A FIRST BIOLOGY

CADMAN

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FOREWORD

WHEN Dr Elsie J. Cadman was preparing the manuscript of this book she asked me to write a foreword to it. She died a few weeks after the manuscript was completed, and it has fallen to me to select the figures and to see it through the press.

The book is designed as an introduction to Biology suitable for children of about twelve to fifteen years of age, and is based on her long experience of teaching. Dr Cadman encouraged practical work in her teaching, and the book is intended as a guide to the pupil both in the schoolroom and in the countryside.

It was almost her last wish that the book should be published, and I sincerely hope that it will help to inculcate in children an interest in the lives of animals and plants, and be a valuable introduction to Human Physiology.

MALCOLM WILSON

University of Edinburgh, 1951

NOTE

The opportunity of a second edition has been taken to make a number of minor amendments. An Index has also been added in response to requests from teachers using the book.

CONTENTS

CHAPTER I

INTRODUCTION

MEANING OF BIOLOGY – DIFFERENCES BETWEEN LIVING AND NON-LIVING OBJECTS – DIFFERENCES BETWEEN PLANTS AND ANIMALS – FUNCTIONS WHICH LIVING THINGS HAVE TO PERFORM

Meaning of Biology

As the title of this book indicates, its purpose is to introduce you to the study of Biology, and before you go further it is essential to understand clearly what is meant by the word Biology. It is derived from two Greek words, 'bios,' meaning life, and 'logos,' meaning word. One dictionary states that the original meaning of the word 'Biology' was 'discoursing about life.' This would cover a very wide field and would have appealed to the ancient Greeks, who delighted in lengthy talks on every conceivable subject. In another dictionary Biology is defined as 'the science which deals with the living functions and activities of both plants and animals,' and this is the meaning of the term which has been kept in mind during the preparation of this book. Biology, therefore, is *the study of everything connected with the life of plant or animal*, e.g. how it 'breathes' or respires, grows, moves and produces individuals like itself. To understand how these functions are performed the structure of plant and animal will have to be examined.

Differences between Living and Non-living Objects

Since Biology is the *Science of Life*, we must first study the meaning of the word *life* itself. By non-living objects you must clearly understand that we do not mean plants and animals which are dead, that is which have had life and no longer possess it. It is only those objects which have never had life and cannot be included in the plant or animal kingdom that are regarded as non-living objects.

The following may be taken as the main differences between living and non-living objects, though, as you go further into the study of Biology, you may find that there are exceptions to nearly every one.

(1) *Living things can move, non-living things are unable to move.* Exceptions to this difference can be found quite readily. You, yourself, can make a stone move by throwing it, but the stone does not move of itself; you have made it move. A more striking exception will be found when you come to use the microscope. Tiny, solid, non-living particles, so small that they are only visible when very highly magnified, may often be seen to have a dancing movement, called 'Brownian movement' after the man who discovered it. Any movement of a non-living object must be directed by a living organism or it is purposeless. The movement of a living object, on the other hand, is directed towards a useful end—for example, a plant may move to climb round some support, and an animal moves in search of food. It would be well, here, to distinguish between *movement* and *locomotion*. By simple movement let us understand any movement which is carried out by plant or animal without leaving the place in which it is situated. By locomotion is meant movement to a new position. This is more characteristic of the typical animal than of the typical plant.

(2) *Irritability.* Living things respond to outside influences, non-living things do not. If you touch the head of your pet tortoise it will probably withdraw its head into its shell, unless it has got to know you very well. In this way the tortoise makes use of its shell for protection. The broad bean plants you are growing in the classroom window bend towards the light and the leaves may make use of it during the manufacture of food.

(3) *Respiration.* All living things respire continually. The process of respiration will be described fully in a later chapter.

(4) *Nutrition and Growth.* Living things are able to obtain food and to use it in building up their bodies. Non-living things cannot do this. As a result of the food taken in, the young animal or plant is enabled to grow or increase in size. The food taken in must be changed in form so that it can be built up into the structure of the plant or animal.

When you make crystals of alum or of copper sulphate in the laboratory you will notice that they increase in size, but this is only because the solid alum or copper sulphate dissolved in the water becomes deposited on the surface of the crystal and so causes it to increase in size.

