The gardener replied: "You just goes on like that for three hundred years or so."

The histories of some of our beautiful lawns, across which long shadows trace an ever changing pattern when the sun is low and the branches of some ancient tree sway in the wind, date from the seventeenth century. But what is the age of the oldest constituent grass plant in any one of these famous lawns? By a very simple device you can find the answer to the same question applied to any lawn but probably the one you study will be much less ancient and much less free from intruding weeds. In fact we shall be content to study a small lawn rather new and somewhat neglected (Fig. 111).



Fl. *In Flower* *Fr.* *In Fruit*
P *Ribwort Plantain; a few Fl.*
,, Fr.
R *Creeping Buttercup*
D *Dandelion; a few Fl., a few Fr.*
H *Hawkweed; a few Fl.*
Y *Yarrow or Milfoil*
O *Common Daisy; a few Fl.*
S *Scarlet Pimpernel*
Gr. *Groundsel; Fl.*
C *Hairy Rock cress*
L *Clover*
Unmarked areas occupied by grass
Bare sandy patch
M *Small mosses & bare soil*
A *Ants - small, yellow*
Worm casts
Edge of Lawn
Soil level in Section XY

FIG. 111.

Perhaps the best way of showing what we find is to make one or more quadrats using squared paper and letting one square inch represent an area 9 or 16 times as large so that most of the plants in a square half yard of lawn can be plotted on a page of an ordinary notebook.

The corners of each quadrat are marked in a way likely to be permanent, yet without causing trouble to the person who looks after the lawn, for example, by wooden pegs. Observations can be made monthly or twice a term. If continued for three years much will be learned. At the outset mark a few of the individual grass plants, Annual Meadow Grass (*Poa annua*), with small wire loops or their equivalents and watch them with particular care. A square metre, in September, is shown.

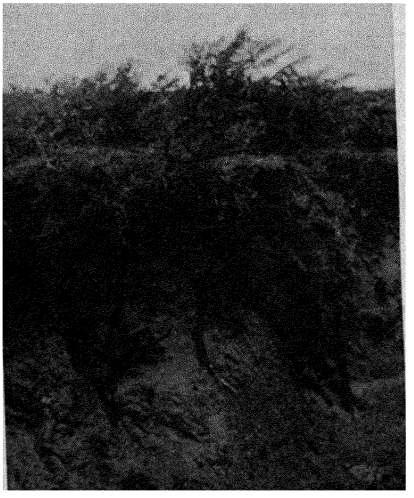
The rooting systems and other underground parts of the different kinds of plants should be studied, if possible, in a corner of the lawn but not within a quadrat. Actual plants could be removed, washed free from soil, dried, pressed and mounted in relation to a line which would represent ground level. Here would be a good opportunity of seeing the larger animals present in the soil and some of their activities.

Dates of mowing, rolling and watering can all be inserted on the left side of a calendar and weather notes on the right. Then the plans of any one quadrat for successive dates in the year can be read in a context which makes them meaningful. Naturally, plans of quadrats made just before mowing and rolling will be more interesting than those made just afterwards but in our neglected lawn this event will be infrequent.

Prominent among the animals of the lawn are earthworms whose activity, especially during warm moist nights will cover some small plants completely and render the task of plotting rather difficult. To gain some idea of the amount of work done by earthworms you can remove all the castings from one quadrat at frequent intervals, weigh them, dry them and weigh them again.

You can also remove the leaves which have been drawn part way into burrows, and treat them similarly.

In warm dry weather you are likely to encounter a colony of Yellow Meadow Ants or some other kind, ceaselessly busy in fetching and moving eggs, grubs, food



M. Munro

FIG. 112.

On a light sandy soil Bracken often thrives. The underground stems in this road-side cutting are three and four feet long. This fern continually invades the turf of the adjacent golf course. Pennard, S.W. Wales.

or building materials. These insects are amazingly active and can be watched very closely, for unless disturbed they carry on as though no one were near, and when disturbed their activities are greater.

It is interesting when larger areas than square half yard quadrats can be studied to keep one, say *A*, as free from

weeds as possible and let the grass compete with all invaders in the others, *B* and *C*.

In *A* we shall try to remove the roots and underground stems of weeds completely before any seeds are ripe. Failing such satisfactory weeding, during very dry weather it may be, we shall certainly try to remove flower heads and fruits, taking care not to scatter any seeds or fruits, whether of Ribwort Plantain, Dandelion, or Milfoil to name three among the worst offenders. The last, Milfoil, is likely to be the most difficult to get rid of; its underground stems may traverse the soil in a close network, five or six layers deep. Nothing short of thorough digging and wholesale destruction will serve.

A Tree

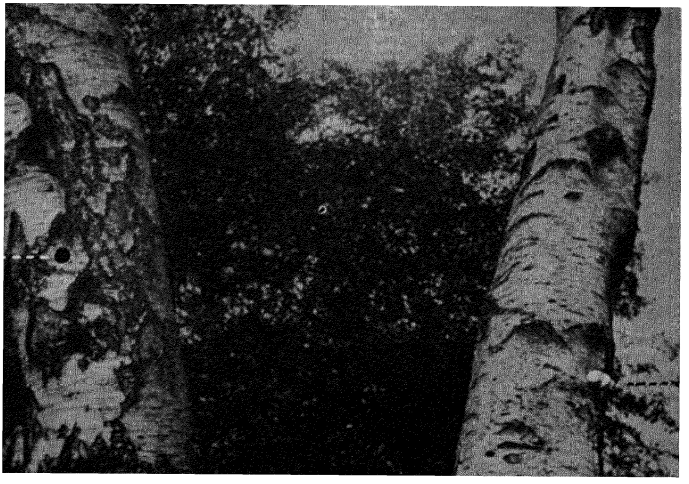
In some ways a lawn is less attractive as a subject for study than a tree. Think for a minute of the things that happen in spring, summer, autumn and winter, by day and at night in some old elm, ash, oak or beech which you know about already. You may be sure that this is but a tiny fraction of all that happens in the life of the tree itself, the plants that cling to it without causing injury, the diseases it has to resist, the birds, bats and squirrels which it may shelter and for which it provides food.

