# MOSSES

*A King Penguin Book*

THE KING PENGUIN BOOKS

57

A BOOK OF MOSSES

PAUL RICHARDS

# A BOOK OF MOSSES

WITH 16 PLATES
FROM JOHANNES HEDWIG'S
DESCRIPTIO MUSCORUM



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# INTRODUCTION

> I carried a basket for mosses and gathered some wild plants. Oh! that we had a book of botany.
>
> DOROTHY WORDSWORTH'S *Grasmere Journal*

'BEFORE Dr Dillenius gave me a hint of it, I took no particular notice of mosses, but looked upon them as a cow looks at a pair of new barn doors.' The celebrated American botanist John Bartram wrote this in the eighteenth century; to-day, though much has been written about mosses since Dr John James Dillenius published his bulky *Historia Muscorum* in 1741, most people, even many professed botanists, would probably admit that they had taken 'no particular notice' of mosses. Yet mosses can be studied anywhere and at any time and they are among the most beautiful of plants, though much of their beauty can be seen only with the help of microscope or hand-lens. According to some, 'the hyssop that springeth out of the wall' which King Solomon studied was a moss.

What are mosses? In ordinary language the word is used loosely. Club moss, Iceland moss, reindeer moss and carrageen moss are all alike 'mosses', but none of them are mosses in the scientific sense. The club mosses, common on the northern fells and the hills of Wales and Scotland, are larger than most of the true mosses and are more nearly related to the ferns; Iceland moss and reindeer moss are lichens; carrageen moss is a seaweed. Bacon thought a moss was 'but the rudiment of a plant and (as it were)

the mould of earth or barke', but in fact mosses are fairly highly organized plants, with stems and leaves. Botanically they belong to the class Musci, which together with the Hepaticae or liverworts forms the section of the plant kingdom called the Bryophyta. Mosses and liverworts are cryptogams, that is to say they are plants which have no flowers and reproduce by minute single-celled spores, not by seeds. They are the least highly evolved of the green land plants; they have no roots and their structure is much simpler than that of the higher plants, such as ferns and flowering plants.

Most mosses are quite small. The largest British moss is the Hair Moss, *Polytrichum commune*,* which may grow to a height of eighteen inches or two feet; some mosses are so small that they can barely be seen with the naked eye. The small size of the individual plant is partly compensated for by the habit of growing in cushions or carpets; many millions of separate moss plants may grow together and cover square yards, or even acres, of bare rock or soil.

Mosses and lichens are easily distinguished from one another. Lichens are usually grey, yellow or brown; most mosses are bright green, though occasionally they are red, yellow, brown or even black. None of the lichens have leafy stems like those of mosses and their methods of reproduction are quite different. Mosses and liverworts are much more alike; the 'leafy' liverworts (as distinct from those which have a 'thallus' like a seaweed) have leaves,

* The species of mosses will be referred to in this book by their Latin names. Various authors have tried to translate them into English: Dillenius in 1741 attempted to provide every moss with an English name. As these included 'the curled Cypress-like Hypnum' and 'the lesser thick Mouse-tail Hypnum with stooping heads', it is not surprising that they failed to become popular.

but their leaves are generally cleft or divided into segments, while those of mosses are never divided; the leaves of mosses usually have a thickened midrib, those of liverworts never have. In mosses

*Fig.* 1. *A moss* (Funaria *species*). *The plant grows in a tuft, from which the three stems shown have been pulled out. Two of the stems bear spore capsules and the right-hand of these is still partly covered by its transparent calyptra.*

the leaves are arranged spirally all round the stem; in the liverworts the stem (which is generally creeping) has a row of leaves at each side and often a row of much smaller leaves beneath. There

are also many differences in microscopic structure and in the reproductive organs.

The class Musci falls naturally into two subdivisions, the Bryales or true mosses, to which the great majority of the species belong, and the Sphagnales or bog mosses. The latter grow mainly in very wet places – moorlands, peat bogs and swampy woodlands – and cover vast areas of ground, especially in Ireland, Wales and the Western Highlands of Scotland. They can easily be recognized by their spongy, often whitish, appearance and their habit of growth. In this volume only the Bryales are illustrated.

## THE LIFE-HISTORY OF A MOSS

To understand more clearly what a moss is like, how it is constructed, how it grows and reproduces, we must trace the development of the moss plant and follow it through its life-history.

It has already been said that mosses grow from spores, not seeds. These spores, which are produced in the spore capsules, usually in vast numbers, are microscopic and look, in the mass, like a very fine greenish or brownish powder. Individually the spores are more or less rounded, smooth or rough on the surface, and measure from about $\frac{1}{200}$ to $\frac{1}{50}$ of a millimetre across (exceptionally as much as $\frac{1}{5}$ of a millimetre). They are thus considerably smaller than the seeds of orchids, the smallest-seeded of British flowering plants; they are carried about in the wind and when they settle in a place with sufficient light and moisture (it may be on soil, on a rock or on a tree trunk) they begin to grow, though sometimes only after an interval of several weeks or perhaps months.

They do not, however, at first grow into anything closely resembling the full-grown moss. The earliest stages in the germination of the spores (Fig. 2) can be conveniently watched under the microscope if a few of them are scattered on a transparent medium (such as agar-agar jelly with nutrient salts added) in a glass dish. The spore first of all swells and bursts its outer coat; a slender thread emerges which becomes divided into cells placed end to end. Later a second thread emerges and both grow and

branch until the young plant (known as the protonema) may cover an area an inch or two across. Threads exposed to the light become green, as the cells, like those of other green plants, contain chloroplasts, the tiny disc-like bodies in which the green pigment of plants is found. Other threads, called rhizoids, grow down into the substratum; these are colourless or brownish and contain no chloroplasts. The young moss in the protonemal stage resembles a filamentous alga or pond scum; except that most of it is green, it also resembles the mycelium or weft of threads of a mould fungus.

