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PRACTICAL FIELD BOTANY

BY

A. R. HORWOOD, F.L.S.

MEMBER OF THE ECOLOGICAL, CONCHOLOGICAL AND OTHER SOCIETIES
AUTHOR OF "PLANT LIFE IN THE BRITISH ISLES," ETC.

Illustrated with 20 plates and 26 figures in the text



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PREFACE

As the ground that this little work covers is somewhat new, and the plan is largely original, a few words of explanation are required to state the objects I have had in view in writing it.

Considerable experience in the requirements of a mixed public as to the most useful and popular branches of museum exposition has impressed me with the fact that the knowledge-seeking section is on the increase.

At the outset it should be stated that the public can be divided, in so far as science goes, into two sections, (i) those that come to learn; (ii) those who have but a dilettante interest in things in general.

The first section, with which I am concerned, is made up again of (*a*) the amateur, with little or no expert knowledge; (*b*) the student who has some expert knowledge, and an object in view.

Under (*a*) we may include that increasing body of people, children and teachers in elementary schools, as well as a large body of the general public interested in Nature, all of whom are ardent devotees to the comparatively new science, Nature Study. At present the State has made no provision for the teaching of this subject in the schools, except by voluntary effort, hence those who teach and those who are taught must perforce be styled amateurs. But since all nature students are progressive, they are by dint of personal effort, though self-taught, destined to become experts sooner or later, as the value of Nature Study is better recognized both by the individual and the State.

Some idea of the extent of Nature Study may be gained from indirect evidence by the following result of an appeal to Nature Study teachers to prevent any extermination of wild plants in the pursuit of the subject by children in the elementary schools.

An appeal was made to over sixty County Councils to enable the Plant Protection Section of the Selborne Society, of which Dr. A. B. Rendle, F.R.S., is Chairman, to distribute leaflets

(*see* Chap. III) to the schools. As a result nearly all of them responded, and the teachers applied for some 50,000 leaflets for distribution. Had more been available they could no doubt have been usefully employed in the same direction.

This tends to show that Nature Study is generally popular amongst the general public.

By a similar method it is possible to estimate the extent of interest in botany from the more serious or special point of view evinced by the student.

In this respect museums to-day have adopted the principle of devoting certain types of exhibits to the four main sections of the public, (i) general public; (ii) collector; (iii) student; (iv) research student. And the sections set apart for the collector and student are as important as the first, which is also adapted to elementary Nature Study. In its advanced stages the latter is progressive to sections (ii) and (iii).

Not only are the usual students' series in the cases largely used, but the plant-tables, now so general in museums, are increasingly popular and used systematically and scientifically by the student (*see* Chap. III).

These healthy signs show that botany is becoming more popular. They also indicate that the time has come to foster the interest by a more intelligent means than has been employed in the past.

Fortunately for the student, the new study of plants in their habitat, or ecology, has arisen as a means of stimulating and developing that interest, which is now evident on all hands. But till recently it has been studied on scientific lines only by the fortunate few who have ready access to the work of the specialist. Its methods, aims, and scope have not been explained to the large, and increasing, number of its adherents. The time has therefore arrived to explain and set forth the principles by which the ecologist should be guided, and the apparatus and plan to be adopted to enable him or her to work upon sound and approved lines.

The five chapters into which this book is divided aim at supplying this need. And I think it should be recognized that between Nature Study on the one hand, as a popular science, and Ecology on the other, which is an exact or more systematic science, there is an intimate connexion. Hence the scope of this book, in which the two are combined, is wide, and whilst offering suggestions for more elementary

work, the book also describes in outline the ideals and methods of the more advanced worker. As a matter of fact the chapters are arranged so that the progressive character of Nature Study, and the inter-connexion it may be said to have with Ecology, may be clearly recognized.

The first chapter, on the scope, object, and aims of botany, therefore, deals with the manner in which plants may be studied in the open, as this work is restricted to field botany, from a broad and popular point of view.

The lines of work suggested are thus broad and easy, whilst more detailed methods are described for the student who has advanced still further than the amateur. It has been our object to satisfy the requirements of both Nature Study and pure Ecology at the outset, and more special work has been reserved for Chaps. III, IV, and V.

In the second chapter I have attempted to set forth the best methods to be adopted in carrying out field-work, and preserving the material collected for future study. In this section the collector is, I trust, amply provided for, and the student also equipped with a guide more or less complete, I hope, to botanical methods in the field and study. Not only have the better known processes been described, but a number of more special and refined methods, accessible only to the specialist, have also been set forth for the first time in a popular treatise, a few being entirely new.

Proceeding upon the same progressive principles, I have described in the third chapter, on the encouragement of Ecology and the study of life-histories of plants by existing institutions, the ways and means that can be utilized to establish the study of Nature, particularly botany, upon a firm basis. The preliminary remarks in this introduction will here be found more fully expanded.

This aspect of the subject is extremely important, for we are, I believe, on the eve of the recognition that ideally education is comprehensive of all institutions that cater for knowledge, and that each has an inter-connexion. The object of this chapter is to help the reader to realize what possibilities lie at his command, to be used for his own advantage or that of others in any subject he chooses to study.

The fourth chapter brings the reader to the recognition of the value of the new botany, and the renewed interest to be derived from a study of plants upon such lines. Recogniz-

ing the value of the study of Ecology, and proceeding still progressively, it is recommended that at this stage encouragement be given to the study of plants bionomically, or in every phase of their life-history, over and above the study of their habitat and its characteristics, the inter-relation of species, embraced by Ecology.

The aspects of botanical work outlined in this chapter provide a fund of interest and opportunity for original work, which is possible for every zealous worker, and I have little or no doubt that when the interest these features present is better recognized and more generally followed up, the number of botanical students will be immeasurably augmented. A great deal of scope for original observation is afforded in this direction. For as yet but little is known of the life-history of plants.

The fifth chapter describes the general characteristics of the different types of vegetation that may be recognized on a wide and convenient basis. There is ample scope for observation upon the types that are represented in every part of the British Isles. And when the manner in which these tracts can be studied is widely known the opportunities presented in this field will not, I think, be long neglected. The publication of Prof. Tansley's "Types of Vegetation" will, I think, do much to promote this branch of the subject, and I have followed that work in the main, adapting the divisions to the needs of the beginner.

I have gathered information from many quarters, and desire to acknowledge help derived from the Museums Association or Museums Journal, the Annual Reports of Museums, especially those of the Smithsonian Institution, and Royal Botanic Gardens, Edinburgh.

My thanks are tendered to Miss Isabella M. Charters, for drawings reproduced in this volume; to Miss C. E. C. Measham, for reading the manuscript for press; to Mr. W. E. Mayes, for his account of the modelling of flowers in wax; to Mr. W. M. Webb, F.L.S., for permission to use the illustrations of the travelling Exhibit, and to many other friends for kind suggestions. I am indebted to my publishers for securing the copyright in the photographs of Messrs. L. R. J. Horn and A. Newton, and I am also under obligation to Mr. T. R. Goddard for a photograph.

So far as possible I have undertaken to illustrate this

manual by drawings or photographs of the equipment required, or the processes to be employed. The photographs of the types of vegetation in themselves should prove a stimulus to those who are unacquainted with this branch of botany; but this number must be increasingly smaller, for only recently, whilst these chapters were being written, a society has been formed for the promotion of Ecology in this country. This fact in itself may be regarded as sufficient reason for the appearance of a manual, preliminary though it be, upon the subject. In attempting to supply such a need I hope that I have succeeded in the main.

The author will be glad to receive any suggestions that may be made in regard to the principles or methods here described.

A. R. HORWOOD.

LEICESTER MUSEUM, 1914.

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PRACTICAL FIELD BOTANY

CHAPTER I

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1. The New Botany. Their classification as herbs, trees, or shrubs, and certain mystic properties with which they were endowed by aid of the Doctrine of Signatures, was practically the limit of the knowledge of plants of our forefathers in the Middle Ages, though it should be pointed out that apart from this there were many who recognized real medicinal properties on a rational basis. And it must not be forgotten, however much we depreciate (as is necessary) some of the work of the past, that all the present is built up upon not only the successes but also on the failures of the past.

This gave way to a much more intelligent, if more detailed, study of the morphology or external anatomy of plants ; and, with the introduction of the microscope, to that of their histology. Men's interests were almost solely absorbed at first, however, in the exhaustive analysis and accumulation of facts, and if the botanists of those days attempted to generalize or to theorize it was with too great a mass of undigested material that they had to deal, so that their notions appear necessarily crude in our eyes. They laboured under disadvantages that we can hardly realize, hence any criticism that present knowledge demands as to their results must be tempered with a real admiration of their foresight and skill. Later, systematic botany held the field and, together with morphology and anatomy, continued to constitute the main lines of botanical research till the latter part of last century, when the inspiring results of Darwin's theory of natural selection had just begun to show fruits. Physiology also at last became an exact science, having played far back some part in the principles of classification.

At the present day the study of the plant's life-history and its relationship to its surroundings, or the ecology of plants, bids fair to hold the field in the direction at least of outdoor work.

This new botany,* as we may call it, since it has given an entirely new phase or impetus to the subject, has not unnaturally helped to infuse it with fresh interest, and the subject has many fascinations. It is with the ecological aspect of botany, then, more especially that this book is principally concerned.

In the same way as the " new collecting," of which we have heard so much, ecology is a great factor in the preservation of our wild flowers, and for that reason alone it is to be hoped it will not lose any of its present popularity. As will be seen, it gives an opportunity for the student or observer to accumulate many interesting facts without collecting material. It sharpens the intellect by guiding the reasoning powers along various new channels, and has thus a healthy and invigorating influence on the human intellect.