A complete study of this kind has, I think, never been made. The particular kind of tree chosen here for study is the Silver Birch because it has a very wide range in this country. The older it is the better; you can judge the age by measuring the girth of the trunk at shoulder height; when the chance occurs, count the annual rings of wood in a felled branch of the same girth. It may be so tall that

from the ground you cannot see the crown in detail but you can calculate the height of another of about the same diameter and in the same district. The record can be illustrated by (1) photographs of the tree as a whole in different seasons but always from the same point; (2) pencil drawings (with notes on the colours) of twigs bearing leaf-buds, the large pollen-bearing catkins in groups of 2, 3 or 4 and the smaller, less obvious ovule-bearing catkins. These last become particularly attractive after the seed has set and the tiny two-winged fruits, packed securely and regularly among the minute three-fingered scales called *bracts*, are ready for dispersal. (3) Pencil sketches or rubbings of parts of the bark in three different regions, (*a*) a slender young branch whose colour is still a deep copper-red or reddish-brown; (*b*) a thicker, older branch in which the bark is silvery white; (*c*) a still thicker and much older branch, or the base of the trunk in which the bark is deeply furrowed.

Transition regions between (*a*) and (*b*), and (*b*) and (*c*) deserve close study. Notice the distribution of a powder-like green alga and mosses in relation to aspect and dripping water.

If the Silver Birch has one limb injured, by lopping or the fall of a neighbouring tree in the first instance, it may be attacked by a bracket fungus called *Polyporus Betulinus*. From such a branch some of the bark can be stripped and examined closely in thin papery layers. The lenticels are oval and very long from left to right. This fungus grows slowly; it is parasitic on the decaying wood which becomes more rotten year by year. Often in a diseased branch such as this there are one or more deep round holes high up, and on the ground hundreds of chips of



M. Munro

FIG. 113.

A Silver Birch: hole of greater spotted Wood-pecker at H; fungus (*Polyporus Betulinus*) at F is still small. Tooting Graveney Common, S.W. London, October, 1938.

the cream-coloured rotten wood. If you cover these with some soil and return within a few days you can judge whether the excavating is going on. You may be fortunate enough to see the bird, the Greater Spotted Woodpecker on this tree or close at hand. Its length is 9½ in. and its colours black and white with scarlet on the lower part of the body near the tail; the cock bird has a scarlet spot on the nape. In summer this bird seeks the grubs (larvae) of wood-boring insects, for example moths and beetles, and also bark beetles and their grubs. The nesting hole may be a foot deep, but only the small neat round entrance can be seen.

Many birds visit the Silver Birch for minute insects: throughout the year, tits of several kinds, readily recognized by their acrobatic movements, and in the summer, some of the migrant warblers may often be seen in parties, working without ceasing along the twigs. Birds devour countless insects which escape our eyes, and the small fruits clustered in the catkins when these are ripe.

The twigs of the Silver Birch are remarkably flexible, responding to the lightest breezes and drooping under the weight of the least of our birds. You can tie bows without making these twigs snap; this quality of flexibility must surely help it to remain intact during gales, when other trees lose great numbers of their twigs and even quite large branches. The Silver Birch is common in many of the wildest parts of Scotland where few other trees are seen. It seems to tolerate not only violent winds but also poor, acid soils (see frontispiece). In some woods and commons you find certain fungi, e.g. the Fly Agaric, its brilliant scarlet cap, when well-grown, bearing irregular flecks of its white sheathing layer, under the Silver Birches rather than elsewhere.

These trees, like others, depend in an intimate way on the work of particular fungi; we recognize them readily when their spore-laden caps rise above the soil, but these toadstools are linked with fine strands which cling to the rootlets of the tree and help it to thrive.

Unlike the bracket fungus, attacking the branches as a parasite, the Fly Agaric is a helpful and indeed a necessary partner of the Silver Birch. As the name suggests it is attractive to certain flies which lay their eggs in the fleshy parts; there they develop, in the course of a few

days, into grubs which feed on the toadstool, hastening its decay. Other kinds of fungi and bacteria help to finish the work and in time the soil is enriched in this way. The decay of the leaves of the Silver Birch which remain under its branches is also brought about by the work of

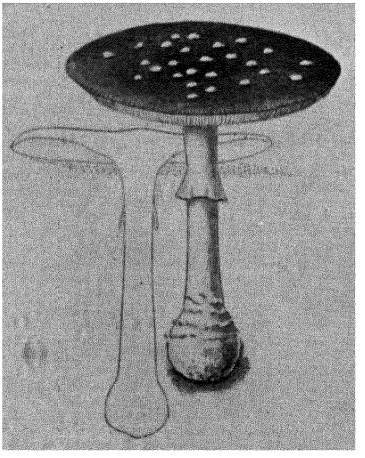


FIG. 114.

Fly Agaric showing irregular white flecks on the cap (scarlet in life), radiating gills, the stipe with a ring (*annulus*) and at the base the universal veil (*volva*), which was continued right over the cap when this was small, and the stipe short.

other fungi and bacteria. In these several ways those things which the *living* tree had collected and used for its growth are put back into the soil and the air, and made available once more. Though the tree perishes, seedlings take its place. Here is a tale which has no ending.