(5) *Reproduction.* Living plants and animals have the power of giving rise to offspring like themselves. Non-living things have not this power. As you will see in later chapters, there are many interesting ways in which this process of reproduction is carried out.

Differences between Plants and Animals

All living things belong either to the plant or the animal kingdom. These kingdoms have gradually developed from very simple one-celled plants and animals to the more complex —for example, flowers and man. You will understand this much better when you have completed your course in Biology. All I want you to realise now is that when one is dealing with the simplest plants and animals it is not always easy to distinguish as to whether they belong to the plant or animal kingdoms. Exceptions can be found to each of the following distinctions, but they will form a foundation upon which to build.

(1) *Animals have power of locomotion; plants, as a rule, do not have this power.* Generally, animals can move freely from one place to another, while plants are fixed. There are exceptions to this rule for some simple animals, e.g. the corals and sponges are fixed, while some simple plants have the power of locomotion, at least during a large part of their existence.

(2) *Nutrition of plants and animals differs widely.* Plants contain green colouring material called *chlorophyll,* the presence of which enables them, in sunlight, to manufacture food-stuffs, such as starches and sugars, from the water in the soil and the carbon dioxide in the atmosphere. Animals do not possess chlorophyll, and so are unable to manufacture simple food-stuffs for themselves. They must rely upon plants and other animals for their food supply. With this method of nutrition is connected the power of locomotion possessed by animals. They have to move about in search of their food, while the plant has its sources of food surrounding it.

All plants are not green—for example, the common mushroom does not possess chlorophyll and therefore has to rely upon dead plants and animals for its food supply, and there are some plant-like animals which contain chlorophyll. Here is one of the difficulties in deciding whether certain organisms belong to the plant or animal kingdom. The expert has to weigh up the plant- and animal-like characters of these puzzling organisms and decide whether plant- or animal-like characters are more numerous. For example, the plant-like animal, Euglena, possesses chlorophyll; but this is its only distinctly plant-like character, whilst it has several animal-like characters and is generally described in a zoology textbook, not in one on botany.

(3) The plant relies for its *rigidity* upon its cell structure. The plant body is built up of a great number of minute, brick-like cells. These cells are kept firm by a constant supply of water, and so they build up a rigid structure which is sufficiently strong to resist the breezes which blow over the plant. Very often the walls of the plant cells are specially strengthened and so aid in keeping it firm and upright.

Most animals have either an external or an internal skeleton to give them the required support, and the animal cell has usually a very thin cell wall. Those animals which have no firm skeleton are generally small and live surrounded by water. Being protected by the water they have no need for a supported skeleton.

Functions which Living Things have to Perform

In concluding this chapter, it must be emphasised that all living things have the following functions to perform. They must *respire*, *feed*, *grow*, *respond to external stimuli*, *excrete waste material* and *reproduce*. These functions and the manner in which they are performed will be considered in the following chapters.

CHAPTER II

STRUCTURE OF A TYPICAL PLANT

SHEPHERD'S PURSE – EXTERNAL STRUCTURE OF ROOT, STEM AND LEAF – FUNCTIONS OF EACH PART – FLOWER OF LESSER CELANDINE – STRUCTURE AND USES OF EACH PART – COMPARISON WITH FLOWER OF PRIMROSE

A Typical Flowering Plant

In commencing our study of Biology let us dig up a plant of Shepherd's Purse or any other typical flowering plant, and examine each part (Fig. 1). Carefully wash all soil from the roots and you will at once see that the part below ground, the *root*, and the part above ground, the *shoot*, differ very markedly in colour. The root is white or pale brown, whilst most of the rest of the plant is green.

The Root. The root is white in colour because it is the part of the plant which grows below ground and is not exposed to the light. In the shepherd's purse there is a principal or main root which grows downwards into the soil and is called a *tap* or *primary* root. This may become forked if it should encounter a stone or other obstacle round which it has to grow. From the tap root smaller roots arise called *secondary roots*, because they are formed after the tap or primary root. Primary and secondary roots form a branching mass of roots known as a *tap root system*.