This new collecting instinct indeed may apply equally well to plants as to animals. The need for preservation is quite as

* In the sense that it has given an entirely fresh character to field-work, old as that is from a more general point of view.

great, as will be shown. It is therefore just as necessary and important to substitute for material a photograph or a series, and to treat it as a link in a chain of aspects of the life-history, and so allow others to study the plant, at different times, in different stages, and from any standpoint. There is in this case no danger of disturbing the plant by frequent "sittings" for photographs; and though colour photography is in its infancy it is safe to predict that in ten years' time it will be as easy to photograph flowers in colours as it is to take an ordinary photograph to-day.

The prevalence of flower-photography is to be measured perhaps by the numerous Christmas and New Year cards that are composed of floral subjects. Moreover in many cases botanists are in the habit of preparing small specimens to paste upon cards for this purpose, and it is desirable that prints should take their place—a practice on the increase.

2. The Relative Importance of Field-work compared with Laboratory or Herbarium Work. The study of plants must obviously begin in the field, for the procuring of material, by that necessary means to an end, collecting, must be done in the field, and intelligently. Field-work at one time, moreover, more or less began and ended with collecting.

Work in the Laboratory or the Herbarium was at one time always held to be of paramount importance, though field-work was undertaken on a small scale. But all things have their place, and the slavish adherence of the old school to the bench and basin has been a fruitful source of ignorance in the conception of the true functions of plant organs and their adaptation to the external conditions of the plant's environment or its own requirements, through want of insight into the actual surroundings of the plants themselves. An exception must be made here in the case of the early expeditions made by botanists to various parts of the world, when large numbers of new plants were collected.

The necessary operations of preparing, slicing, and mounting of sections, their microscopical examination, or the dissection, reconstruction, comparison, and arrangement of plants, fresh or dried, necessarily takes place in the laboratory, and in similar directions herbarium work equally has its place. Not the least important, too, is the study of botanical properties in the library and the careful working out of distribution, theories of origin, etc., required in the library or study.

But the new botany has so great an attraction for the student from the first-hand information to be gained in the field on the new, broad, but infinitely patient lines of the ecological method, that there is little doubt that the generations to come, like the present one, will be imbued with that love of the open, the fresh air, the beauties of the sky, field, and wood, that lend such a charm to our English landscape. The study of landscape indeed, if it rests with the painter in the mass, is being built up to-day little by little by the study of its parts, from a strictly scientific point of view, by the botanist. So that if a rising generation of painters be first trained in botany they will, if landscape artists, be as nearly as possible versed in the empirical lines of true art. Then it will be possible to say of a man, "He has the eye of a naturalist (or botanist) and the hand of an artist."

What possibilities lie indeed in the path of ecology we can only unfold in a slight degree in these pages. But it is enough to say that whereas field-work in the past was very much neglected, or, as mere collector's work, dealt only with one aspect of the subject, at the present day the case is different; and the work of the section-cutter and maker of a *hortus siccus* to-day is regarded as less important than formerly. We wish here to try to adjust the proportions between the two branches of plant geography.

3. What to Study. In trying to indicate some aspects of the subject-matter of botany as a whole, in relation to the British flora more especially, one is met, not with the difficulty of a dearth of material, but rather with its wealth. We may select* a few questions from an abundance of sources, such as the titles of articles in journals, matters of interest dealing with the natural history of the plant more especially, or subjects that will attract. First of all there is the subject of "plants of the district." Even if the question resolves itself into how many wild flowers grow in one district, it is worth the study to compare the flora of one district with another, to note its composition and so on. "How plants wage war below the surface" is another topic we may study, noting how bulbous plants force their way up through leaf-mould or other plants.

* The selection made is purposely drawn from a variety of sources, dealing with subjects outside the usual well-known courses followed out in botanical text-books or by lecturers in the lecture-hall or study or in the school.

Then we could take up the study of "leaves," to note their shape, the relation of this to moisture, the stomata, hairs, glands, etc., on the surface for transpiration, protection, etc., the nature and distribution of the veins, how the leaves are protected in the bud, by stipules and so on. The spines borne by trees or other plants protect them from drought in some cases.

Then "the reason why leaves fall" is of interest, as it is not explained so easily as appears at first sight. It is, briefly, because a layer of corky cells is formed where the petiole and stem meet, to prevent an undue loss of water in winter, which without special adaptations all but evergreens cannot avoid in winter. The time when trees come into leaf (or their affoliation) is of equal interest, as also when they are in full leaf, when partly so, when bare but budding, when quite bare; and to compare different trees in these respects at the same time is of importance.

"Plant hairs" and their functions, whether confined to leaves, stem, or other parts, would yield material of value. "Evening-blooming flowers and how quickly they unfold, their relations to insects and why they are so sweet-scented, and usually white-flowered, or yellow," is a subject filled with possibilities.

"Why are hedgerow shrubs usually white-flowered," might prove again a fruitful subject for investigation. The "use of wild-flower waste products" would show the use of poplar catkin cotton and thistle-down, as well as dandelion "clocks," etc. The form and size of "pollen-grains" would be an interesting object of inquiry, some being triangular, some hexagonal, some circular, spinose, polyhedral, and so on. "Seeds," again, whether enclosed permanently or not in their outer covering or fruit, yield the same interesting matter for thought, some having a netted or mucilaginous surface to aid them in adhering to the earth particles, some, like the stork's bill, with a hygroscopic appendage or awn which helps to bury them under the surface.

The question of how to procure fruits and berries of foliage for decoration at Christmas, and how to preserve them, is one which once pursued might lead to a further inquiry and gradually awaken botanical interest. In the same way a study of "autumn fruits" would yield such a wealth of interesting facts that it would be sure to lead the inquirer

to pursue the subject further. The application of such specimens too, when dried, to the ornament of wooden frames, for instance, is worthy of more attention.

The subject of trees is an exhaustive one. If we consider only " wayside trees " we may compare those of our country lanes with those of the towns. And in this matter we could go further and compare our roads and their upkeep with similar roads and lanes abroad, for, to our discredit, we are more badly off in this respect than other countries. Tree lore is full of interest, for men once thought the tree was the first life-giver, and as it is probable that the smaller non-arboreal types once all grew in forests, and our early angiosperms were arboreal, probably this theory is based on some analogy with fact in so far as botanical origins go. The curious instances of double trunks, or trunks surrounding a stone around which they have grown, plants united above, and how herbs are found inside tree-trunks, are topics that, if pursued and answered, as they may be, might lead to a continued interest in plant-life generally.

The composition of the landscape and the trees that form it, their relation to it, the way in which landscape is influenced by trees, and vice versa, are subjects that are full of practical and æsthetic problems. Then there is the question of the herb-collecting which in botany centred around this, but is now extended to all kinds of plants. The half-dozen or more royal trees, or an inquiry into the size and age of our oldest oaks, if followed up might be the means of making a botanist.

The whole question of plant scent is full of material for research. So too is the little understood albinism and mimicry of which a few cases occur, or the evolution of plants and the relation of animals to plants.

4. How to Study Botany. It is probable that the disinclination of older members of the present generation for botany in their youth was largely caused by the inability of even our leading botanists in those days to provide the most attractive and ready means of cultivating a taste for botany. It may also be attributed to the lack of any facilities such as we enjoy to-day for education, and for science in particular.

Till recently one might almost say there was no such thing as outdoor work required by a study of ecology, and indoor work was confined to the study of tissues or dried stems, etc., or preserved specimens. Many specimens, orders, genera, and

species, were studied, and it was not thought necessary to do more than give a general grounding in such subjects as physiology. But the last subject is intimately connected with the plant's vital activities, and their expression in habits and characters in the field, and is of prime importance in the understanding of function.

Now matters are considerably changed. As we do not here wish to give detailed instructions concerning the general botanical course, but only to satisfy the requirements of the ecologist or field botanist, we need not do more than give a few general remarks (amplified under survey work, and in Chap. II) as to what is needed by a beginner.

One should have good eyes, for this is as important in ecology, in order to detect differences on a small scale in plants, as to discern the colours and forms of birds on the wing in ornithology.

In the field it is as necessary to see over long distances, and catch the general habit of a tree, or the general contour of a botanical association, the contour of a formation, and in a bird's-eye view sum up mentally the general relationship of parts, as it is, at closer quarters, to detect a small duckweed, such as *Wolffia* on water, or filamentous pondweeds below the surface. Therefore let the sight be well looked after.

Again, to the eyes must be added the regular companionship of a good lens, which is the constant mentor in small matters of the itinerant botanist, especially if he be a cryptogamist.

Also a botanist must be a good walker, for neither cycling nor driving is of any use when one has mile after mile of survey work of a detailed character to get through. And to get a comprehensive view of a botanical district one needs to penetrate into all its nooks and corners, dry and wet, therefore one must have good boots. A stick is a helpful aid to walking and is very useful on many occasions.

The power of endurance must be unlimited, for field-work, while *par excellence* healthy work, is also arduous. The mental grasp must be well balanced. One has to be able to analyse details, to pick to pieces, as it were, the ground inch by inch, and at the same time to lose sight of them more or less in attaining to a grander and wider view of the whole structure at once. Such are the main qualities and some needful accessories that one requires for field-work in general. And it is by the

aid of this field-work that we wish the necessary botanical work to become interesting.

To study wild flowers one needs to get a general idea of the scope and importance as well as the lines of work laid down in a general work of botany, such as Dr. D. H. Scott's "Structural Botany," Prof. Strasburger's "Text-book of Botany," or, if too large, a smaller one, such as Francis Darwin's "Elements of Botany."*

Having learnt the general principles of morphology, and studied in outline the classification of the main groups, a few groups should be selected, and typical examples of each (not allied species) should be dissected (for details see Chap. II); and the plants should be described according to an approved plan, and compared with published types or preserved and named material (dried or in spirit). It is well to draw the essential parts, such as the flower, and to keep these diagrams for reference. Take one of the **Ranunculaceæ**, a **Crucifer**, a **Caryophyllaceous, Leguminous, Rosaceous, Umbelliferous, Composite, Labiate, Orchidaceous, Liliaceous,** and **Gramineous** type, and later proceed to study others.