Directions given for setting up an aquarium will have suggested to you ways of studying a pond in the open :

even when a pond dries up during a prolonged hot dry spell, scrapings of the mud from the centre and two different levels above the centre, if put in three bowls of water will soon yield three groups of small active animals as well as green plants which, when threatened by desiccation had *encysted* themselves or made other safe provision.

In the pond as in the few well-marked *environments* which you have studied, the plants and animals dwelling there together constitute a *community*. Each member is dependent on other members, yet each lives its own distinctive and individual life, whether brief or long.

SUMMARY OF THE CHAPTER

Things to Note

1. Ways of studying groups of plants and animals which dwell together in different environments.
2. Old Walls; gravel pits; woods; lawns; trees.
3. The colonizing of new surfaces.
4. The succession of forms as conditions change in a coppice.
5. Life in a community.

APPENDIX I

SOME TYPICAL FOOD STUDIES

Food of Ring Dove or Wood Pigeon

(Varies with supplies available)

January - - Marked preferences not noted. Bread taken eagerly; animal food when the ground is soft.

Early February - Elm flowers exclusively, to judge by contents of crop, on some days.

Late February - Pollen catkins of Alder.

Early March - Pollen catkins of Black Poplar.

Late in March - Plump flower buds of Lilac. Plane catkins.

April - - Young leaves of Ash, Beech and Oak.

May - - - Caterpillars of moths which feed on

June - - - foliage of trees, clover leaves.

Summer - - Slugs; various insects and grass tops. Seeds of Charlock and Ragwort. Leaves of young vegetables, small potatoes. Grain in large quantity.

Autumn and Winter - - Beech mast, haws, Ivy and many other berries; Acorns in vast numbers. Animal food when ground is soft. Grass.

Based on observation of living birds and the crops of a few dead ones.

Food of Black-headed Gull

Follows plough and takes many leather jackets (larvae of Daddy-long-legs), and wire-worms (larvae of Click-beetle),

but also harmless insects and earth-worms. Large numbers of birds gather on football grounds in winter where grass is thin or absent ; they feed eagerly, probably on animal life and especially worms. Catch May Fly and Crane Flies.

The good done by these gulls far outweighs the harm.

At the coast small marine animals are sought in shallow water, bare tidal muds, and marshes. These gulls are poor fishers, lacking speed and diving skill.

Food of Mallard

The Wild Duck generally feeds at night. From the mud and water it sifts small animals and bits of plants. It collects cockles and other molluscs from sand between tides ; on land it takes worms, snails, slugs and insects ; grain, acorns, ripe blackberries and the seeds of some saltmarsh plants are also eaten.

Food of Herring

The chief food consists of the minute plants and animals which float in the surface water and together are called the *Plankton* ; the herring goes forward with its mouth open. In addition it takes small crustaceans, including a few young crabs and lobsters, small many-bristled sea worms, the young of molluscs and jellyfish, young sand eels, and, on occasion, young herrings.

Food of Cod	Contents of stomach examined.
Lobsters, crabs and other crustaceans occur in	83 per cent.
Fishes in	35 ,,
Many bristled worms in	16 ,,
Molluscs, especially whelks in	9 ,,

Information from Natural History Museum (London) exhibits, 1938. In Fish Gallery.

Food of Trout up to 15 inches long

Lake Windermere.

October-February.

The permanent animal population at bottom, especially the water slater, shrimp and snails. In November eggs of char in great numbers.

March-July.

The temporary animal population at bottom, especially insect larvae and pupae.

May-September.

Surface food, chiefly insects, many of which fall on to the water.

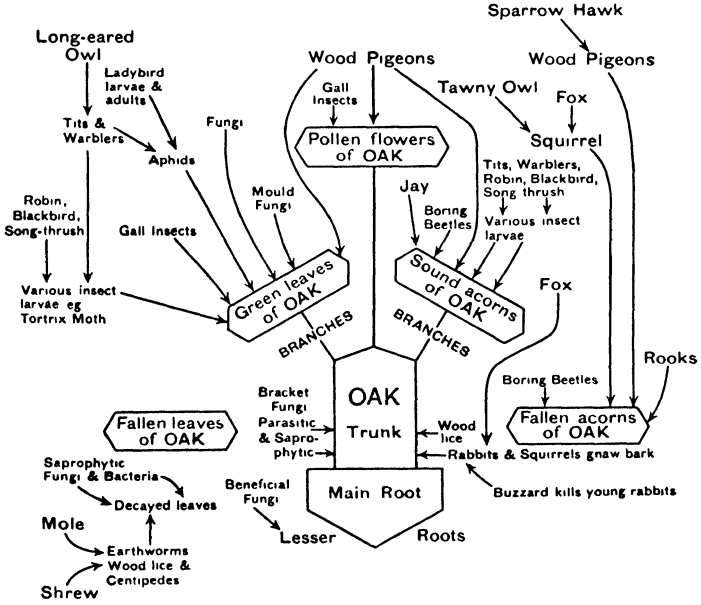


FIG. 115.

The enemies of the Oak are in turn attacked.

APPENDIX II

AIDS TO OUT-DOOR STUDY

Description of a Bird

NAME :

Sex, or age, or both.

For all activities give dates throughout.

State general locality and climate.

Length in inches of

Whole bird ;

Beak only ;

Tail only.

Sketch of bird in side view.

Colour of plumage on

Head ;

Throat ;

Breast ;

Back ;

Rump ;

Tail ;

Wings ;

Colours of feet and beak.

Habits :

e.g. Solitary or gregarious.

Where seen when flying.

Roosting site.

Preening ground.

Feeding place.
Drinking place.
Nesting site.

Locomotion :

Mode of flight.
Gait on ground.
Mode of swimming.
Diving or
Up-ending.