In some plants, e.g. the grasses, the primary root dies off very early and its place is taken by a number of fibrous roots which arise just above it in the young seedling. These form a *fibrous root system*, and it is equally effective in spreading through the soil.

Functions of the Root. The root has two very important duties to perform.

(1) As the root system spreads through the soil it obtains a footing for the plant and anchors it firmly so that it is not readily uprooted.

(2) Grow some cress on a piece of damp blotting-paper and you will see a number of tiny, silky hairs near the tip of the

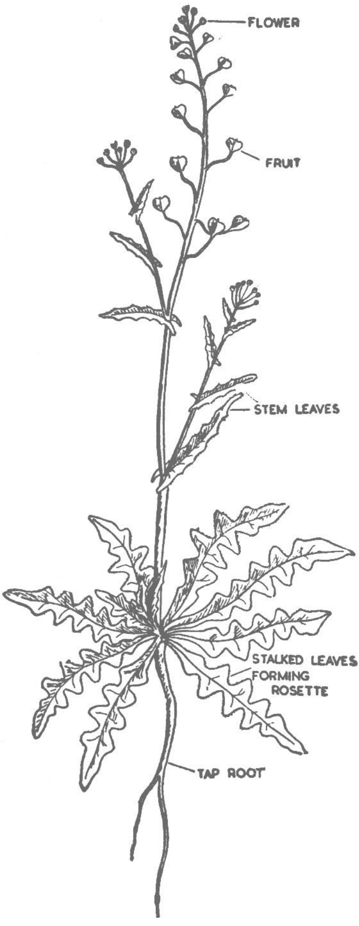


FIG. 1. Shepherd's Purse.

root. These are called *root hairs*, and they are one of the most important parts of the plant, for it is through them that the plant takes in a great part of its food supply in the form of the water present in the soil and the simple salts dissolved in the water. These simple salts, when united with the sugars and starches formed from water and carbon dioxide, help to form the more complex proteins and other substances which build up plant and animal bodies.

The Shoot. The shoot is made up of a number of different parts, stem, leaf and flower. Each of these has special duties to perform and is adapted to carry them out efficiently.

The Stem. In the shepherd's purse the stem is erect and green in colour. On it are borne the leaves and the flowers. In some plants, e.g. goose-grass or cleavers, the stem is weak and unable to stand erect, so it scrambles over the other plants in the hedgerow instead of relying on its own strength.

Functions of the Stem. Like the root the stem has two important duties to perform.

(1) The erect stem of the shepherd's purse and the scrambling stem of the goose-grass alike enable the flowers and leaves to obtain the light they need to obtain their full development.

(2) Place some willow twigs in water containing a little red ink and leave for one or two days. Cut across the stem, and you will see that there are little red streaks passing up through it. If there are leaves on the willow twigs you will find that the veins have become tinged with pink.

The above experiment can be repeated using a white flower such as a chrysanthemum instead of the willow twigs. In a few days the petals become delicately veined with pink.

Both experiments prove that the water taken in by the plant travels upwards through the stem to the leaves and flowers. The streaks shown in the willow stem show further that the water only passes up certain parts of the stem. Down certain parts of the stem, different from those up which the water with its dissolved salts passed to the leaves, the manufactured food-stuffs pass to every part of the plant. The stem provides passages up which water and dissolved salts pass to the leaves, and other passages down which manufactured food passes to every part of the plant which requires it.

The Leaf. In the shepherd's purse the leaf is flat with an upper and a lower surface. The leaves are of two kinds. Those lower down the plant are larger and have short stalks. They often form a rosette round the stem of the plant just above ground-level. This *rosette habit* is very useful, because the thick covering of leaves shuts out the light from any seedlings which may be growing beneath and so they cannot flourish, and the plant has less competition in the struggle for existence.

The margins of the lower leaves are deeply indented, but those of the upper leaves are entire and the leaves themselves have no stalks. They are attached directly to the stem as if they sat right on it, so they are said to be *sessile*.

Functions of the Leaf. The leaf is one of the most important parts of the plant and it has several essential duties to perform.

(1) The green cells of the leaf form a great kitchen or laboratory in which sugars and starches are manufactured from the water which has entered from the soil and the carbon dioxide which has entered from the air. These sugars and starches unite with the simple salts which have entered from the soil to form more complex substances which are finally built up into the body of the plant or animal.