If work is begun in the winter, by the time the flowers are in bloom the list can be extended, and it is an excellent plan to study the germination, budding, unfolding of leaf, growth and branching of the stem, flowering, and maturing of the fruit or seed, as well as their form and structure out in the open, under the blue sky and in the fresh air. Having mastered several types, it should be possible to go on and study generally the reasons (by the comparison of characters) of their classification into orders, families, genera, etc. Then the idea of the species will gradually unfold itself. But one should not study too many types at once, and the whole life-history of each type should appeal to one's interest, and give one a more complete knowledge of each. Then the otherwise often fragmentary knowledge of the systematic characters alone will no longer repel, but attract.

An attempt has been made to suggest here a more comprehensive mode of study, which it is hoped will be the means of fostering a deeper study of each plant in so far as the descriptions of the habitat, habit, pollination, dispersal, relation to insects or fungi and soil are concerned.

Had space allowed, some further items in the life-history

* Other works are mentioned in the Appendix.

of the individual might have been included, but this has not been deemed advisable at this stage. What have been given are the more essential activities of the plant in its struggle for existence.

Some aids to the study of botany are given in Chap. III under the relation of schools to museums, and other State or municipal institutions. If the student is under a tutor let him visit a botanic garden or arboretum or park, and study in the open some of the details explained in lecture time, on the blackboard or otherwise, and let these visits be paid on a definite plan, suited to the time of year and subject.

When the general characters of the principal orders have been studied in the herbarium, study, or in the field, and a good grasp of principles has been obtained, the interest aroused by repeated ecological excursions may be further stimulated by the undertaking when ready of a definite piece of survey work. The details of this are described later.

Generally speaking, for study work have a good set of dissecting instruments, drawing materials, good paper, pencils, etc., lens, note-book, vasculum, glasses, and other requisites mentioned in Chap. II.

At all times sustained patience and a dogged determination to master detail at the expense of unlimited pains alone ensure success.

5. When to Study Wild Flowers. As our work in ecology is largely dependent upon the period of flowering, and many hardy perennials as well as bulbs die down, whilst annuals and biennials also entirely disappear during winter, it is well to consider when to study in the field.

Really there is always something to do. But whilst Christmas flowers are few and far between, there are the leafless trees to study in their winter stage, and later the budding of the twigs. It is a good time to measure the girth in winter, by tape or by increment borer, also the effects of pruning or transplantation.

Such winter aspects of trees may be photographed, and also frosted foliage to show the effect on evergreens, which latter are always accessible for observation. The flowering of a Bramble such as *Rubus rusticanus* on December 21, and the production of fruit, would alone be worth noticing, if it were not one amongst many such.

Work in winter will indeed be very varied. It is possible

then to see the mechanism of plant stems in the wreckage of last year's growth, not obscured now by the foliage. It is only when the leaves have fallen in hedgerow, wood, and forest that one can see how the deciduous trees and shrubs really grow, their relation to each other, the light, warmth, etc.

Young plants such as **Wood Sorrel** are peeping up beneath the carpet of leaves. It is then possible to find plants which have not quite died down, which are obscured in the shade or by surrounding sturdier competitors in the summer. There are indeed a few plants in bloom, as **Buttercup, Daisy, Groundsel, Shepherd's Purse, Winter Aconite, Snowdrop,** etc. Then one may find many fruits and berries suited to the birds, or seeds or fruits fallen from last autumn's stems, and one can study their shape and adaptation to germination or dispersal.

The flowers that bloom early can be noted, and a calendar formed showing when each opens out. Indeed, each month has its complement of flowers ; and ferns, trees, the wreckage of last year may be studied in winter, by aid of Nature's mode of skeletonizing leaves. Leaves so preserved may be compared with those that may be treated artificially. We find February and March bring us to the month of buds and sprouting bulbs, sap rising in the trees, and all living things renewing their activities.

It would be a record to find **Ivy-leaved Toadflax** on January 19, **Red Lychnis** on January 27, **Cuckoo Flower** on January 29, or **Lesser Celandine** on the 23rd, though **Hazel, Primrose, Gorse,** and **Dog's Mercury** are more commonly in flower by then. And we could continue this record through the year, noting **Butterbur** on February 5, and its ally, **Coltsfoot,** also the **Dog Violet,** on the same date. Again, March 5 is early for **Red Deadnettle,** March 12 for **Hairy Bitter Cress,** March 22 for **Greater Stitchwort,** April 1 for **Cherry, Cowslip, Lesser Stitchwort.**

But flowering periods differ in the North and the South, and depend upon the amount of sunlight and warmth in each locality, and it could be ascertained whether it is sufficient to establish a definite known thermal constant for the expansion of leaf or flower.

The flowers to be found in bloom from April to October are the non-bulbous, the annual, biennial, and later perennial plants. Here we have a regular succession of flowers in each

month, with April characterized by early moist meadow and woodland herbaceous plants. Then trees begin to bud and leaf, after flowering earlier and being wind-pollinated. No grasses have as yet appeared. In May we have **Hawthorn, Dog Rose,** and the **Meadow Grasses** and early **Orchids.** In June the cornfield weeds appear, **Charlock,** etc. July, August, and September give us a wealth of **Umbellifers** and **Labiates,** and **Sedges** are by now in fruit. **Brambles** fruit in August, and **Chenopodia, Oraches,** and still later **Hawkweeds** are by then in bloom. The latest flowering plant is **Ivy,** which blooms in November. The autumn is the time for observing fruits and seeds, and their modes of dispersal. All through the summer we shall have been busy with the flowers and the bees. During autumn we can observe the relationship of plants to fungi, and collect the leaf-forms. It is well to remark here the need of collecting catkins and leaves at two different seasons in the case of willows and other trees. Brambles also require that the flower and panicle should be collected as well as a piece of the barren stem. The height of flowering plants should be measured at the time of seeding before they begin to shrink and shrivel.

It is the flowers of summer that attract us most, perhaps because of their brilliance, their frequency, and their generally massed effect. It is then, moreover, that the ecologist must be most busy, because he can then obtain the most accurate record of the true flora of any one tract, the plant association, the type of formation it represents, the component constituents and their frequency. If it is then most difficult to wander about in a meadow on account of the uncut hay, none the less it is possible to obtain a larger assemblage of wild flowers in one's photographs and sketches of a district. Then the air is heavy with the scent of **Honeysuckle,** the hum of the bees. Across the valley the **Thistle-down** floats in the air, to fall perhaps a mile away.

The air is clear, field-glasses are scarcely needed, and one can almost discern each insect at each flower without their aid. Moreover the air is fresh and light, so must our spirits rise as we drink of the pleasures of Nature's storehouse.

6. Where to Study Wild Flowers.* This leads us at once into the habitats or haunts of plants. Before essaying forth on any journey a definite object should be held in view, part of

* *See* Chap. V, where typical associations are given.

a wide scheme, or merely an isolated aim, but none the less definite. Paraphernalia necessary for lowland, hill country, or aquatic work should be packed and got ready. A map should be consulted and the route followed out, as well as such necessary details as the time of trains, the whereabouts of inns (this is very necessary, as in some country districts one may pass through several villages that offer no hospitality to the traveller). It is necessary also to cater for one's lunch, tea, etc., if the journey is extended. A journey or excursion of more than one day away from home of course requires still more careful thought, and one needs more personal equipment. It is well to know or decide what type of vegetation one is going to examine, that is, whether it is a field (or series of fields), a cornfield (or series), woodlands, etc.

It may be helpful, here, to point out the *modus operandi* to be pursued in studying any particular botanical formation.

In meadows and fields it is necessary to follow the hedgerows, to look over the ridge and furrow in grass country, noting, for instance, that **Eyebright** grows on the ridges, tussocks in the furrows, to examine carefully all bare patches, noting new arrivals on fresh soil. Banks are very characteristic habitats, the usual manure-heap will yield a few aliens, and all mole-heaps, tumuli, and other mounds are likely to yield interesting materials. The hedgebank and the ditch will each have its typical flora. The pond will occupy some time. The field or meadow itself needs careful examination.

In the cornfield one will study first the border, the fallow margin and the hedgerows, or the dykes, as in Lincolnshire, enclosing the grain, then the bare patches where competition is least severe, next the ground between the furrows, and finally one must search amongst the grain itself. **Veronicas** and the **Mousetail** appear quite early when the young blades have only just appeared.

In woods and copses search along the artificial ridges and the boundary ditches, then examine plant growth under the trees, the climbing plants on the trees, and carefully look along the borders of the woods where sunlight penetrates, on stony patches and rocks in the woods. Then there is the character of the wood itself to be determined, viz. whether it is an oak, beech, or ash wood or other association.

Along the roadside and hedgerows we recommend the student to examine first the margin of the macadam, then the sward

on either side, the ditches, hedgebanks, and hedges. It is necessary to look at the boulders on roadsides, bridges, and curbstones, as well as all waste places, greens, ponds, sheep-dips, and stone-heaps, adjacent to such highways.

Mountains and dry places, bare open tracts, wild furze patches, stony places, and the hillsides around the tarns and lochs in alpine districts, cultivated fields, chalk-downs, bleak open moor-like tracts, and clefts in rocky, hilly country all need examining singly or as a whole.

Along the sea-coast one should work from high-water mark to low, beginning at ebb-tide, and working backwards. At low-water mark certain plants will be found, *e.g.* Saltworts, etc., and others on sand between tide-marks, at high-water level, on sand-dunes, at the mouths of estuaries, on rocks, shelving precipitous cliffs, stony débris, etc., or submerged plants such as *Zostera*.

In bogs and marshes it is necessary to look in wet spongy ground, in deeper water and on higher ground, but based on *Sphagnum* beds, enclosed amid high moors, or at lower levels in the lowlands connected with rivers, etc., in the Fens.

On heaths and moors which form wide open tracts, common land at high or low levels, one can walk round, across, and in and out, and then study them, as the sea-coast, tract by tract, zonally or otherwise.