Chief food at different seasons.

Call on different occasions, e.g. when alarmed, song or fighting. Song at different hours and seasons.

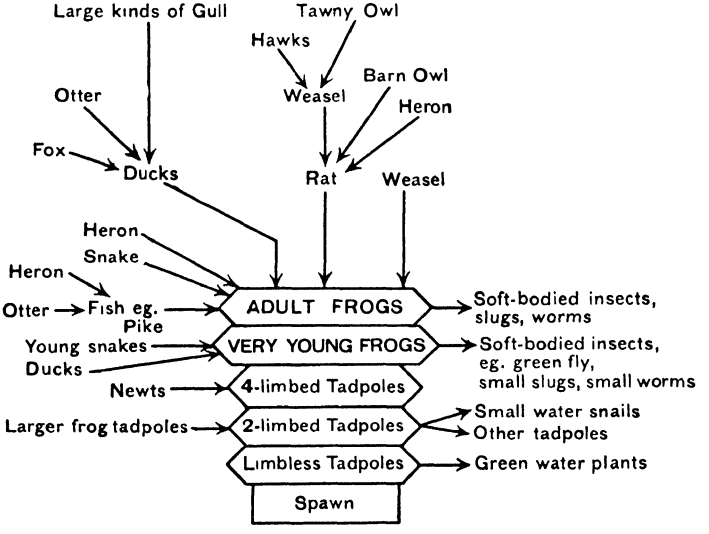


FIG. 116.

The Common Frog have many animal enemies which in turn are preyed on by others.

Description of a Tree

NAME :

Give dates throughout.
State general locality and climate.
Soil.
Site.

Stature. Height.
Girth of trunk at 5 feet above ground.
Span of branches.
Span of visible roots.

Bark character of trunk and main branches	where diameter is	Take bark rubbings.
	3 inches	,,
	6 ,,	,,
	1 foot	,,
	2 feet	,,
	4 ,,	,,
	6 ,,	,,

Arrangement of twigs and of leaves in whose axils they arise.

Leaf Buds size, form, colour, texture.
Flower Buds appearance and distribution on twigs. } Sketches.

Foliage typical at different seasons to be pressed and mounted to indicate changes in size, thickness and colour.

Flowers ; possibly of two kinds. Press and mount.

Fruit and Seeds } size, form, colour, surface texture.

Seedling in year of germination.

Young plant in second year.
,, ,, third year. } Follow suggestions given above and describe root as well.

Young sapling.
Older sapling. } Follow suggestions for study of tree. Calculate age at which flowers first appear and age at which fruit sets.

Photograph the whole tree from the same spot when it is in full leaf and when (if ever) it is bare.

List the kinds of tree seedlings, herbs and other plants, including the fungi which you see beneath the tree in spring and in autumn.

List the plants, other than parasites, which are attached to the tree. Notice whether they flourish more on south than north, or on west rather than east faces of trunk and branches, e.g. mosses and lichens.

Description of a Mammal

NAME :

Sex, or age, or both if known.

Approximate length in inches of

Whole animal when at rest ;
Head without ears ;
Ears alone ;
Neck ;
Body ;
Tail ;
Fore foot ;
Hind foot.

General locality.

Detail for places where it is most often seen.

Sketch of animal in side view.

Eyes : size and position.

Colour of coat of

Head ;
Back ;
Throat ;
Underparts ;
Tail ;
Feet.

Gait when unhurried.

Gait when seeking safety.

Notes on fore limbs
and hind limbs.

Positions of body when feeding.
" " " drinking.
" " " resting but awake.
" " " sleeping.

Care of young.
Training of young to fend for themselves.
Family life, if observed.
Chief kinds of food at different seasons.
Damage done, if serious.
Good done, if known.
Chief natural enemies.
Evidence of { keen scent. / " hearing. / " sight. / good sense of touch.
Notes on voice, if heard, e.g. when alarmed, when injured.

Descriptions of Common Plants and Animals.

A. Woody with leaves simple, evergreen, prickly and arranged in a spiral on twig. Fruit scarlet. Up to 30 feet.

B. Total length about 16 inches, tail very long, colour of fur ruddy brown; holds food in forepaws; builds nest of leafy twigs in tall trees; gnaws bark.

C. Width about two and a half inches; has two pairs of large white wings marked with a few black spots, feelers long and knobbed at tip. Sucks up nectar from flowers with its long coiled proboscis. Seen in late spring and summer.

Can you tell what *A*, *B*, *C* are? Can you give descriptions of other familiar plants and animals as brief as these but good enough for your schoolfellows to identify?

ONE HUNDRED QUESTIONS

THESE questions will test your knowledge of the work you have done and of the books you have read. When you find one that you cannot answer, make a point of revising the work by first-hand study and by consulting reference books.

1. State some of the ways in which plants and animals resemble one another.

2. What are the chief necessities of life?

3. What is the importance of oxygen to animals and plants?

4. What is the special work of chlorophyll?

5. In what ways is sugar unlike starch?

6. Name one or more substances which readily absorb oxygen from the air, and a few substances which readily combine with carbon dioxide.

7. With what parts of their bodies do these animals breathe: (*a*) Human beings; (*b*) cats; (*c*) sparrows; (*d*) cod; (*e*) gold-fish; (*f*) newt; (*g*) snake?

8. What do you know about the process called respiration?

9. Find out the approximate ages of (*a*) some long-lived animals when you next visit a zoo, and (*b*) some great trees when you visit a timber-yard, forest, botanical garden, or museum, by direct observation.

10. How long is Midsummer day in (*a*) London; (*b*) Hungerford; (*c*) Newcastle; (*d*) Carlisle?

What is the length of the night in these same four places on March 21st?