(2) If the leaf is examined carefully under the microscope little *pores* will be found present on the lower surface.

Through these pores air containing oxygen and carbon dioxide is taken in. Some of the oxygen is used up in respiration and some of the carbon dioxide in food manufacture. The air that remains passes out through the pores and fresh air enters to take its place. It must be understood that the pores are not the only entrance and exit for air in every leaf. If the skin of the leaf is provided with a thin covering, instead of the waxy covering found on the holly leaf, a certain amount of air may enter directly through the skin. It must also be realised that the leaf is not the only part of the plant which respires. Every part of the plant, root, stem and flower, as well as leaf, have to respire. The green stem respires in the same way as the leaf. The young root is able to take in air over its entire surface because it has a very thin covering. The older stem and root, which are covered with a corky layer, have special organs through which the air enters.

(3) Through the same pores on the lower surface of the leaf water passes out in the form of water vapour. The salts in the soil can only enter the root in very weak solution, so that much more water is taken in than the plant requires for food manufacture or for keeping its cells firm. The water not required must pass out or the cells of the plant will become too full and will rupture.

Sometimes, in the morning, you may have noticed that each grass-leaf has a tiny drop of water at its tip. This water has passed up through the plant during the night and is oozing out as liquid water through a specially large pore at the tip of the leaf. Very often, in the morning, nasturtiums have little drops of water present round the edges of the leaves, for there is a specially large pore at the end of each vein.

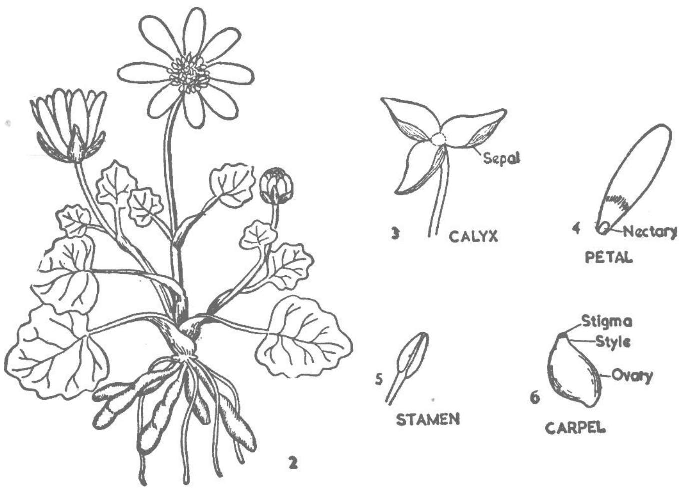
The Flower. The most important use of the flower is to produce the fruit and seed and to protect them until they are ripe. You will find from examination of the Lesser Celandine and Primrose flowers how they are constructed to perform this duty.

The Lesser Celandine

The flower of the Lesser Celandine (Fig. 2) is made up of a number of different parts arranged roughly in *whorls* or rings.

The Calyx. The outermost whorl consists of three boat-shaped structures called *sepals* (Fig. 3). The sepals are green in colour and are strongly made, and they protect the inner parts of the flower when it is a bud. Each sepal is free from its neighbour. They often wither and drop off early, after their work has been accomplished when the flower is in bloom.

The Corolla. The corolla is the whorl just inside the calyx. It is made up of a varying number of *petals*, usually from seven to eleven. The petals are of a bright, buttercup-yellow



FIGS. 2–6. Lesser Celandine. 2. Whole plant; 3. Calyx; 4. Petal; 5. Stamen; 6. Carpel.

colour, and their shape is not unlike that of the sepals. They are a little flatter and more oval in shape, and are also free from each other (Fig. 4). The bright colour attracts bees to come from another flower, bringing with them the pollen which has been dusted on to them. Down each petal run distinct lines, which some botanists call honey guides, leading to the nectar which is formed at the foot of the petals. The flower often has a pleasant smell, which is also attractive to the bee.

The Andrœcium. Inside the whorl formed by the petals is a large number of *stamens*. It would probably take some time to count them, though one industrious pupil found that there were thirty-eight in his flower. The number varies in