Lakes and rivers also require a special treatment. First it is best to study the flora of the banks, from the top of the bank downwards for a definite length, then one may take a punt and examine the plants in the water, dredging up samples. Carefully examine wharves, locks, etc., in canals, for aliens.

In the case of waste places it is a good plan to examine and collect, or note down, all aliens along the roadsides, in yards (farmyards or other), quarries, garden ground, building ground, railway station yards, docks, factory premises, mills, granaries, etc.

When examining rocks, walls, gravelly or sandy places, look at all exposed rocks wherever they crop out, in highlands or elsewhere, walls in towns, villages, churchyards, gardens, ruins, etc., and look at the foot and top of walls.

To take a typical excursion or two. If we go to the Lakes, say, Cumberland, and examine a "moss" or peat-bog up in the hills we may find plants quite different from those of the lowlands or centre of England. There we may see **Grass of**

Parnassus, Globe Flower, Bird's Eye, Mealy Primrose, Winter-green, and many **Saxifrages, Sweet Gale, Marsh Succory, Water Violet, Bog Bean, Bladderwort,** etc. Or take the Great Whinsill. There may be found on the hills such plants as the **Shrubby Cinquefoil,** *Sedum*, *Rhodiola*, *Scilla verna*, *Dianthus Deltoides*, **Chives, Rock Roses, Gentians,** etc.

Then compare this with the south country. If one searched for those typical chalk plants, the rarer orchids, one might find any of the following: **Tway Blade, White Helleborine, Bird's Nest, Butterfly, Early Purple,** and **Green-veined** or **Meadow Orchids, Fragrant, Spotted, Bee, Man, Pyramidal, Frog, Fly, Lizard Orchids,** and **Narrow-leaved Helleborine.**

A Scotchman resident in south-west Scotland visited Shropshire and found only the **Dwarf Furze,** none of the common. He found much **Musk,** now spread over every part of the country, originally introduced from America. He missed the **Bell Heathers** of the North, and found only **Ling. Carnation Sedge** was common, with **Bog Pimpernel** and **Butterwort,** but no **Grass of Parnassus** was found, though it is so frequent in Scotland. There was no **Sundew,** which grows so much in the Scotch peat-bogs, nor any **Bog Myrtle** with its fragrant scent.

Though this is merely typical of a short stay in a district, and some of the above plants, if rare, are found in the Midlands, but not now so abundantly, it shows what diversity exists in the plant formations of different areas, due to variation in the soil, etc.

Or let us go to the eastern counties and examine the flora of a Norfolk salt-marsh. There one may find on the sands **Marram Grass, Sea Holly, Yellow Horned Poppy, Prickly Saltwort, Pale Lilac Rocket, Sea Campion, Sea Bindweed,** on grassy stretches **Rest-harrow, Bird's Foot Trefoil, Hop Trefoil, Kidney-vetch, Yellow Stonecrop, Eyebright;** along the river **Shrubby Sea Blite, Annual Sea Blite, Marsh Samphire;** while amid the grassy swamps **Sea Wormwood, Sea Purslane, Sea Lavender, White Brookweed, Sea Milkwort, Lilac Starwort, Thrift, Sea Heath, Scurvy Grass, Pink Sandwort,** are some of the flowers we shall find.

Harking back to the chalk downs, we may find in the vicinity of many a quiet village such an assemblage as the following. Where beech trees form avenues and clumps, there as a rule grow thickets of **Yew, Hawthorn, Furze,**

Heath, with **Juniper** bushes here and there. Amongst the turf are the little **Milkwort, Tormentil, Bird's Foot Trefoil, Quaking Grass, Sedges, Woodrushes,** in coarser pasture **Musk Thistle, Deadly Nightshade** in chalk cuttings, and nearly all the **Orchids** may be found here close to Gilbert White's home, as in Kent.

In upland lanes the following plants may be found, viz. **Black Bryony, Hedge Maple, Dogwood, Wayfaring Tree, Clematis, Bryony, Wood Spurge,** while in the meadows and lanes in the lowlands **Comfrey, Sorrels,** Grasses galore, **Sainfoin, Self-heal, Speedwell, Rose Campion, Yellow Crosswort,** etc., are all common wild flowers.

Or let us survey the possibilities of a piece of waste ground. On one such some forty flowers, largely aliens or colonists, were recently found at Paisley.

Corn Buttercup
Larkspur
Glaucium corniculatum
Flixweed
Erysimum repandum
Flax
Medicago hispida, var. *denticulata*
Melilot
White Melilot
Wormseed
Lonringia orientalis
Gold of Pleasure, and a variety.
Pepperwort
Penny Cress
Weld
Soapwort
Night-flowering Catchfly
Round-leaved Mallow
Malva parviflora
Hare's Foot Trefoil
Vicea lutea
,, *bithynica*
Lathyrus Aphaca
Caucalis Daucoides
,, *latifolia*
Hare's Ear
Stinking Mayweed
Cirsium arvense, var. *setosum f. argenteum*
Chicory
Ambrosia trifida
Great Yellow Loosestrife
Lappula echinata
Bindweed
Thorn Apple
Calamint
Amaranthus retroflexus
Setaria viridis
Canary Grass
Wild Oat.

A tour in the Hebrides would probably yield a few uncommon plants such as *Pinguicula lusitanica,* **Alpine Lady's Mantle, Chickweed Willow Herb,** and some others, but in this case common flowers would be found, as **Angelica,**

Corn Marigold, Marsh Woundwort, Betony, Eyebright, Sea Plantain, etc.

A walk into a wood would reveal to one all the flowers of the forest, the trees, the shade-lovers, and those plants that prefer perennial moisture, and do not need abundant light. Here we should meet with a number of wild flowers too numerous to mention. And the delightful charm of stillness and solitude would not be the least pleasant of the memories to be thus recalled.

7. Plant Watching. It seems rather an anomaly to write of plant-watching when one of the chief characteristics of flowers is their inability to move in the same way as an animal, so that there can be no need to keep them under constant observation.

But in the relationship between plants and animals it is well to accustom oneself to the use of (and need for) field-glasses ; an ordinary short-range pair will do, for the observation of bees and other insects visiting flowers in order to pollinate them. It is necessary, especially in the case of flies, either to capture them on the spot, as soon as they are sighted (and before it is possible to identify them, else they would certainly fly away), or to devise some means of observing them at a distance, undisturbed, and to identify them thus. One can only do this during the daytime, so that night-moths, etc., must be caught at light, and not observed in this way. It is important to pick the best time for observation. In the early morning when all is laden with dew few insects are on the wing, but when the sun has risen and dispersed the moisture they are busy and on the go all the day, especially at midday and just before evening. It is advisable to have a note-book at hand to jot down the visitors, and to make a note as to whether pollen or honey is sought, and any characters needed for identification.

Then the relation of browsing animals to poisonous or nauseous plants can best be studied by means of glasses.

The idea that all plants with brilliant colours are distasteful which are generally held to attract insects to the source of pollen or honey, could be thus tested.

Again, it is only possible to watch the movements of sensitive and insectivorous plants, even though close at hand, by using a pair of glasses, and the natural closing of plants when night falls or rain suddenly descends can be seen without any trouble.

Such automatic movements as the fall of leaves, or the dropping of ripe fruits or seeds, and the dispersal of explosive seeds can only be seen to advantage by the aid of a pair of field-glasses, or by some similar method, when studied in the open.

Another very useful application of field-glasses is in the study of what birds eat in the way of plant food, and it should be possible to settle the question of the value of birds to agriculture by this method. Then the ravages caterpillars make upon trees, at a height, can best be gauged by using glasses, and this applies as well to the state of catkins or flowers growing on tall trees, which are inaccessible for collection without climbing.

8. Caravans and Wild Flowers. Many a tired city worker with a taste for the natural would be far wiser when his nerves are "jumpy" and he is below par, if he avoided the noisy, busy seaside in the summer, and took his holiday in a caravan, in a free and easy way, with nothing to worry about but mealtimes. This mode of travelling is now becoming quite common, and the botanist can utilize it with advantage, for he can trundle leisurely along and collect his treasures (or photographs), or make notes, carrying his home, like the snail, as it were, behind him. As soon as the plant is picked it can be laid on the table in the caravan and dried before it has withered.

9. Marking Down Wild Plants. It is often necessary to note the position in a meadow of, say, a wild Orchid which is in bud or just unfolding, to which it is necessary to return after it is in full bloom, or to wait till a flower has seeded, to study its dispersal. If there are hedges in the field it is a good plan to put up a stick some little (measured) distance away in a line with the plant and a corner of the field on the other side. A walk of so many paces will then bring one to the desired spot; or if it is impossible to make such an alignment, one may put up a stick, and then when it is found tie a piece of string to it and work round it until the spot is found. This method applies equally well to the marking down of mosses or ground lichens.

10. Making a Diary. We have so far dealt only with the observation or examination of plants in the field, but it is necessary to have aids for the memory, and to jot down observations in written form.

This may be done in one direction by the mere construction of a floral calendar. Gilbert White was one of the pioneers in this direction, as he was more especially in zoology. The following is an extract from his and Markwick's calendars combined to show the earliest and latest dates of flowering, with the interspersed bird notes combined:

	White	Markwick
Redbreast whistles . .	Jan. 1–12.	Jan. 3–31 and Oct. 6.
Larks congregate . .	,, 1–18.	Oct. 16 and Feb. 9.
Nuthatch chatters .	,, 1–14.	March 3 and April 10.
Winter Aconite flowering .	,, 1 and Feb. 18.	Feb. 28 and April 7.
Shell-less Snail or Slug (Limax) appears . . .	,, 2.	Jan. 16 and May 31.
Grey Wagtail appears. .	,, 2–11.	,, 24 and March 26.
White Wagtail appears .	,, 2–11.	Dec. 12 and Feb. 23.
Missel Thrush sings . .	,, 2–14.	Feb. 19 and Apr. 14.
Bearsfoot flowering . .	,, 2 and Feb. 14.	March 1 and May 5.
Polyanthus flowering . .	,, 2 and April 12.	Jan. 1 and April 9.
Double Daisy flowering .	,, 2 and Feb. 1.	March 17 and April 29.
Mezereon flowering . .	,, 3 and Feb. 16.	Jan. 2 and April 4.
Pansy flowering. . .	,, 3.	,, 1 and May 10.
Red Dead Nettle flowering .	,, 3–21.	,, 1 and April 5.
Groundsel	,, 3–15.	,, 1 and April 9.
Hazel catkins open . .	,, 3 and Feb. 28.	,, 21 and March 11.
Hepatica flowers . .	,, 4 and ,, 18.	,, 17 and April 9.
Hedge Sparrow whistles .	,, 5–12.	,, 16 and March 13.
Common flies seen in windows	,, 5–Feb. 3.	May 15.