11. What do you know about (*a*) the houses in which

humming-birds are kept at the London Zoo ; (*b*) their native country?

12. What are some of the advantages of a card-index record for (*a*) books in a library ; (*b*) natural history notes?

13. In which week in the year does the shortest day occur (*a*) in London ; (*b*) in Newcastle?

What are the lengths of this day in the two places?

14. What aspect would you choose in our country for (*a*) a breakfast room ; (*b*) a general living room ; (*c*) a toddlers' nursery ; (*d*) a florist's shop? Give your reasons.

15. If you had an orchard in an exposed part of the country, *i.e.* without natural shelter from severe gales, on which side would you plant a wind screen?

Why are Lombardy poplars and Mediterranean cypresses often used together for wind screens?

16. How is it that the shadows cast during a sunny day by a vertical post on a horizontal floor are equal in length at 10 a.m. and 2 p.m. but have different positions?

17. What is the value of (*a*) picking wild flowers from shady places, and (*b*) wrapping them up with damp moss in large leaves?

18. What is one reason for removing the lower leaves from marguerites, stocks and similar flowers before putting them in water?

19. What are the general effects of (*a*) draughts, and (*b*) hot air, on cut flowers in vases?

20. Draw in profile (or in lengthways section) vases or jars suitable for (*a*) small wild flowers, *e.g.* Lesser Celandine, and (*b*) buttercups and other tall meadow flowers.

21. What do you know about (*a*) the pith of the stems of Elder, and (*b*) the tissue called cambium in the same plant?

22. What are some of the chief characters of cork? What are the chief uses of cork in our homes?

23. Name six or more different tissues which are present in each of your fingers and toes.

24. How do these animals guard themselves against the risk of being desiccated: (*a*) Earthworm; (*b*) Garden Snail, (*c*) Lung Fish?

25. During respiration all animals and plants get rid of an excess of a particular gas. Name this and explain how it may be collected and tested (*a*) when green land plants are growing; (*b*) when seeds are germinating in air.

26. How can you show that it is the *oxygen* in the air which is required by living plants if their growth is to be satisfactory?

27. What is anaerobic respiration? Describe briefly a method of showing that it takes place.

28. What are Fungi? Name three or more kinds of Fungi. What is yeast? Name two chief kinds of yeast.

29. What do you know about fermentation?

30. Give a simple definition of enzymes and one or more examples.

31. In what chief ways do lungs resemble gills? What is the chief difference between them?

32. All animals and plants use oxygen in respiration. How is it that there is a sufficient supply of this year after year?

33. What is haemoglobin? Where is it found? What is its chief work in the body?

34. How do insects obtain the oxygen they need in the innermost parts of their bodies?

35. Give the approximate composition of fresh air (which is a mixture of four gases mentioned in this book, together with other gases in small amounts. Disregard the latter).

36. State concisely how you have shown that green plants in sunlight can manufacture sugar and then make starch,

when carbon dioxide is available, but not when this gas is absent.

37. Why is it important to use plants with variegated leaves for the experiments referred to in the previous question?

38. Make a list of the chief conditions required by a living plant for photosynthesis.

39. How have you shown that green water-plants give off oxygen while they are carrying out photosynthesis?

40. In a green plant, during the day, which is the more active process, respiration or photosynthesis? Give reasons for your answer.

41. Give the formula for a complete food solution for green plants deprived of soil.

42. How can you make a simple mechanical analysis of soil? What are the six chief constituents of a soil, e.g. loam? What is the chief value to the farmer of growing leguminous crops?

43. Watch the feeding habits of a number of birds and a number of other back-boned animals, both young and adult in each group. How did they use their beaks, lips, jaws, teeth or tongues?

44. Can you explain why many long-lived plants store large quantities of food reserves while most long-lived animals do not?

45. Why is it important for us to masticate starchy foods? What is the work of the saliva?

46. When our food has been changed into simpler substances by the action of various juices which are poured into the food passage, how are they distributed to all the different tissues of the body?

47. How is respiration important in connection with the growth and repair of the body of an animal?

48. In what different ways does water pass out of our bodies?

49. Explain these three terms very briefly : feeding, digesting, assimilating.

50. What is cross-pollination? What is self-pollination?

51. In what ways are seeds different from ovules?

52. Make a list of the plants mentioned in Chapter VII which are dicœcious. What kind of pollination occurs in them?

53. Watch one Butterfly or one Honey Bee for two minutes or longer when it is collecting nectar. How many different flowers are visited? Are they all of one kind? Answer the same questions for a honey bee which is collecting pollen. Try to name the butterfly you watch.

54. Write down an average number of babies born at one time to a sow, a tigress, a mother elephant, a ewe, a mother kangaroo.

55. Study every third flower in a raceme of Foxglove, Snapdragon, Bluebell or Wallflower, beginning with the youngest. Then describe how the oldest flower has developed as far as you can judge.

56. To which of the five groups named in Note 3 at end of Chapter VII do these animals belong :

Cat	Skate	Penguin	Tortoise
Toad	Horse	Cod	Swan
Wolf	Giraffe	Parrot	Adder?

57. Give examples of parental care among birds from (*a*) your own observation ; (*b*) your general reading and study of photographs.

58. From the same two sources give examples of parental care (*a*) among domesticated mammals, (*b*) wild mammals, and (*c*) cold-blooded animals.

59. What is an average number of eggs laid by each of these animals at one time :

Female Herring
Female Frog
Female Adder
Hen House Sparrow
Mallard Duck, Mute Swan?