After a time, however, the moss ceases to grow as branching filaments; buds, formed of clusters of cells, appear here and there on the threads of the protonema and each bud develops into a stem, upright or creeping in its growth, bearing very small, but perfectly formed leaves. These are very delicate in texture, consisting in most mosses of only a single layer of cells; they usually have a central vein or midrib, which, unlike the veins of most leaves, is not branched. When these leafy stems are fully grown, the thread-like protonema usually withers and disappears; the stem never acquires a true root, but anchors itself to the ground by rhizoids, similar to those of the protonema, borne in tufts at the base of the stem or at intervals along its length. Since a moss, unlike most larger plants, can absorb water and dissolved food material over any part of its surface, the main function of the rhizoids is to make a firm attachment. Many mosses will grow quite happily on smooth vertical faces of rock; this they can do because their thread-like rhizoids push their way into the tiniest crevices and prevent the plant from being washed away by the rain.

The first leafy stems which grow from the buds on the protonema are the forerunners of many others which arise as branches from the first ones, or from buds on the rhizoids (Fig. 2). Each stem lengthens and branches and gradually the tuft or carpet of interwoven stems, typical of the full-grown moss, is built up. If

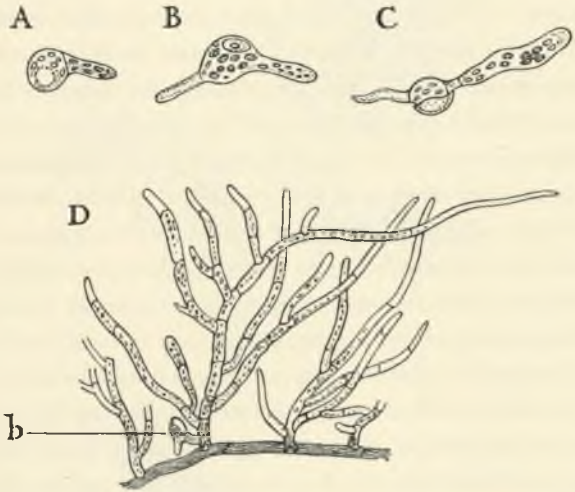



*Fig. 2. Early stages in the life-history of a moss. A, B, C: three successive stages in the germination of a spore (the small round bodies in the cells are chloroplasts). D: part of a protonema (at b is a bud from which a leafy shoot will develop).*

conditions are good, the tuft spreads outwards and upwards and grows almost indefinitely. The stems forming the tuft are sometimes tightly bound together by rhizoids, sometimes so loosely joined that when the tuft is pulled up, they fall apart. A tuft may develop from a single spore or from several which have germinated close together but in either case it may be very difficult

to trace a connection between the stems in a tuft, so that to say exactly what constitutes an individual moss plant is by no means easy. In many mosses the stem has the power of indefinite growth and rots away only slowly at the base, so that the tufts may reach a prodigious size. Dr Spruce wrote of *Leucobrycum glaucum* at Strensall Moor, near York: '... It forms immense rounded hassocks, some of which in my youth were as much as three feet high. ... When the late Mr Wilson [a celebrated student of mosses] first saw them, he took them at a distance for sheep, as he approached them he changed his mind for haycocks; but when he actually came up and saw what they were he was astonished and declared he had never seen such gigantic moss-tufts elsewhere.'

In nearly all the thousands of known species of mosses the general plan of construction is much the same, but within the general plan there is almost infinite variation in detail. The stems may be creeping or stiffly upright; they may be richly and regularly branched, so that the moss resembles a miniature fern, as in the common woodland moss *Thuidium tamariscinum* (Fig. 3), or there may be little or no branching. The leaves, which vary in shape from almost round to long and needle-like, may be closely overlapping, so that the whole shoot is like a catkin, or they may be wide apart so that the individual leaves are clearly and distinctly seen. There is wide variation in colour from emerald green to chestnut brown and black; some mosses are brilliant golden or wine-red and some have a gloss which gives them a lustre like burnished metal. Sometimes the leaves end in hoary points giving the whole tuft a woolly, ashen or dusty appearance. All these variations of form and colour are characteristic of the various genera and species and are used in identifying them.

At most times of year, but especially in the spring, the moss bears its spore capsules, each held aloft on a very delicate wiry

*Fig. 3.* Thuidium tamariscinum, *a common moss of woods and hedgebanks.*

stalk which may be as much as three or four inches long, arising from the tip or the side of the leafy stem. The capsules, which vary greatly in shape, are often nodding or bent downwards;

when young they are green, but by the time the spores are ripe they become orange, brown or deep red and contrast prettily in colour with the leaves. These capsules are the reproductive organs of the moss and are formed as a consequence of the union of male and female cells, much as the fruit of a flowering plant arises after the female parts of the flower have been fertilized by the pollen.

The sexual organs of the moss are minute and only just visible to the naked eye – because of their minuteness it was some time before the early naturalists discovered their true significance and to this day mosses are classed by botanists as Cryptogamia, the plants of the 'hidden marriage'. The male and female organs are found, sometimes together, sometimes on different parts of the same plant, sometimes on different plants, just as among flowering plants the flowers of a buttercup or rose have both stamens and ovaries, in a hazel there are separate male and female flowers on the same tree, while in most willows one tree bears male or female flowers but never both. The male organs, termed antheridia, are brownish and grow in groups at the tip of the main stem or of a side branch. Each group is surrounded by a rosette of leaves; in many mosses these leaves spread widely apart, so that the groups of antheridia look like tiny flowers with green petals and a brown centre; the older botanists in fact used to speak of them as the 'male flowers' of the moss. Each antheridium is sausage-shaped and stalked and forms within itself a mass of microscopic male cells which are not pollen grains, but corkscrew-shaped bodies which can swim in water by means of the two extremely fine threads or flagella with which they are provided; from their resemblance to the spermatozoa of animals they are called spermato-

zoids. The archegonia or female organs are also found in groups surrounded by special leaves, but the 'female flowers' are usually less conspicuous than the groups of antheridia. The individual archegonium is less than half a millimetre long and shaped like a long-necked bottle, with a single female cell or egg inside. Both antheridia and archegonia usually ripen in spring or autumn and in moist weather, when the moss is soaked with rain or dew and covered with a film of water, the antheridia burst open, the spermatozoids spread rapidly over the water film and swim by means of their flagella towards the archegonia (the necks of which are by now open), to which a chemical secretion attracts them. Eventually the spermatozoid reaches the egg, fuses with it and fertilization is completed.