Recently a Nature Calendar for 1766, by Gilbert White, has been unearthed by Mr. W. M. Webb and published in facsimile form under the auspices of the Selborne Society.

The work of Gilbert White has been largely advanced by the works of Mr. Westell, who has published in his "Country Rambles" and "A Year with Nature" observations upon plants and animals seriatim round the year. For instance, in January there are entries under the 1st as to the berries on Holly and Mountain Ash, and the network of trees, the first bulbs through. On the 21st he remarks on the headway of the Honeysuckle, and on the 24th as to the bulbs and Honeysuckle again, on the 25th giving a list of trees delicate in form and colour on that date.

A nature-study printed calendar diary has been prepared by him for use in schools ruled with spaces for notes under the

following headings, which we give to enable others to profit by their suggestiveness:

Date	Rainfall
Barometer	Direction and Velocity of Wind
Thermometer	Locality, Soil, etc.
Seaweed	Ornithology
Wild Flowers	Entomology
Farm and Crops	Garden
Farmyard	General Notes and Obser-
Garden	vations.

There is space for sketches or drawings and ruled pages for making an index. This is an excellent plan.

The diary may be made seriatim in a pocket-book or diary, records under some of the headings above being made of observations taken, or, as referring more especially here to flowers, to the sort of subjects outlined previously as well as the ordinary notes as to flowering, occurrence at such and such a spot, the soil, and any of the natural history features under which the descriptions are arranged in Chap IV. Meteorology is perhaps best noted in a separate book kept indoors with the instruments. Of special interest will be the notes on pollination or dispersal and any other bionomic details. This pocket note-book can be utilized in the field and notes of value copied into a large chronological day diary at home, enlarged upon and neatly written in ink. A series of such diaries would enable one gradually to fill in details for every day on a variety of subjects.

This diary is supplemented by another note-book in which all the information is given under the headings to which each belongs, thus bringing all facts relating to the same subject together, impossible in a journal. Instead of using a bound book one may use separate sheets on the card system, and so allow of an extension or alteration of the arrangement of each unit.

It is well also for ecological work when on an excursion to have a list of plants made at each spot surveyed, or an itinerary of the whole journey as one goes along, or both.

Details of other notes of a more special character and of sketches and maps are given under " survey work."

11. Flower Photography. One of the most interesting and necessary adjuncts to field-work is the photographing of wild

flowers. This requires both patience and interest, for as it is a means to an end it must be done with intelligence or else the results will be poor.

The camera should be both light and portable.* It may be a half-plate stand camera, that can be focussed near the object (Fig. 1). This is impossible or difficult in the case of a hand camera which cannot be focussed, and the use of focussing board and

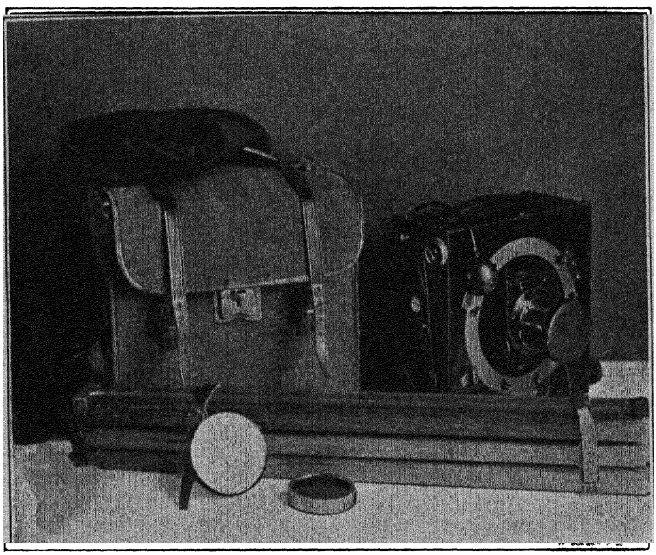


FIG. 1. Camera for photographing plants, with bag, cloth, stand, colour screen.
(Photo, A. Newton)

table of distances will hardly meet the case here. It is important that the shutter be a good one, and the bellows must be light-proof. The fittings of the frame and other parts, struts, etc., are a matter of taste ; but the lens must be a good one.

The stand, if of wood, is rigid, but cannot be shortened satisfactorily, like the more convenient and portable metal tele-

* The ¼-plate size is now in more general use.

scopic and collapsible stands. For flowers, the ordinary tripod head will not do, as it is often necessary to invert the position of the camera or turn it through a wide angle ; hence a tilting-table is necessary. It may be of two pieces of wood hinged together, the one fixed to the stand and the other to the camera base, the two being manipulated by struts and screws at the side (Fig. 2) ; or a more expensive ball-and-socket joint may be fitted to the camera, allowing it to swing in any direction. This allows the lens to be fixed immediately above a plant on the ground.

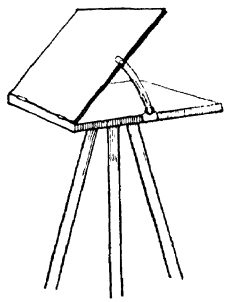


FIG. 2. Tilting-table (I. M. Charters, *del.*)

The lens should be of short focus, say five or six inches. The stops should be at least F11, F16, or F22, and allow the objects to be focussed sharply. This gives definition to all parts of the photograph. Exposure according to time of day and sunlight is best found by use of an exposure-meter. If a series of exposures with details of date, light, etc., is kept, a certain rule-of-thumb method can then be followed.

The plates should be extra rapid if for use with the screen. They should be backed to prevent halation, and be orthochromatic, and sensitive to the action of light diffused by a colour screen, which is useful for flower pictures. A screen is necessary for deep yellow, orange, or blue colours, correcting the defects of black-and-white representation of ordinary negatives. This is 5–15 times, and the exposure must be by that much longer ; hence the necessity of a fine day with no wind for success in this work. The kind of plate is a matter for choice. Paget, Imperial Sovereign, rapid or ordinary, Standard or Ilford plates, etc., can be used to advantage.

The papers employed in printing are glossy printing-out paper, Paget Prize or gaslight paper, which last is used at night with artificial light, or, with certain kinds, even in daylight.

The developer recommended is Pyro-Soda* 10 per cent. solution to which may be added 1 drachm of Rodinal to each

* Or Hydroquinone.

ounce of developer. If over-exposed add 10 per cent. solution of Bromide as needed ; develop slowly to get detail.

The subject of flowers is a difficult one in photography ; a day without wind is needed when the light is well diffused, and there is no direct sunlight. One can photograph either the complete plant with or without its surroundings, or take home a spray of the plant to photograph indoors and enlarge. If the plant is tall it is well to tie the stem to a walking-stick firmly fixed in the ground to prevent it from swaying in the

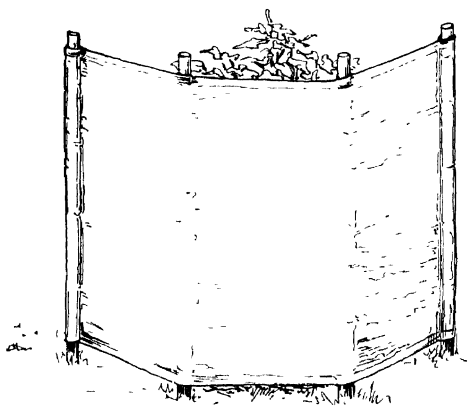


FIG. 3. Wind-screen for photographing wild flowers.
(I. M. Charters, *del.*)

wind. If a spray is taken and photographed at home, place it in a jar of sand or bottle plugged with wool. Plasticine is also useful. It is best lighted from the side, illuminating the side away from the light by a white card placed there. A screen of canvas with a frame of wood may be used with advantage, especially when photographing in colours (Fig. 3).

It is well to insert a paper inch rule in the picture to show the size of the flowers.

For enlarging, a simple method is to put a camera with the lens outwards in a window frame, and exclude all light except through the lens ; put the negative in the focussing screen of the camera, and have an easel placed a yard away with a piece of bromide paper pinned on a white card ground.

Careful attention should be paid to backgrounds. Paper may be used, or special grey or buff grounds placed behind the specimens. For light objects use velvet; for dark, buff or grey. Out of doors, if need be, a screen with sticks may be placed around the flower if desired, especially for colour photography (Fig. 3).

For leaves it is recommended that they be damped, but it is safer to regulate the lighting by tilting them sideways and to arrange the background to avoid shadow;* a thin and soft negative is needed. Plants lend themselves well to stereoscopic work, and for this one ought to take the same picture in different positions at varying distances.

Herbarium specimens can be photographed on the sheets by pinning them up and arranging a side light as before for sprays and leaves.

A simple mode of obtaining sun pictures is to take a leaf, place it in a printing frame, between the glass and a piece of glossy paper, print in gaslight or sun, according to papers; and to guess the time needed use a bit of the printing-out paper. Then fix in hyposulphite of soda for ten minutes and wash the prints in running water for half an hour. Silhouette forms may be got by placing flowers in a stand in the form of a right angle, placed in a box (or two joined) with paper pasted over one end and the other end of the box open. Opposite the last, focus the camera, and take the flowers against the background of the feebly lighted tissue paper. The negatives require slow development.