60. In what ways does the Brown Hare differ from the Rabbit? In what ways are the two animals similar?

61. How does a House Spider's activity differ from that of the Garden Spider?

62. What is the meaning of the term *Camouflage*? Think of good natural backgrounds for a Fallow Deer, Brown Hare, Partridge, Mallard Duck, Skylark, Common Toad, Plaice, Shrimp and Looper Caterpillar and write them down.

63. What activities have you noticed during *one* day (when you had plenty of time to watch) for each of these or other birds: a Robin, a Wood-pigeon, a Starling?

64. What plants in your district have flowered in January? Include garden plants, both herbs and trees, and also weeds. Continue your record for February and March. Carry it on in a second year. Collect weather records from weekly or daily papers for the periods in question.

65. In late summer or early autumn on a dry day collect the seeds of Bluebell, Primrose and Foxglove in separate envelopes, bearing date, place and name of plant. When you have prepared a bed, plant these seeds and keep a record of their germination.

66. Explain what you understand by these terms : *Rowing*, *Punting*.

What animals which you have watched may be said to *row* (*a*) through water and (*b*) through air?

67. Give a simple definition of a machine, a lever, a pump and a bellows.

68. Why is a comparison made between a muscle and a steam engine? In what chief ways are they different?

69. Name a few different forms of energy and give an example of each.

70. Explain what happens (*a*) when a Limpet clings closely to a smooth rock, (*b*) when it lifts its shell and moves forward.

In summer Limpets in a pool of sea-water often proceed at a rate of an inch in 1½ minutes. What is the rate in yards per hour?

71. What three groups of animals are capable of true flight? Name some of the fastest in each group.

72. What happens when a bird or other animal *glides*?

73. Name some birds which you have seen *soaring*. Try to describe for one occasion the path through the air and the kind of weather, with date and place.

74. Watch a bird coming to rest on water. How is the *braking* carried out?

75. On the basis of the figures quoted in Chapter X work out the speed in yards per minute of a Swift in air, a Greyhound and man on land, Trout and man in water.

76. A small humming-bird when hovering beats the air with its wings 60 times a second. How many wing beats will there be in half-a-minute?

77. What does this expression mean :

"A well-balanced aquarium"?

78. What reasons are given (*a*) for washing water-plants thoroughly, (*b*) for providing a light screen, and (*c*) using a dust excluder when setting up an aquarium?

79. What kinds of food are eaten by (*a*) Pond Snails, (*b*) Water Slaters, (*c*) Leeches?

80. Why is a little water added frequently and by means of a sprinkler to aquaria?

81. What is meant by the term *metamorphosis*? In what animals have you watched this process? For one of them give a full account.

82. State briefly what you know about the aeration of the tanks in the Aquarium at the Zoo in London or elsewhere.

83. Try to find out the sizes of some of the big Antelope or Zebra paddocks at a Zoo (*a*) by studying a plan with a scale of yards or (*b*) by pacing and making rough calculations.

84. U.F.A.W. recommend for pets' hutches a length at least four times that of the animal's body. What area do you suggest for (*a*) a tame Rabbit, (*b*) a Guinea Pig?

85. In what special ways have captive Chimpanzees been cared for in this country?

86. Name a few of our native mammals and birds which are nocturnal though they are occasionally seen by day.

87. What is meant by " the aspect of a room " ? What is the best aspect for a larder?

88. What are the chief advantages of the windows shown in Fig. 101? Are there any disadvantages? (Ignore costs.)

89. In what way may butter and milk be kept at a temperature lower than that of the air where they are stored?

90. How can we keep flies away from a living-room or kitchen? Why is it important to do so?

91. What are some of the ways by which we can take care of our eyes (*a*) at home, (*b*) elsewhere?

92. What are the chief carbohydrates? Besides these, what other food constituents do we need in our diet so that we have good, *complete* meals?

93. What proof have you that milk alone is a well-balanced food?

94. In what ways is rubber used to reduce noise (*a*) in the streets, and (*b*) inside buildings.

What materials besides rubber serve to reduce noise and also serve as shock-absorbers?

95. For your school give the name of the County and state the subsoil on which it is built,

the latitude,
the altitude above mean sea-level,
the distance from the sea,
the annual rainfall,
the source of the water supply.

96. On the farms near your school what crops are grown and what animals are reared?

97. What kinds of woodland occur in the neighbourhood of your home? Describe one kind of tree as it appears at different seasons and at different ages.

98. Select one arable field for study. What kind of soil occurs in it? What crop is being grown this year? What crop was in the same field last year and in the year before that? What are the principal weeds?

99. What kinds of food are given, (*a*) in summer, and (*b*) in winter, to cattle, sheep, pigs and poultry on the farm nearest to your home or your school?

100. What insect pests are common (*a*) on field crops, and (*b*) in orchards in your district?

How do farmers and gardeners try to control them?

GLOSSARY

abdomen. The lower cavity of the body, i.e. below (or behind) the diaphragm, in *mammal.* The rear part of body in insects, spiders, prawns, etc.

adventitious. Applied to roots which like those of Ivy, Crocus and Iris arise from *stems* in large numbers.

aerobic. Living and growing only in the presence of free oxygen whether of the air or dissolved in water.

aestivate. Spend the summer in a state of torpor or dormancy.

alimentary canal. The whole passage through the body by which food is received and digested.

anaerobic. Capable of living without air.

annual plants typically pass through the whole of their lives from seed to seed within the space of a *year.*

annual rings. Concentric rings of wood (xylem) laid down by the active cambium in woody plants, one each *year.*

antipodes. Region of earth far distant from us *opposite* our *feet.*

aroma. Distinctive fragrance of a plant.

artery. A blood vessel carrying blood *away* from the heart.

asphyxiate. To suffocate, due to lack of oxygen in blood.

assimilation. A process which occurs when part of the food is absorbed and becomes part of the living animal or plant.