The fertilized egg cell begins to develop at once; it does not grow into a leafy moss plant, but into a spore capsule on a stalk (Fig. 1). At first it is only the stalk that grows and only when this has reached almost its full length does the tip swell and become the capsule itself. The archegonium within which the egg cell develops stretches and eventually tears, its remains forming a delicate membranous cover, shaped like a hood or cap, known as the calyptra; this completely or partly conceals the capsule until it is ripe. The full-grown capsule has a complicated structure. The details need not concern us here, and it will be sufficient to mention that a large number of spores is formed inside the capsule and that it has a conical lid or operculum, which is finally thrown off (though in some mosses the capsule has no properly formed lid and the spores escape by the gradual rotting, or irregular tearing, of the capsule wall). In most mosses when the calyptra and lid are removed a fringe of delicate teeth is seen, arranged in a single or

double ring; these teeth are called the peristome teeth and have the function of regulating or assisting the escape of the spores from the capsule. More will be said later about this singularly interesting and beautiful part of the structure of the moss. The spores after escaping from the capsule are carried away by the wind, some of them (though doubtless only a small fraction) finding places in which to grow and develop into new moss plants.

Such, briefly, is the life-history of a moss, which has now been traced through its whole cycle, from spore to spore. The story is thus a remarkable one, the spore growing first into the thread-like protonema, then into something seemingly quite different, the leafy moss plant which reproduces sexually to give something quite different again, the stalked spore capsule. In the technical language of botanists the moss is said to have two 'generations' in its life-history, the leafy moss plant (with a youthful stage, the protonema) and the leafless spore capsule with its slender stalk. The latter does not become an independent plant, but remains attached to the parent leafy shoot, on which it is partly parasitic since it depends on it for a large part of its nourishment. The moss is thus said to show 'alternation of generations' and the two generations are quite unlike both in their appearance and their methods of reproduction.

To what has been said about the structure and life-history of a moss, it need only be added that in many mosses as well as, or in place of, its normal sexual method of reproduction leading to the development of spores, the leafy moss plant has other ways of multiplying itself. Thus, in some mosses the leaves break off, blow away and, if they land in a suitable place, grow into a new leafy plant; in fact almost any small piece of a moss plant may, under

the right conditions, grow into a complete plant. In other species small bud-like bodies called gemmae, consisting of clusters of a few cells, are produced on the stem or leaves and serve as reproductive organs.

## PERISTOME TEETH

Few microscopic objects are more fascinating to study than the peristome teeth which guard the mouth of the spore capsule in mosses. One of their most remarkable features is their sensitiveness to slight changes in the humidity of the air. They bend inwards in moist air and outwards in dry, or, in some kinds of moss, inwards in dry air and outwards in moist. These movements are rapid and can easily be observed by breathing gently on an open capsule and watching it under a magnifying glass. In a few species, e.g. *Atrichum undulatum* (Plates 1 (a) and 2), the teeth, which are differently constructed from those of other mosses, do not move.

Plate 1 will convey a faint idea of the variety of form and intricacy of construction of moss peristomes. Sometimes there is one ring of teeth, sometimes two, an outer and an inner. When there are two rings it is only the outer teeth which bend in response to changes of humidity. The number of teeth in each ring may be four, sixteen or sixty-four; it is always a multiple of four.

The individual teeth of the outer peristome are elaborately ornamented with cross-bars and ridges; under the high power of the microscope they often show a finely sculptured pattern as well. In many cases the tooth is forked towards its tip or perforated by small holes. The colour is generally yellow, reddish brown or bright crimson. The inner peristome, when present, is more delicate and fragile than the outer and is usually lighter in colour.

Its teeth, though of much the same shape as those of the outer peristome, are simpler in structure and are usually joined at the base so as to form a tube, only the upper parts being separated. In some mosses even the upper parts of the inner peristome teeth are joined by slender cross-bars so that the whole structure is like a very fine lattice-work.

How are the hygroscopic movements of the outer peristome teeth brought about? To explain this fully would demand a longer account of the minute details of their structure than space will permit, but it can be understood if it is realized that each tooth is composed of two membranous layers joined together, one forming the outer suface, the other the inner. One layer lengthens when it is moistened and shortens when it dries, the other layer remaining the same length whether it is wet or dry; the tooth as a whole consequently bends inwards or straightens out as it takes up or loses water. In mosses where it is the outer layer of the tooth which lengthens when it is moistened, the teeth bend inwards in a damp atmosphere; in those where the inner layer lengthens, the reverse movement takes place. The whole mechanism is somewhat comparable to a 'bimetallic strip' of two different metals which expand at different rates when heated. If the metal with the greater rate of expansion is at the outside, such a strip will bend inwards when heated and outwards when cooled; if the more expansible metal is at the inside, the strip will bend outwards when heated and inwards when cooled. The movement of the bimetallic strip is due to expansion or contraction with change of temperature; in the peristome tooth of the moss the movement is brought about by taking up or losing water from the air, but in either case the mechanical principle is the same. The movements of peri-

stome teeth depend on the properties of non-living cell walls; the teeth are just as sensitive and move just as rapidly in a dead moss capsule as in a living one.