Full of interest is the question of photographing flowers or shoots in winter, when they are covered with snow, and also early foliage. The photographing of plants by magnesium or flash-light is another branch of this work.

Leaf impressions can also be prepared thus. Take a sheet of paper, coat it with sweet oil, in a minute or two rub this off, and hang the paper up in the air. Then pass it over a candle-flame till it is black. Lay the leaf on it and then put a piece of paper on top of it and rub it. Take the leaf and put it on a sheet of paper and cover it with blotting-paper, when on rubbing the leaf impression will be produced.

12. Survey Work.† Apart from the ordinary methods of

* This is best secured by placing the object half-way between the camera lens and the background.

† *See also* Chap. II, section 11.

floristic work, or the recording of plants in any given localities, which we have noticed so far, there is the more careful survey work required by an ecological study of a district in detail. Ecology has been defined as the topographical physiology of plants. It may be merely descriptive and record real pictures of the vegetation, or be also experimental, or etiological, and arrive later at the causes of the distribution of plants on a small or large scale at any definite spot, and explain the relationship of the arrangements between themselves and to the edaphic factors of soil, climate, etc. Here, not species, but groups of individual plants of one or more species growing together, are the units. When a type of vegetation is thus studied it is as a plant-association, and any larger units of which these are made up are called plant-formations. The grouping of plants into communities, then, is the *motif* of ecology. The two aspects merge into each other, but it is usual to study the smaller units individually. A good example of such botanical associations is an Oak wood. In this we have the dominance of the **Oak** as an outstanding feature, giving the name to the type. Within it we may find minor associations such as **Hazel, Birch,** which are overgrown by Oaks and so not dominant. Beneath these again we may find **Bracken, Bluebell,** or **Ling,** which may be sub-dominant as a ground flora.

There is also the characteristic cryptogamic flora to consider. Within the limits of this formation the different units or associations compete for prominence, but are united as a whole, and the same type recurs in many places.

Then there is the Beech wood with its native flora equally characteristic on the Chalk, and the Scots Pine in the north, or the Birch wood.

Xerophilous plants are linked together in numerous types of association such as Heather-moor with Ling, Cotton Grass, Moor (or Moss) with Cotton Grass, Grass-land with Grasses, etc. Or we may take the coast where there is a definite association connected with the sand dunes, salt marshes, shingle beaches, and sea cliffs.

The arrangement of the plants under the different headings in Chap. IV is more or less ecological, depending on habitat and surroundings, the special subject of inquiry of ecology. As remarked, the associations may be made up of one or several species which recur under similar conditions on the

same ground. In the Oak wood we have alluded to as a common type, we may have not only Bracken or Bluebell, or Yorkshire Fog Grass, but the three may be equally dominant or sub-dominant, and so together form an association which is characteristic of the ground flora of an Oak wood. The same applies to other associations.

To take up the study of any one formation or a series of associations, it is necessary to decide upon a definite piece of ground to survey, which will depend on the object in view. Whatever it be get the owner's permission beforehand to undertake the work. Having roughly traversed the tract or traced the boundaries as in a preliminary geological survey or ordnance work, it is necessary to find out the details of the region by the construction of a map on a small scale. For this purpose note-books, ruled in squares, of say at least 6 in. by 6 in. total measurement, are needed, with a second note-book for any features not to be noted down by symbols upon the squared sheets. This is done on the ground itself, which is plotted in squares or rectangles (as below). The notes in the note-book serve for transfer to the ordnance maps with a scale of 25 in. to the mile. On these not only are roads and landmarks as well as altitudes, woods, water, trees, etc., shown, but other symbols that can be applied to botanical survey work are also given. These are described in the Ordnance "Description of scales and characteristics" (6d.). It is best to use the 6 in. maps on a scale of $\frac{1}{1\,0\,5\,6\,0\,0}$; for detailed work larger scales can be used, such as $\frac{1}{5\,0\,0}$ or up to $\frac{1}{6\,0}$.

There are two ways of mapping. The first is by squares, which does best for larger work. A base line is chosen, preferably on the level, and on this rectangles are plotted on each side, to cover the area to be examined. The base line is indicated by flagged sticks placed at intervals of, say, 100 ft., and the same is done for the rectangles along the sides. This allows the plotting out of each rectangle into squares of 100 ft. by the pegging out of the ground by bamboo sticks placed at intervals of 100 ft. aligned with the base line, its perpendiculars and parallels. Having mapped out the ground thus, divide the work into surveying, recording, and drawing in the map and collecting. For this use a single ruled sheet for each 100 ft. (scale $\frac{1}{2\,4\,0}$).

It is best to put in the physical features by a thick continuous line, then the boundaries of each plant association by

dotted lines. Contour lines ($\frac{1}{10}$ ft. apart) are shown by lines made up of a dot and a dash. Bare patches, etc., can be marked in black. Levels are made with a theodolite and levelling staff corrected to some datum chosen. In this salient features are put in where necessary. Detailed notes on the vegetation are recorded in a second note-book, and a representative series of plants is collected, labelled, and pressed for reference, etc.

It is necessary to take a rectangle at a time, or a square of 100 ft.; any point can be fixed upon in this square by means of imaginary lines drawn perpendicular to the sides, and standing there one can fix the position by optical measuring from the side lines. This can be simplified by having smaller sticks or pegs at intervals of 20 ft. in each 100 ft. square. If it is desired to map any part of the square (100 ft.) or the rectangle itself on a smaller scale for greater accuracy, the gridiron method is adopted. This is done by means of 25 ft. squares, divided up by parallel lines, with five sections, by four lines measured out by tapes. The scale here is $\frac{1}{600}$ and is plotted on a square of 5 in., and a $\frac{1}{10}$ in. ruling is equivalent to 6 in. on the ground, below which there may be slight inaccuracy but no more. It is possible to level with a telescope and levelling staff to $\frac{1}{1000}$ ft., and thereby construct contour lines of $\frac{1}{10}$ ft. apart. This method is suited to ground showing variation within slight differences in an apparently uniform flora and is facilitated by the bars of the gridiron, which are not in the square method on the larger scale. Scattered plants can thus be noted in addition to small plant communities, with absolute accuracy as to the position. It is only adapted to flat or undulating ground, not hilly ground.

In the recording of the features, etc., of a formation, it is necessary to define the character of the flora, such as whether it is forest, woodland, coppice, scrub, whether made up of dwarf shrubs or grassland. Dominant plants should be named in relation to their association as Oak, Hazel, Ling-bilberry, and the formation of each should be stated, and whether it is of a closed or open character.

The topography is important, and the boundaries should be accurately defined. The altitude should be given from the ordnance survey, also slope and exposure. The geological formation should be noted and put in from the geological survey drift maps, as well as its individual characteristics.

The soil, its texture and moistness, and if derived from rocks or peat or humus, or glacially derived, or alluvial, is determined. Also the soil water should be noted, whether moving, stagnant, constant, etc.

A list of all plants observed in flower or not is made, and unknown material on the spot can be worked out afterwards.

A collection should be made of the specimens, which should be numbered and preserved.

It is not sufficient to make a mere list of plants, but the relative abundance and arrangement of the species should be given. The following is a typical illustration.

Larch wood with a few Spruces, trees about 70 ft. high, and from 6 to 10 ft. apart, two distinct associations found, **Calluna, Bracken**; the latter in hollows, the former occupying the larger more level floor of the wood. (Soil—thin, peaty humus, overlying liassic Limestone, 650 ft. altitude, Cleveland, N. York.)

Calluna Association

Social Species :

Dominant, *Calluna Erica*, 40–50 per cent. } about 70 per
,, *Erica cinerea*, 20–30 per cent. } cent.

Sub-dominant *Vaccinum Myrtillus*, 5–10 per cent.

,, ,, *Festuca ovina*
,, ,, *Aira flexuosa*
,, ,, *Agrostis vulgaris* } about 30 per cent.
,, ,, *Anthoxanthum*

Isolated Species :

Characteristic : 1. *Potentilla sylvestris.*
2. *Galium saxatile.*
3. *Oxalis Acetosella* in decreasing abundance.

Sporadic : *Carduus arvensis* from farm-land.

Not only is it necessary to study the plant and its association, but also the surroundings, and for this purpose one or two species can better be studied thoroughly than a number inadequately.

It is necessary to inquire into the climate, slope, sun or shade conditions under which a plant grows, and into the influence of soil, its moisture, its texture, acidity or lime content. Estimations of soil composition may be made by making soil-sections, by using boring-rods, and the amount

of carbonate of lime can be tested by acid. For soil water fresh air-dry desiccated samples may be taken. The mode of growth, morphology, hibernation and structure, and their physiology should be studied. Moreover there is the succession of formations to be noted, as, for instance, the convertal of a low moor into a high moor, woodland into meadow, and the succession on the coast, where the character of dunes is constantly changing.

Such work as this can only be done in certain districts by the ordinary botanist, who is not also a specialist in this direction, and certain types of formation are more suited to it than others. But it can be attempted on a less systematic basis in every district, and it is hoped that the progress already made by this method of studying vegetation will hold the field. The particulars given in this section are more fully discussed in articles in the " New Phytologist " by Dr. Moss, Prof. Tansley, Prof. Oliver, and others.

13. The Life-history of the Plant. The questions dealt with in section 12, or the study of plant formations and associations, are concerned largely with the habitat of plants, and in this sense the term is restricted, and does not equal in meaning bionomics, or the whole life-history and activities.

Having thus eliminated the question of habitat, we may remark that it is best to include in our study of plants not only their ecology pure and simple, but other factors of the life-history. Reference to the plan of each description of the species dealt with in Chap. IV shows that we have endeavoured to give information as to twelve other points that are of interest, omitting that of the occurrence, (*a*) in time as fossils; (*b*) in space, geographical distribution; (*c*) in the British Isles, which precedes, as a natural inquiry, the question of habitat.