autogyro. A type of aeroplane, designed for vertical ascent and descent, the main feature being an extra horizontal screw rotating under wind-pressure.

bacteria. A group of extremely small plants which exist in air, water, soil and the bodies of plants and animals. Some are the causes of diseases; others are valuable.

bladder. An organ which receives urine from the kidneys and holds it temporarily.

bone. A tissue making up a large portion of skeleton of vertebrate animal; one part of the skeleton.

breath. Air taken into and sent out of lungs.

cannibal. An animal which devours others of its own kind.

capillary. A very narrow blood vessel with extremely thin walls and linking up small arteries with small veins.

carnivorous. Flesh-eating, of animals, and also of certain plants.

cartilage. Gristle, a tissue free from nerves.

chlorophyll. The green colouring matter of plants which traps the red-orange rays of sunlight and uses part of their radiant energy in making from very simple substances others which are more complex, namely sugars, e.g. glucose.

climate. The average condition of the atmosphere in which the period in question may be the whole year and the area a very large one.

clinical. For use in examining a patient in bed.

close season. One during which animals are protected by law from danger by hunting or other attack by any person.

combustion. The action or process of burning. In slow combustion little heat and no light is produced.

constituent. Helping to compose a whole.

cork. Bark of Cork Oak or other woody plant formed by cork cambium.

deciduous. A term applied to woody plants whose leaves fall off at a certain season leaving the twigs bare for some months.

decompose. To rot, or to separate into its elements.

desiccation. A process whereby water is lost in amounts such that the plant, animal or object dries up.

digit. Finger or toe.

dimorphic. Having two different forms, e.g. Primrose flower, Cowslip flower.

dioecious. Seed plants, e.g. willow, which have the ovule and the pollen flowers on separate individuals.

egg. Accurately, a single female cell in plant or animal. Popularly, egg and covering envelopes, including often a hard shell.

embryo animal. The young individual recognized in early stages of development either within an egg-shell, e.g. bird, or in the spawn of amphibia, and later in water, e.g. frog tadpole.

embryo plant. The very young plant, e.g. inside the seed of ash, or pea.

encysted. Enclosed in a weather- or water-resistant coat; applied to small plants and animals in certain stages of their lives.

energy. Power or force which may be used or latent, i.e. lying hid and inactive.

epidermis. In a plant the outermost tissue of stem or leaf.

epiphragm. A closing layer made by a land snail when it withdraws into its shell because the air is too cool or too dry, or food not abundant.

equinox. The period when sunlight reaches both poles at the same time and every place on the Earth's surface is lighted up for twelve hours and plunged in darkness for the other twelve hours. The nights are equal everywhere and so too are the days. Vernal or spring Equinox is March 21st. Autumn Equinox is September 22nd.

evergreen. A term applied to woody plants whose leaves remain in position on the twigs for almost a year or for several years so that the twigs are never really bare.

fermentation. A process resulting from the action of leaven on dough, or on a sugary liquid.

fungi. A group of plants having no chlorophyll and therefore unable to obtain energy from the sun's rays for the building up from very simple substances of sugar for food.

Fungi break down complex substances already built up by other plants or by animals and so obtain the energy which they need.

gizzard. A kind of second stomach in a bird, in which the food is ground.

glucose, or grape sugar. Present in green plants, in the muscles of animals. See respiration; it takes up oxygen more readily than other sugars; it acts as a "reducing agent".

gravity. The quality of having weight.

gregarious. Of animals, living in large groups, e.g. flocks, herds.

growing. Getting bigger, *increasing* in size and weight. The growth of plants is controlled, in part, by substances present in minute quantities and called *auxins*.

guano. A natural manure found on some sea coasts, especially on the islands about Peru and consisting of the waste cast out of the body by sea birds.

gullet. Passage from mouth to stomach.

haemoglobin. The colouring matter of the red corpuscles of the blood, containing iron.

helicopter. A type of flying machine, made to rise and sink vertically, by means of horizontal propellers and revolving vanes.

herbivorous. Feeding on herbage, or plants other than herbs.

hibernation is a peculiar condition associated with the cold season of the year in which some animals go into a kind of sleep and all living processes are reduced to a minimum.

intestine. That part of the alimentary canal beyond the stomach within which a chief part of digestion is carried on.

irrigation. The action of supplying land with water by means of channels or streams under control.

kidneys. Organs whose special work is to collect waste substances from the blood and pass it on to the bladder.

lactic acid. A fatigue product of active muscles which are using up glucose.

larva. The early form of an animal which is very unlike the parent and undergoes great changes called a metamorphosis—Caterpillars and tadpoles are larvae of certain insects and amphibia respectively.

latitude is angular distance from the equator measured towards the poles. The equator is chosen as 0°of latitude; the north pole has latitude 90° N. and the south pole latitude 90° S. One degree of latitude is a little more than sixty-nine miles.

leeward. The side *towards* which the wind is blowing, and therefore the sheltered side of a tree or ship.

lever. A lifter, a rigid bar which rests and moves at one point upon a prop, and lifts a weight at a second point by means of power brought to bear upon a third point.

leveret. A young hare.

lichens. A large group of lowly plants in which a green or blue-green alga lives in very intimate partnership with a fungus. They often cover rocks, tree trunks and walls completely.

longitude of a place is the angular distance of its meridian measured from a chosen meridian namely that passing through Greenwich. Places on meridians to the East of this have their noon earlier and places on meridians to the West of this have their noon later, for the Earth is always turning to the East. It is 11 a.m. at all places 15° E. of Greenwich when it is noon or mid-day at Greenwich observatory. Allow one hour for 15°, and 4 minutes for 1° of longitude.