Elaborate as are the structure and mechanism of the peristome, its significance for the life of the moss is simple. When the outer peristome teeth bend inwards they close the mouth of the capsule almost completely, so that it is difficult or impossible for spores to escape; when they are bent outwards the spores are blown away or shaken out as the capsule sways on its wiry stalk. The inner peristome teeth, which show no bending movements, do not completely close the capsule mouth and act as a kind of sieve allowing the spores to escape a few at a time and preventing them from falling out in a mass. It is usually assumed that in those mosses where the outer peristome bends outwards in dry air dry conditions are suitable for the dispersal of the spores, and in those where they bend outwards in moist air damper conditions are desirable, but of this there is no direct proof.

## THE HOMES OF MOSSES

Mosses grow nearly everywhere, so long as there is some moisture and a little space not occupied by taller and stronger-growing forms of vegetation. They are as much at home in the Arctic tundra or the rocky islands of the Antarctic ocean as in the dank forests of the equator; only in deserts and in the sea are they entirely absent. On Mt Everest a moss has been collected at almost 20,000 ft.

In our own country they may be found even in the centre of large towns. The silvery tufts of *Bryum argenteum* manage to

flourish between paving-stones and on slate roofs even in the most smoky surroundings. Probably at least three different species could be found in the City of London itself, but though a few unexacting species tolerate the hardships of town life, it is only in the pure air of the open country that mosses are seen at their best. The favoured homes of mosses, where they will be seen in the greatest luxuriance and variety, are woods, heaths, moorlands and old stone walls, especially in the mild and rainy climate of Devon, Wales, the Lake District, Scotland and the west of Ireland. In such places they grow in abundance, associated with the ferns, liverworts and lichens which share their preference for a moist and smokeless atmosphere.

In open grassy fields there are few mosses, as the close turf of a hayfield or pasture leaves little room for such small and delicate plants. Arable land is more promising; in any field which has not been too recently ploughed a careful search will reveal small mosses, especially in spring and autumn after the land has lain fallow for a time. These mosses of ploughed fields are minute – some are less than a millimetre high – and even on hands and knees it needs a sharp eye to detect them. In a wood mosses at once become more conspicuous and many of the larger forms become plentiful. Here they sometimes grow on the ground, but more abundantly on tree trunks, old stumps, fallen logs and on steep banks where the danger of being smothered by the carpet of fallen leaves is not so great. 'Variety upon variety, dark green and pale green; mosses like little fir-trees, like plush, like malachite stars, like nothing on earth except moss', wrote Thomas Hardy of the Dorset woodlands.

One of the first mosses to strike our eyes in a wood might be

*Thuidium tamariscinum* (Fig. 3), a species in which the stem branches and re-branches with almost perfect regularity; all the branches lie in one plane, so that the whole plant is fern-like. Almost equally common is *Mnium hornum* which grows upright forming vigorous tufts; in spring the pale green of its young leaves contrasts strongly with the dull colour of last year's shoots. The female plant bears the plump nodding spore capsules in abundance; on the male the observant eye will notice the star-like 'male flowers'. There are many others, erect mosses such as *Polytrichum formosum* and *Atrichum undulatum* (Pl. 2), mosses such as *Porotrichum alopecurum* which are like miniature trees, feathery creeping forms such as *Eurhynchium Swartzii* (Pl. 4), and carpet-formers such as the very common *Hypnum cupressiforme* (Pl. 5) which covers tree trunks and old logs with a brilliant yellow-green tapestry.

Woodland mosses occasionally grow as loose balls or cushions entirely unattached to the soil. This often happens with *Leucobryum glaucum*, a spongy, whitish-green moss which forms the enormous tussocks referred to on p. 12. The ordinary rounded tufts of this plant may be scratched up by a rabbit or pheasant or kicked by the foot of a passer-by. When the tuft is turned over it continues to grow, but in the opposite direction, so that a cushion shaped like a ball or a bun is formed, green on both sides, and lying loosely on the floor of the wood. These curious unattached *Leucobryum* cushions are said to be common in the woods at Fawley in Hampshire where they are locally known as 'Fawley buns'.

On the hedgebanks of a lane many species may be found, mostly the same as those of the wood. An old brick or stone wall will be

well worth examination, and will provide a quite different flora. Almost any old wall will have *Tortula muralis*, a small tufted moss whose bright-green leaves end in a long greyish hair. With it there may usually be seen a variety of species of *Barbula* (Pl. 13), vivid green after rain, but shrivelled and hardly recognizable in dry weather. Another common wall moss is *Grimmia pulvinata*, which forms shaggy silver-grey tufts like the coat of some animal. Creeping forms are less common on walls, but *Camptothecium sericeum* (Pl. 3) can usually be found; this has a brilliant golden silky sheen. Some mosses are fond of the roofs of barns and old cottages, especially when they are thatched. A common species on roofs is *Tortula ruralis*, which forms much larger and more swollen tufts than its relative *Tortula muralis*.

A moorland district where the road is bordered by a wall of rough unmortared stone would be equally productive, and most of the mosses seen would be different from those in a lowland district of field, wood and hedgerow. The species of *Rhacomitrium* are particularly abundant on dry stone walls and boulders of granite, sandstone and similar rocks. The finest of these is *Rhacomitrium lanuginosum* (Pl. 7) which often forms cushions nine inches or more in thickness and over a foot wide; it has a grey woolly appearance due to the long colourless points of the leaves. Smaller mosses, such as *Grimmia apocarpa* (Pl. 8) whose brilliant red peristome is a charming object under the lens or microscope, are also plentiful in such situations.