Following this we have the habit of the plant, which is a great factor in the plant's existence, for the habit expresses outwardly the adaptation of the plant to its surroundings, and its contrivance for meeting the exigencies of the locality are shown in the nature of the stem and leaves or less often the root. The other organs or characters are largely those upon which the main affinities of the plants are based, *i.e.* flowers and fruits, and are less dependent on physiological than morphological influences.

The question of habit includes inquiries into the meaning

of autumn tints, or that of leaf fall, intimately allied to it, the first indicating the presence of anthocyanin, which assists in promoting warmth, and the second, means for retaining water. Twining, climbing, and other types of plants are all dependent on habit and the factors that cause it, and the stem habit is modelled thereby. The struggle for existence again comes into play when one of these plants in its twining goes so far as to strangle its support in the process. Then the influence of temperature prompts questions such as " why ? " and " when ? " and " how ? " leaves open and close, a factor which is dependent on the habit of the plant.

The characters also yield the materials for the study of variation of plants. Their mode of æstivation and hibernation, or the period of flowering, and duration or perennation are points upon which a great deal more work might be done. The average date upon which a flower opens should be studied (given in White's calendar for a few species). Then the actual duration of plants is variable, and the conditions which govern this, and the details of it need study. The aspect and nature of perennials in autumn and winter, the character of the dried herbage, the affoliation of leaves in spring, are all phenological questions wrapped up with the blooming and life-time of wild flowers.

The most important office of flowering, however, is connected with *pollination*, and it is for that reason that we have given it prominence. The relation of insects to the colours and scents of flowers, and the connexion of their visits with cross pollination or the transfer of pollen from one flower to another in exchange for honey, are full of interest. Next to this grand act in the plant's life, or its bid for posterity, is its manner of dispersal of fruit or seed, the promise of the next year's round of life. Here again there is much to learn, much to note.

The nature of the soil or other requisites naturally follows the dispersal of fruit or seed, for it is here that germination begins, and the numerous variations of soil, or water, etc., are in themselves enough for a life-study. Soil being again dependent on the character of the geological formation, in order to study rock-soils one needs a knowledge of geology to some extent, and the more intimate it is the more detailed will our knowledge of soils be. Here again we have the interesting question of the relative dependence of the plant

upon food derived from the atmosphere or the soil. It is largely a biological question, hence its inclusion.

Next in importance to the dependence of the plant upon its food-sources is the exposure to the depredations of insects, parasitic fungi, or animals it has to face. In other words we need a knowledge of the food-plants of insects, and of the requirements of snails and other herbivorous animals. The whole question of galls and insects is here raised, and this affords matter for extensive research.

Leaving the plant's activities to consider why and how plants received their *scientific and popular names*, we are led into an ultra-botanical realm, or the associations of plants in the popular or lay mind. Here is much to interest the philologist and the archæologist. Moreover there is a delicious fragrance in the names of many of our English wild flowers, and to strip botany pure and simple of its connexion with popular plant names and the suggestiveness of many of them is to lose much of their charm as wild flowers, literary and historical. In a similar manner the *folk lore* of plants, which has centred around them from early pre-botanical days, gives us an inkling of the state of science in those days ; and the explanation of such and such a quaint custom connected with flowers is as much a part of our public life as to the botanist is the study of plants pure and simple. Moreover it indicates man's relationship (if mistaken) with plants, and that for us is as much an appendix to their life-history as the following section.

This has to do with their economics or use. Many plants have real medical properties shorn of the absurd superstitions of the past, and a knowledge of these is essential to any student of plants, being to-day increasingly important.

Other Subjects for Study

14. Recording and Preserving Freaks. There is no work, except Master's " Teratology," like Bateson's " Materials for the Study of Variation," which does for plants what that work does for animals.

But the recording and preservation of those numerous teratological states that are caused by this or that abnormal factor is one which, though dealing with phyto-pathology to some extent, has none the less a place in the economy of the

plant's life. Numerous cases occur from time to time of such abnormalities as fasciated plantain-heads, ribbon-growth, proliferous flowers of Scabious, etc., or peloria states of Snapdragon, or campanulate states of Foxglove. Here we have an ample field for the accumulation of data as to how, when, and where these and the many other diseased, atrophied, or peculiar growth-forms occur.

15. Plant Diseases. The last section brings us to the wider field of plant diseases, which in itself forms a life study for any student. The influence of fungi or insects respectively is largely depredative, and preliminary to leaf or stem destruction. Fungi may promote decay, causing withering or allowing water to enter trees. This may set up further disease. The influence of climate and atmosphere is also an important factor amongst many others that are all linked with the plant's history.

16. Plant Economics. There is a large field for investigation here. Plants yield a variety of products which may be classified under various headings, such as gums, oils, dyes, inks and tannin, fibre and bast; whilst large numbers yield drugs, tobacco, perfumes (the scents are possibly to attract and to repel), which last are often only obtained by pressure, like volatile oils.

Allied to drugs are ointments, soaps, etc. Then plants yield food for man and beast in a variety of ways, *e.g.* cereals, fodder, fruits, etc., nuts, spices, sugar, and lastly (yielded by the agency of insects) honey, that most delicious of products. There are also hosts of unknown or forgotten pot-herbs, salads, pickles. Many yield confectionery, beer, wines, tea, coffee, and jalap. Trees yield woods or timber of ancient usage, used for a variety of purposes, and for basket-work, besoms, fuel, etc. Charcoal burning is alone a big industry. There are also garden flowers of which many wild plants are the parents, and many more are suited for this use.

Finally there is the score or so of poisonous plants of which so little is known by those most likely to be harmed thereby—children. It is well to select this subject as a school lesson in Nature Study.

17. Cultivating Wild Plants in the Garden. There are many reasons for establishing a section in the garden of wild flowers. One is obvious. Many of our wild flowers are as beautiful as the handsome garden forms whose natural parents are now

unknown. It is true that here and there in a large garden a copse of hazels is found, but they are grown, not for their natural beauty, but for the filberts which figure in dessert. But take so lovely a wild flower as the Pasque flower. There we have a "thing of beauty and a joy for ever," as charming as any of the spring Auriculas, etc. Then "New Mown Hay" already in our gardens might well be more frequently cultivated. But there is no need to run through the whole gamut. It is sufficient to say there are numerous others, such as Stonecrops and Saxifrages, that can be utilized in the garden. They can be utilized to grow in the shade, *e.g.* **Spurge Laurel, Woodruff,** etc., and thus fill up blank spaces. But the object of planting them is not merely to gratify the æsthetic taste, but to apply the test of experiment to them, as to their permanence or otherwise, especially so-called forms or varieties in a state of nature. The growing of such plants in a garden, apart from this test, which affords much valuable information as to their variation under altering conditions, is, however, supplementary to the growing of these plants, in order to study their mode of pollination and dispersal, as well as all the other equally interesting phenomena or activities of plant life.

The systematic botanist interested in a rare plant which he can only see in one place (or rarely) is to be excused if he takes a small portion and grows it in his garden for scientific purposes, but we deprecate the growing of wild flowers that are rare for the sole purpose of gratifying the senses.

Beds of critical species such as Epilobia, Hieracia, Willows, and other large groups containing many closely allied forms or species may be grown in the garden to study how they alter under culture. Again cultivation of a plant in the garden enables one at once to procure it in bloom, and, if need be, to go and sketch or paint it, or to pluck it and dry it in the press. This leads us at once to the next section.

18. Collecting Seeds and Sowing. In order to cultivate plants in the garden it is necessary to get seeds for the annuals and biennials, and although one can dig up the perennials in autumn and transplant them, without having to sow seed, yet there is no doubt that the pleasure and instruction to be obtained from growing plants from seed are far greater. The seeds can be obtained in autumn when the capsules are ripe, by going afield to procure them and by putting each set in a

piece of tissue paper, screwing it up, or else in an envelope. See that the seed is ripe. Having sown it in flower-pots or boxes, or in the open, out of doors, or in the greenhouse indoors, the seed as it germinates needs constant watching and attention so that one is irresistibly led, even if this had not been the original intention, to study the germination and progressive growth of the plant from the seedling to the mature plant.

Again seeds may be collected with the object of growing plants, to distribute them for reasons which would assist the cause of preservation ; or they may be sown broadcast along the hedgerows. Roebuck says of John Stuart Mill, " On these country excursions Mill would fill his pocket with Sweet Violet seeds, and scatter it in the hedges as he went along." Much as we admire the scent of a bed of violets in a native state, the artificial dispersal of wild flowers is to be deprecated.

19. Flora of a New Soil. There is a continual struggle going on between plants and their neighbours, and changes in soil, climate, and the influence of animal life greatly modify this.

The changes may be of two kinds as regards soil ; there is the formation of new soil, and a change in the old soil, or its supported vegetation. New soil, however originated, is soon peopled by plants, and it is an interesting study to watch this peopling by ecological methods. New soil is added to the sea-coast in some places, in others it is removed. Where it is added, forming banks and dunes, **Polygonum, Chenopodium, Willow, Poplar,** forming bush forest, follow meadow, and herbaceous plants with creeping rhizomes spring up. On heath moor thus formed we find **Green Algæ, Hair Moss,** *Radiola, Juncus capitatus,* then **Bog Mosses, Sedum, Ling,** etc.

Fine mud, clay, sand, humus, are produced at the mouths of rivers. In pools *Zostera marina* occurs, then as the sand rises some *Salicornia, Festuca, Juncus,* etc. When a river-bed is raised or a lake-level depressed, new aquatic or amphibious types spring up round the margins.

After volcanic eruptions new mud or soil is formed, and plants colonize it. The Krakatoa case is a notable one, and a remarkable series of plants recorded by Prof. A. C. Seward has been found there. First came Blue-Green Algæ, then Ferns, then seed plants, and after sixty years virgin forest appeared.