lungfish. Fish having lung as well as gills.

machine. A device for transmitting and modifying power so as to direct motion and perform a certain kind of work. A lever is a very simple kind.

meridian. A line joining places which have noon, or the middle of the day, at the same moment. Every meridian

extends from pole to pole and crosses the equator at right angles.

metamorphosis. See larva.

midsummer day. June 21—in the northern hemisphere. It is the longest day, but the hottest part of the year comes later when the days are shorter.

monoecious. Seed plants, e.g. Hazel which have the ovule and the pollen flowers separate but on the same individual.

mouth. The opening protected by lips, through which food is taken in; also the cavity containing tongue and teeth.

muscle. A band of elastic fibrous tissue in an animal body, having the power of contraction from which movement results.

nerve. Solid white threads linked with the brain or with the great nerve cord inside the backbone.

nocturnal. Active chiefly at night, e.g. Barn Owls.

oils. (Vegetable and animal) substances, liquid at ordinary temperatures, lighter than water and not soluble in it.

omnivorous. Eating both plant and animal food.

organ. A part of an animal or plant which has a structure suited to a particular kind of work, e.g. heart, stamen.

ovary. In animals, a female organ in which ova or eggs are produced. In seed plants that part of the flower where ovules develop.

ovum. See egg.

pedi-palp. In a spider, a leg-like appendage whose basal joint helps in crushing food. In the tip, in the male, sperms are carried.

pellet. A rounded mass of undigested fur, bones, horny parts of insects, etc., ejected by way of mouth.

perspiration. Sweating, a process in which moisture passes out through the pores of the skin in mammals.

photosynthesis. The building up by *green* plants only, in the presence of light, food substances, especially sugar, from carbon dioxide and water.

pivot. A fixed point, generally a short shaft or pin, on the end of which something turns or hinges.

precipitate. To throw down as a solid deposit a substance from a solution by a chemical reagent or by heat.

preening, an activity limited to birds; with the beak oil from the preen gland just above the tail is distributed to all the feathers.

proteins. The essential nitrogen-containing constituents of the food of animals, and present in all plants.

protozoa. A group of small or extremely small animals, consisting of a single cell and yet able to carry on all the usual activities, e.g. respiration.

pulse. A wave effect which can be felt in the walls of all large arteries.

raceme. A grouping of flowers, each with its own little stalk, on a common stem with the youngest at the top, as in Bluebell.

reproduction. A process carried out by plants and animals which results in new individuals coming into existence. Each kind can give rise to offspring which resemble the parents closely. In sexual reproduction among the higher animals there are always two parents, e.g. duck and drake, cow and bull. In the plant world sexual reproduction is more difficult to understand but in maize, marrow, poplars and willows the parent plants are of two distinct kinds. Some of the lower animals and very many plants reproduce their kind by budding as well as by the sexual method. This is true of the Bluebell with its seeds as well as bulbs and of the Crocus with its seeds as well as corms.

reptiles. Land animals breathing by lungs and having body covered by scales. Four limbs, e.g. lizard and tortoise, or none, e.g. snake and slow worm, a legless lizard.

respiration. A process which goes on in all living plants and animals continually; oxygen is taken in, generally from the air, and used for the breaking down of complex substances, especially sugar, with release of energy and the

formation of simple waste products, carbon-dioxide being the commonest. Respiration is like combustion; the rate is slow, however.

specific gravity. The degree of relative heaviness of any kind of matter compared with a standard, e.g. water.

stomach. A broad part of the alimentary canal.

sucrose or cane sugar. Is not a reducing sugar. In living tissues it is converted into glucose or some similar sugar before being oxidised. Much sweeter than glucose.

testis. In animals, a male organ in which sperms are produced.

tissue. A number of cells collected together, all looking alike and all performing the same work, whether in a plant or an animal.

to breathe. To use definite organs of respiration, e.g. gills, lungs, for the intake of oxygen and the giving out of carbon-dioxide.

to camouflage. To disguise or conceal anything.

to masticate. To grind, especially with the teeth, to chew.

trachea. Wind pipe in the higher kinds of backboned animals, e.g. birds and mammals.

transparent. Allowing rays of light to pass through so that bodies behind can be seen distinctly.

transpiration. A process shared by all land plants whereby water is lost from stems and leaves to the air.

translucent. Allowing rays of light to pass through, but not transparent.

ultra-violet rays. Those beyond the visible violet of the light spectrum.

urine. The waste product of the blood, collected by the kidney and containing nitrogen compounds.

vein. A blood vessel carrying blood *towards* the heart.

ventral. Belonging to the lower side, or under side.

vita glass. Glass which gives passage to ultra-violet rays.

vitamins. Substances present in very minute quantities in *living* plants and animals but of very great importance for the resisting of diseases, the making of sound bones and for protecting health. A, B, C, D, E are five which we all need.

vivarium. A place specially prepared for the keeping of living animals in conditions as nearly natural as possible.

voluntary muscles. Those under the control of the will.

weather. General state of the atmosphere at a definite time and place, including temperature, amount of moisture, strength and direction of wind, clouds, visibility.

windward. The side *from* which the wind is blowing, and therefore the exposed side of a tree or ship.

work. Action, the result of the changing of one kind of energy into another, whether by a machine or an animal or a plant.

The correct scientific names of only a very few plants have been given in this book, but every plant and animal which is known and described is given two names; by these names they can be traced in the literature of any country whether in Europe or beyond. When these scientific names are descriptive they are not difficult to remember (see p. 244). Several kinds of bracket fungus have *Polyporus* for their first name because they have many pores (on the under side), but only one kind is called *Polyporus Betulinus* and this is the one which grows on the Silver Birch (*Betula alba*).

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