Among the commoner mosses of the open moorland may be mentioned *Hypnum cupressiforme* (here looking very unlike its woodland form), *Dicranum scoparium*, a large species growing in loose tufts, and several kinds of *Hylocomium*. One of these,

*Hylocomium splendens*, has a close resemblance to the *Thuidium tamariscinum* of woods and hedges, but can be recognized at once because it has a red, not green, stem. The Hair Mosses (*Polytrichum*) are especially characteristic of moorlands. *Polytrichum commune* here forms large tussocks eighteen inches or a foot in height; it is the largest of British mosses. Its spore capsules on stalks three or four inches long, surmounted by the golden-brown, shaggy calyptra, are a familiar sight in spring and early summer. In boggy places and by moorland streams a great variety of Bog Mosses (*Sphagnum*) are found, often tinged with bright crimson or golden tints. Many other mosses grow with them, such as *Aulacomnium palustre* and the brilliant green *Philonotis fontana*.

In spite of the liking of most mosses for damp places, comparatively few species live actually in water. *Fontinalis antipyretica*, which grows in dark-green streamers, a foot or more in length, is common in most running water; Linnaeus gave it its curious name because it was formerly used in Sweden to stuff into the space between the chimneys and the wooden walls of houses, as a protection against fire. A fast hill stream with a rocky bed is a good place to look for aquatic mosses.

Though mosses as a class are found in all kinds of situations, the individual species are often remarkably selective in their choice of a habitat, so much so indeed that the mosses of a given area are usually a very good indication of the nature of the soil and climate. It is very noticeable, for instance, that the mosses found on sour peaty soils deficient in lime are almost all different from those found on chalk or limestone, though a few species, such as the ubiquitous *Hypnum cupressiforme* and the almost equally

common *Brachythecium rutabulum* (Pl. 6), are indifferent and can grow on almost any kind of soil. All the Bog Mosses (*Sphagnum*) and some species of *Polytrichum* are characteristic of sour soils and avoid the slightest trace of lime or chalk. Other mosses, such as the elegant *Hypnum molluscum*, are equally definite in their preference for a soil containing at least a little lime. A few mosses like decaying animal matter, notably the species of *Splachnum* and their relatives. One species of this group is usually found on the much-decayed carcases of sheep, another on branches of trees where birds of prey perch, and one, which is most often seen on cow-dung, has been found on the foot of an old stocking on Ingleborough in Yorkshire and on the 'half-decayed hat of a traveller who had perished on the mountain of St Bernard in Switzerland'. Though there are no truly marine mosses, one British species, the small, brownish *Grimmia maritima*, is always found on rocks in reach of sea spray, where it grows in company with thrift and sea campion.

Two mosses deserve special mention for their habitat preferences, *Funaria hygrometrica* and *Schistostega pennata*. The former, which is of medium size and very common, is remarkable for its liking for places where there have been fires. A patch in a wood where brushwood has been burnt or the site of a picnic fire, if sufficiently moist, nearly always become covered after a time with a dense carpet of it, which is conspicuous because of its vivid yellowish-green colour. Though it sometimes grows in unburnt habitats, for instance on soil in flower pots and on old walls, *Funaria hygrometrica* on a heath or in a wood is such a reliable index of fire that even where the signs of burning are not obvious, a search beneath the moss carpet will usually reveal fragments of

charcoal or cinders. *Schistostega pennata* (Pl. 9) likes very different conditions; its particular preference is for caves, rabbit-holes and old mine-shafts. It will tolerate, perhaps, a deeper shade than any other moss. On looking into a cave where it grows, the walls seem to be emitting a beautiful emerald-green light. This is due to the protonema, which is not actually luminous, but reflects the light from its lens-shaped cells in much the same way as the red reflector of a bicycle. *Schistostega* is a local moss, very common in some districts and quite absent in others; it usually grows on sandstone or granite.

## HOW TO COLLECT, IDENTIFY AND CULTIVATE MOSSES

To become closely acquainted with mosses, to *know* them, one must study them in their natural surroundings and learn the names of at least some of the commoner species. The best way of doing this is to collect them; they are easily preserved and take up little space. As well as dried collection there is much to be said for making a living one, a moss garden; many mosses can be grown quite easily, and moss cultivation can be recommended as an attractive, as well as neglected, branch of horticulture.

The equipment for a moss-collecting expedition need not be elaborate, indeed all that is required, other than good eyesight and keen powers of observation, is a number of tins of various sizes, a penknife for scraping mosses off rocks and bark, and a pocket-lens with a fairly large field and a magnification of not less than three diameters. Old tobacco or cigarette tins do very well for the smaller mosses; for the larger ones a big tin such as a half-

size biscuit tin with strap attached, or a botanist's 'vasculum', is desirable. Unless the species is known to be a rarity, a fair amount of each moss should be collected; in general the specimen should be as large as the palm of one's hand, since a smaller quantity may not be sufficient to show all the characteristic features. As some mosses can only be identified with the help of their ripe spore capsules, 'fruiting' specimens should be taken if possible. Many mosses, however, can be quite easily named without capsules and some rarely or never produce them. The best advice to the beginner is probably: at first collect only mosses with capsules and leave sterile plants until later, when most of the commoner species have become familiar. Each specimen collected should be put in a separate tin, or if several are put together, each should be separately wrapped up in newspaper. A label giving details of locality, situation (wall, ground, etc., wet or dry, north, south, etc., aspect, geological formation, height above sea-level) and date of collection should be written out in the field and put with each gathering. Mosses are usually in the finest condition in the spring and autumn months, and in showery weather, but collecting may be done at any season, except in very dry or very frosty weather – apparently it can also be done at any hour, since a specimen in the Cambridge University Herbarium bears the note: 'Collected by the light of a bull's eye lantern at 2 A.M.'

Moss left damp in an air-tight tin soon becomes mouldy and rotten, but if the lid of the tin is left open, so that the moss is exposed to the air, or if the moss is allowed to dry before being shut up in the tin, it will keep indefinitely and can be examined at leisure. Mosses have the great advantage for the collector over most other plants that when they are dry they can be soaked for a

while in warm water, the surplus water squeezed out, and they then appear as fresh as when first gathered. Even when kept dry for many years, mosses will regain their original form when soaked in water, though after a time they lose their bright colours. Many mosses, in fact, actually remain alive for years on end when perfectly dry; one investigator found that a moss stored dry for nineteen years was still living and began to grow when moistened.

When making a collection of mosses it is desirable to press as well as dry them. The most convenient way of doing this is to take the moss out of the collecting tin, remove from it any stones, sticks, grass, etc., and put it into a packet of folded newspaper, together with its label (which should be written in pencil, since ink becomes blurred when moist). All the packets collected can then be put between sheets of newspaper, unglazed brown paper or botanical drying paper, and the whole pile pressed between two boards. Pressure can be applied by means of straps or weights, but only very light pressure is necessary. If the moss is very dirty when gathered, or is partly embedded in sand or soil, it should be carefully washed and then squeezed before putting in the packet. If the washing is too thorough the tuft may fall to pieces, and with most mosses which grow on the ground it is necessary to leave a certain amount of soil attached to the specimen.

After pressing and drying (the damp sheets of paper between which the packets are laid should be changed two or three times) the packets can be stored and examined when convenient. To examine a specimen under the microscope a small piece is taken and placed in warm water, gently kneading it with the finger to remove air bubbles. One or two stems can then be placed on a

microscope slide and dissected or examined whole under a coverslip as required.

When the moss has been examined and identified, it can be stored away permanently for reference. For storage the specimens should be transferred from the newspaper packets in which they were dried to similar packets of clean white paper, the particulars on the label being copied on to the outside of the new packet. If the packets are all made approximately the same size (5 × 4 or 4 × 3 inches is convenient for the majority of mosses), they can then be filed in drawers or boxes like cards in a card-index.

The identification of mosses requires some patience and experience as well as a little practice in the use of the microscope, but the beginner will soon learn to recognize some of the larger and commoner species. He must not expect, until he has a fair amount of experience, to identify correctly every moss he meets. The standard work for the identification of British mosses is H. N. Dixon's and H. G. Jameson's *Student's Handbook of British Mosses* (Third Edition, V.V. Sumfield, Eastbourne, 1924. 24s.), a large book which describes all the species known to grow in the British Isles. Though the beginner may find this rather formidable, the technical terms are soon learned and experience will teach how they are to be applied in practice. Over 600 species of mosses have been found in Britain, but many of these are rare and in an average district there are not more than 100 or 200. With the help of Dixon's *Handbook* anyone can learn the names of at least the commoner mosses of his own district.

To cultivate mosses gives one an even more intimate acquaintance with them than merely observing them in the field or forming a collection of dried specimens. In cultivation they can be

watched at all stages of their development, and from their reactions to the seasons and changes of weather there is much to be learned. In moss cultivation, as in other kinds of gardening, the golden rule is: imitate the natural surroundings of the plant as closely as possible. The majority of mosses like a moist atmosphere, but not a water-logged soil, and dislike exposure to direct sunshine. Apart from this, the individual requirements of each species, in cultivation as well as in nature, are different and can only be discovered by experience and by studying the plant in its natural home. In my own moss garden I have found that most mosses grow well either in earthenware pans (about three inches deep and nine inches wide), glazed on the inside, or in ordinary porous flower-pots or pans stood in an inch or two of water. The pot or pan should normally be covered with a sheet of glass, as, even if it is standing in water, the moss may dry out during warm or dry weather. A deep soil is not needed; a layer of clay about half an inch thick makes a good foundation and a thin layer of stones, sand, peat, rotten wood, etc., can be laid on this to suit the particular species of moss. Careful attention is needed as to whether the species likes or dislikes lime; as already mentioned, many mosses are lime-haters and will only flourish on a soil free from the slightest trace of lime. Watering should be done frequently, daily in summer, less often in wet or cold weather. In districts with a soft water supply, tap water may be used, but where the supply is hard or is artificially softened, tap water should never be used, only rain water. Do not water with an ordinary galvanized watering-can, since the water from it will contain small quantities of zinc which seems to be poisonous to mosses.

The mosses should be planted with some of their natural sub-

stratum – rock, peat, soil, bark or rotten wood – adhering; it is only necessary to pack the tufts into the pot and press them down gently. The rhizoids will soon grow and make a firm contact with the soil beneath. Some weeding must be done; certain mosses tend to crowd out others and the common moss *Funaria hygrometrica*, for example, is a pernicious weed which soon chokes every other species if given the chance. Young flowering plants and ferns should also be removed, as they too will soon smother the mosses.

A situation for the moss garden should be chosen which is sheltered from the wind and is protected from direct sunlight, at least from April to September. An ordinary unheated greenhouse is suitable provided there is shade from the summer sun and precautions are taken against over-heating.

With these hints and a little preliminary experience, anyone should be able to embark on a successful career as a moss-gardener. The small amount of trouble involved will be well repaid.

The collecting, naming and classifying of species is, of course, not the beginning and the end of the study of mosses, though for some people this in itself is a sufficiently absorbing occupation. Mosses offer countless subjects for investigation to those who have the time and inclination. The growth and seasonal behaviour of mosses, their methods of spore dispersal, their biological relationships with one another and with other plants, their distribution in relation to soil and climate, all these are full of interest, and anyone who wishes to take up the study of mosses will find no lack of unsolved and fascinating problems, many of which can be studied without elaborate apparatus and can be commended to the amateur as well as to the professional botanist.

Having read thus far, the reader may perhaps ask now: What use are mosses? It may be admitted that mosses are interesting and beautiful things in themselves and therefore worthy of study for their own sake, but are mosses of economic value and do they play an important part in nature?

As far as direct economic value is concerned, mosses are not of great importance. They cannot be eaten and provide no useful drugs or fibres. Such uses as mosses have depend mainly on their absorbent power and their spongy, springy texture when dry. Moss makes an excellent packing material; when dry it can be used for packing fragile objects, when moist it makes the best material for packing living plants. It has the advantage that it does not easily rot or become mouldy. The larger mosses, such as *Hylocomium triquetrum*, are often used for decorations and in making wreaths. For this purpose they are sometimes dyed bright green, because their natural pigments soon become bleached by the sun. In former days they had various uses in rustic life. They were much used for stuffing mattresses and pillows. In the *Natural History of Selborne* Gilbert White speaks of 'little neat besoms which our foresters make from the stalks of the *Polytrichum commune* or Great Golden Maidenhair, which they call Silk Wood and find in plenty in the bogs. When this moss is well combed and dressed and divested of its outer skin, it becomes of a beautiful bright chestnut colour, and being soft and pliant, is very proper for the dusting of beds, curtains, carpets, hangings, etc.' Similar brushes are made, or were made until recently, in other places than Selborne. In some districts the stem of this same moss was

actually woven into baskets. This moss basket-making is evidently a very old craft, as an unfinished *Polytrichum* basket, probably of native British workmanship, has been found in one of the Roman forts at Newstead, Roxburghshire.

*Sphagnum* has far more economic importance than other mosses. It is largely responsible for the formation of peat, in fact some kinds of peat consist of little else than the compressed remains of *Sphagnum* moss. The value of peat for fuel and other purposes is so well known as to need no discussion. Fresh *Sphagnum* chopped up and mixed with potsherds forms a good compost on which to grow plants such as hot-house orchids. It also has several important uses owing to its great absorbent power (it can absorb many times its own weight of water) and its slight antiseptic properties. *Sphagnum* has long been used for making absorbent bandages, and during both the World Wars it was collected in large quantities both in England and America for the Red Cross. Though in various parts of the world *Sphagnum* grows in great abundance, the supply is not inexhaustible, and in America and other countries steps have been taken to conserve it, mainly in order to safeguard the resources of peat.

Though mosses are thus of some direct value to mankind, their indirect value is far greater. This is because of the part they play in the welfare of vegetation, a part which is subtle and inconspicuous, but none the less important. Mosses, for instance, are of great value in colonizing bare rocks and screes. They hold the water and tend to keep the surface moist, and they assist in the weathering of the rock, so that it gradually becomes converted into soil. By doing this they prepare the way for other larger forms of vegetation. In the colonization of rocks mosses are usually not the

earliest pioneers. Algae and lichens, which make still smaller demands for soil and moisture, generally come first; these are followed by mosses and these in turn by trees, shrubs, grasses and herbaceous plants. The moss tufts, because of the moisture and humus which collects in them, form very good seed-beds and many of the flowering plants which grow on rocks can only do so when there are moss tufts in which their seeds can germinate.

Besides this action of mosses in preparing the ground for other plants on bare rock surfaces, mosses are important, especially in mountainous regions, in covering bare soil, diminishing soil erosion and, by decreasing excessive run-off of rainfall, preventing floods. They add valuable humus to the soil, and keep the surface friable, moist and at an even temperature. In woods the moss covering of the soil is important in keeping it in a fit condition for the growth of trees and their young seedlings. In parts of Germany when the peasants collect moss from the forests as litter for their animals, this has been found to have an ill effect on the growth of the trees.

It will now be seen that mosses have an importance in nature which far outweighs their comparatively trivial direct uses. Though moss on a lawn or garden path is regarded as a nuisance, the many beneficial effects of mosses should also be remembered.

## *Johannes Hedwig and his Books on Mosses*

THE plates with which this volume is illustrated are taken from Johannes Hedwig's *Descriptio et adumbratio microscopico-analytica muscorum frondosorum* (Leipzig, 1787–97). This book, because of the accuracy of both text and illustrations, was a landmark in the study of mosses; its author was one of the most remarkable of the many great figures in late eighteenth-century botany and one of the best microscopists of his age, so a few notes on him and his work may be of interest.

Johannes Hedwig was born in 1730 in the beautifully situated town of Kronstadt (or Brassó) in Siebenbürgen (Transylvania), a part of the Carpathians which has in recent times sometimes formed part of Hungary and sometimes of Rumania, but in the eighteenth century was part of the Austro-Hungarian Empire. Like most botanists of his day, Hedwig was by profession a medical man. He qualified as a doctor at the University of Leipzig, but employed part of his time in classifying and arranging the plants in the university Botanic Garden. He worked first at Chemnitz and later at Leipzig, where he obtained an appointment in 1784 at the Military Hospital and in 1786 became Professor Extraordinary of Medicine. His main love, however, was for botanical research, which he had long pursued in spite of great difficulties, and in 1789 he was appointed Professor of Botany at Leipzig, a post which he held till his death in 1799.

Hedwig's work covered several branches of botany, but he is remembered chiefly for his researches in plant anatomy and on the mosses. In his day the life-history and reproduction of the lower plants was still largely a mystery. The mystery was not fully dispersed until the following century, but Hedwig made a notable advance by his 'theory' that the antheridia and archegonia of mosses were respectively their male and female reproductive organs and therefore comparable to the stamens and ovaries of flowers. Previously it was supposed that the spores were the male cells, a view made plausible by their resemblance to pollen grains. His books on mosses were a great improvement on anything that had been done previously because of the accurate description and delineation of microscopic detail. The excellence of Hedwig's work was partly due to the technical improvements in microscopes which had been made during the eighteenth century, but it largely depended on his skill and thoroughness in observation.

## NOTES ON THE PLATES

### 1. Peristome teeth of various mosses

(a) *Atrichum undulatum*. (b) *Grimmia apocarpa*. (c) *Tortula rigida*. (d) *Camptothecium sericeum*. (e) *Fontinalis squamosa*.

### 2. *Atrichum undulatum*

The genus *Atrichum* is closely related to the Hair Mosses (*Polytrichum*), from which it differs in the thinner, paler green and more transparent leaves. *Atrichum undulatum*, a common moss of woodland and hedgerow, is like some species of *Mnium*; it grows stiffly upright; the leaves are wavy at the edges and bear minute teeth. A peculiarity of both *Atrichum* and *Polytrichum* is that the mouth of the capsule is covered with a delicate whitish membrane (the epiphragm) (see Pl. 1, Fig. a), so that the spores can only escape through the minute slits between the peristome teeth. *Atrichum* was formerly called *Catharinea* (named after the Empress Catharine the Great of Russia).

### 3. *Camptothecium sericeum*

This is one of the commonest mosses both on walls and on trees. The stem is creeping, with numerous short branches curling inwards when dry. The finely pointed, almost needle-like leaves and the yellowish, shiny, silky appearance are characteristic.

### 4. *Eurhynchium Swartzii*

This and its near relative, *Eurhynchium praelongum*, are much alike. Both are delicate feathery mosses with creeping, slender, much-branched stems. Besides various other differences, *Eurhynchium Swartzii* can be distinguished from *E. praelongum* by the more yellowish colour. Both mosses are abundant everywhere in shady places, woods, hedges, etc.

5. *Hypnum cupressiforme*

This is perhaps the most widely distributed of all mosses. As well as growing abundantly in every part of the British Isles, it is found almost all over the world and is noted for its many puzzling varieties, some of which superficially look very different from each other. Usually it grows in dense mats which may cover large surfaces of rocks or tree trunks.

6. *Brachythecium rutabulum*

A large, rather coarse, untidily growing species, typically of a pale-yellowish or whitish-green colour. It is one of the commonest of British mosses in woods, hedges and among grass; it is often a pest on lawns. The large swollen spore capsules are often produced in abundance.

7. *Rhacomitrium lanuginosum*

This is one of the most characteristic mosses of moorlands and the tops of dry stone walls in Wales, the Lake District and other hilly country. It forms large swollen cushions, six inches or more thick; the long silvery white tips of the leaves give the whole plant a greyish woolly appearance.

8. *Grimmia apocarpa*

This grows in dark-green tufts about an inch high and is common on rocks and old walls. The wide-mouthed capsules, with a single ring of peristome teeth, are borne on very short stalks, so that they are almost hidden by the upper leaves, but their bright colour makes them conspicuous.

9. *Schistostega pennata*

This is rather an uncommon species, but is generally found in great abundance where it occurs. It grows in caves, rabbit-holes, the entrances of old mine-shafts, etc., and its protonema reflects the light in a remarkable way so that the place where it grows seems to emit a bright emerald-green light, as if the moss were luminous. The leaves are in two rows and placed vertically, as in *Fissidens* (Pl. 10), but they are much more translucent and are quite different in structure.

## 10. *Fissidens bryoides*

A common moss on hedgebanks, sides of ditches, etc., on clayey or loamy soil, where it grows tufts or small carpets thickly covered with spore capsules during the winter and spring. The genus *Fissidens* is easily distinguished from all other mosses, except *Schistostega* (see Pl. 9), by the arrangement of the leaves, which are in two rows, placed in a vertical plane, so that the shoot resembles a tiny fern frond.

## 11. *Dicranella heteromalla*

This moss can be recognized by its long, very narrow leaves, which are bent to one side. The bright orange colour of the spore capsules makes a pretty contrast with the dark green of the leaves. *Dicranella heteromalla* grows in extensive carpets on banks and in woods and is very common, especially on sandy soils.

## 12. *Encalypta vulgaris*

*Encalypta* is sometimes called the Extinguisher Moss, from the shape of the calyptra, which is unusually large and completely conceals the capsule. This species is found growing in small tufts on walls and on the ground on chalky or limestone soil.

## 13. *Barbula unguiculata*

This is a very common plant on paths, bare soil by roadsides, walls and other places. It grows in dense tufts and the long, slender, spirally twisted peristome is a characteristic feature of *Barbula* and its relatives. The numerous species of *Barbula* can only be distinguished from each other by slight, mostly microscopic, differences.

## 14. *Phascum curvicolle*

A minute moss found on bare chalky soil during the early spring. The whole plant is only two or three millimetres high and the spore capsules which peep out sideways from the tuft of small leaves are the most conspicuous part. The capsule of *Phascum*, like that of various other very small mosses, has no lid and the spores are released by the tearing or rotting of the capsule wall.

15. *Pottia truncata*

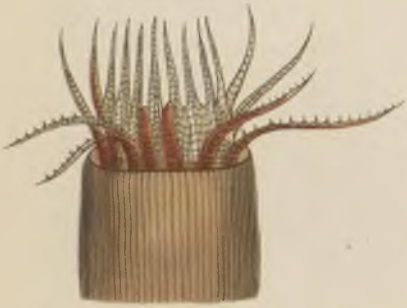
In this moss the capsule opens in the usual way, by means of a lid, but there are no peristome teeth. The plants are found scattered rather than in tufts, on bare soil in fields and on the sides of ditches, during the winter and spring.

16. *Fontinalis squamosa*

The species of *Fontinalis* are large mosses which grow under water. *Fontinalis squamosa* forms long trailing masses of a very dark-green colour attached to stones in swift streams. The commoner *Fontinalis antipyretica* grows mainly in slower streams and in lakes and ponds; it is generally larger and its leaves are sharply keeled and folded along their length.

A *Atrichum undulatum*

C *Tortula rigida*



D *Camptothecium sericeum*

B *Grimmia apocarpa*

E *Fontinalis squamosa*


Atrichum undulatum

*Camptothecium sericeum*

*Eurhynchium Swartzii*

*Hypnum cupressiforme*

*Brachythecium rutabulum*

*Rhacomitrium lanuginosum*

*Grimmia apocarpa*


Schistostega pennata

*Fissidens bryoides*

*Dicranella heteromalla*

*Encalypta vulgaris*

*Barbula unguiculata*

*Phascum curvicolle*

*Pottia truncata*

*Fontinalis squamosa*