After landslips new soil is exposed, and there is again a succession of invading plant-forms, as crustaceous lichens,

algæ, mosses, and they are benefited by the steep slope and weathering of the soil. Then come xerophytic plants, **Rock Rose, Rest Harrow, Marjoram, Silky Wind Grass,** and shrubs, **Hawthorn, Juniper,** and **Mealy Guelder Rose.** Afterwards forest appears with Beech, Sorbus, etc.

Since the introduction of railways, fires (caused by sparks from the engine) have been numerous on heaths as well as in forests and grassland, and on the bare burnt ground a numerous flora gradually establishes itself, including real weeds of cultivation, poppies, **Shepherd's Purse,** etc.

When ground is laid bare for turfing or for building, etc., new plants quickly appear, as they do on railway banks. The old vegetation dies and a new type replaces it. If cultivated ground is left to itself a different type of flora will be produced with fewer weeds, and finally it will return to meadow and the bare patches will gradually become grass-grown.

20. Weeds in a Town. In towns and crowded thoroughfares one is astonished sometimes at the tenacity with which weeds cling to a piece of waste ground. On one such at Aldwych, London, W.C., in 1906 grew grasses, thistles, dandelions, **plantain, groundsel, coltsfoot,** and a strawberry plant, on land previously covered by bricks and mortar. Weeds appear to mimic plants amongst which they grow, being sheltered from drought by large-leaved forms, being then luxuriant, and if growing amid narrow-leaved plants they have the same habit; but the reason is, each is subject to the same conditions and develops accordingly.

On a single piece of land in Farringdon Street, London, E.C., there grew twenty-eight species of plants after it had been cleared two years, viz.:

Wind Distributed

Pale Willow Herb	Great Sallow
Rosebay Willow Herb	Canadian Flea Bane
Coltsfoot	Field Thistle
Dandelion	Ragwort.
Stinking Groundsel	

Kitchen Midden or Refuse Weeds

Radish	Garden or Opium Poppy
Parsley	Fig.
Rape or Turnip	

Forage or Packing Weeds

Field Thistle	Melilot
Dandelion	Bracken Fern
Bladder Campion	Orache
Black Bindweed	Chickweed
Ragwort	Great Plantain or Waybread
Scentless Mayweed	Common Dock
Oat	Shepherd's Purse
Annual Meadow Grass	Spotted Persicaria.
Dutch Clover	

The investigation of these and other building plots in any large city is an interesting study.

21. Plants and the Effects of Grazing. So commonplace a fact is the gradual conquest of the forest by man, and his convertal of it into meadow, common, or cornland, that one does not realize, in spite of the artificial enclosure and boundaries, the tremendous influence that the effect of confining cattle, horses, or sheep within a restricted space, such as a field, can be. Yet it is well known that the vegetation of a field, altered as it is inevitably during this process, is affected in a different manner according as it is grazed by cows, sheep, or horses, and the effect of their respective excreta is equally characteristic and varied. This is a neglected study which will yield interesting information if followed up.

22. Plants and the Influence of Man. The last section is moreover intimately connected with the present one, and one may set down as subjects for equal attention the following ways in which man is responsible for altering the character of vegetation :

By enclosure	By erecting stone walls
,, forming hedgerows	,, ,, thatched roofs
,, ,, ditches	,, ,, farm buildings
,, mowing, etc.	,, making manure heaps
,, arable land and culture	,, ,, stackyards.
,, making roads	

Each of these can be followed up and its influence noted.

23. Birds and Berries. The hackneyed belief that plenty of hips and haws is a sign of a hard winter is one of those characteristic jumpings to conclusions of which our forefathers were often guilty.

Probably the dependence of a berry crop on the previous spring weather is often bound up with an alternation of hard and mild winters, and because these affect the trees, if continuing into spring, the autumn berries are thus affected. Birds are said to prefer yellow berries. They are of course the chief distributors of the seeds of fruits and berries. It is but rarely that the migratory species disperse seeds, as they travel on empty stomachs, but observations on this and the whole question are needed. Rose-hips are taken by the Wood Pigeon whole and the Green Finch picks the seeds out and cracks them. The question as to what poisonous berries serve as food for birds also demands attention.

24. Thunderstorms and Trees. The relationship of the elements to the botanical world is a much neglected subject in some particulars such as this. It would be interesting to know what trees are most likely to be struck—if there is any difference—by lightning. The superstitious have been led to say Beech is exempt from this. It is worth while attempting to decide how, for instance, well-known and large or old trees can be preserved from lightning; the question whether a tree survives or not the effect of being struck by lightning, and the following ravages of fungi and insects as well as birds, is full of possibilities.

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CHAPTER II

THE SPECIAL METHODS USED IN COLLECTING, PRESERVING, MOUNTING, AND STORING PLANTS FOR HERBARIA.

1. Collecting. 2. Preserving and drying wild flowers. 3. Mounting wild flowers. 4. The arrangement to be adopted in the herbarium. 5. Various methods for preserving plants or their parts. 6. Glass models of plants. 7. Drying plants without pressure. 8. The preservation of natural colours in dried plants. 9. Water cultures. 10. Preserving in liquid or other media. 11. Other methods of survey, etc.

In the Middle Ages collections illustrating botany took the form of making a *hortus siccus* or collection of dried plants; and from the name "herb" for plants arose the descriptive title "herbals" for accounts of plants published. To-day we do not speak of *hortus siccus* nor of *exsiccata*, as applied more recently, but of herbaria. It is the object of this chapter to describe how a herbarium is formed and prepared.

1. Collecting. It is almost unnecessary to say that collecting entails the covering of long distances, and exposure to all weathers, so that one needs good boots; and it is necessary to face the possibility of wading ankle deep (or worse) in wet boggy ground on some occasions, so that one must be prepared to risk some discomfort. But "where there's a will there's a way."

Moreover it is well to be provided with a stick, for one may need this to secure objects in water, or otherwise out of reach in a hedgerow, or overhead in a tree. Indeed, frequently in the case of catkin-bearing trees, such as the Poplar, the botanist wishes he were an ornithologist, and expert in the use of climbing-irons.

In order to collect plants a certain number of appliances are necessary, but the fewer tools the better. First of all a receptacle is needed in which to put the plants when they have been collected. Amateurs have used wooden boxes with a handle like a camera handle, for slinging on the back, while a box used for Rowntree's chewing gums has even been employed, or portfolios (much in the same way as the press). If a cardboard box is used and varnished with shellac or painter's varnish it is made waterproof. All these, however, are makeshifts, and if one is going in for the thing seriously it is well to follow the approved lines where they are indispensable and best.

The general method is to use a vasculum, a japanned tin case, which is of variable size, make, etc. But whether large or small (a shilling one can be obtained to go in the pocket), it is best to have the mode of fastening and of slinging or carrying it carefully arranged, for these parts are liable to get out of repair or become awkward to manipulate. The strap should be belted where it is intended to place it over the right shoulder, and should be attached to metal fittings made for this purpose, placed on the side on which the lid is fastened, or at the ends; or, if intended to be carried in the hand by the narrow end, then the strap is quite short. It is best to have a large vasculum and a small one (Fig. 4), and to carry the latter in the pocket for small plants such as Duckweed. Moreover all aquatic plants should be wrapped in thin india-rubber sheetings like a sponge-bag, if collected and carried with land-plants. Wrap up smaller plants like Duckweed in a small piece of transparent glossy paper which is more or less waterproof. The papers that are used to wrap up photographic printing paper are very suitable.

On placing the plants in the vasculum bend them, if tall or long, so that they are not cracked in the process but coiled up along the inside of the case. A vasculum will hold a large number of plants if they are judiciously packed. Fragile flowers should be brought home quickly and separately if need be; or, if small, placed in the small vasculum. This may be constructed so that the inside slides in and out of an outer case open at one end. The larger vasculum should have a handle for carrying as well as a strap for slinging over the shoulder. Watkins and Doncaster, 36 Strand, London, W.C., supply all these requisites, and West, Newman, and Co.,

54 Hatton Garden, London, E.C., the drying paper (*vide post*).

The best colour for the vasculum is green or white, not brown or black, both of which retain heat, but those usually



FIG. 4. Vascula, large and small, for collecting.
(Photo, A. Newton)

sold are of a black colour. It is a good thing to have a newspaper or a sateen cover lined with a padding of wool below the lid to place over the specimens to prevent them from being withered in intense sunshine. If one vasculum is overloaded, a receptacle can be improvised for extra plants with string and

some newspapers, or, better, a fish bag or fruit basket can be utilized.*

For some purposes it is well to carry about a portable press (Fig. 5), which allows the plants to be put into it at once, as soon as gathered, and the process of drying commenced in the field. The press consists of two outer strong boards or wire frames (as used by some in drying and pressing indoors). Between these a sufficient number of sheets, 40–50 say (18 in. by 12 in.), of drying paper of Manilla, or ordinary newspaper, can be carried.

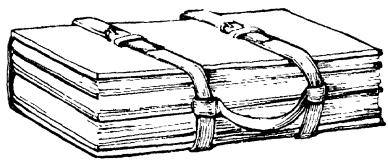


FIG. 5. Portable botanical press.
(I. M. Charters, *del.*)

Manilla is rather stiff and coarse for delicate foliage, and a drying paper more like blotting-paper, but less porous, is better. Take also half a dozen pieces of mill-board to be inserted at intervals between the papers to act as ventilators or supports. Then it is necessary to have a portmanteau strap with a handle to fasten them together and to serve as a carrier, which makes the appliance complete. In place of boards or rack one may use boards, in portfolio fashion, made into a sort of book-cover with canvas tacked over it and leaving a "back" of 3–4 in. to allow a given thickness of papers to be put between the covers. The mill-boards may be attached to that side after the papers have been laid on one side, by large rubber bands stretched across the longer sides. A few pieces of tissue paper upon which to lay delicate flowers should also be carried. In place of mill-board, and for ventilation, one may employ the wooden drying racks used indoors. The press is especially

* A friend of the author whose botanical experience extends over forty years, and whose interest embraces garden flowers as well as wild flowers, uses envelopes in which to place single specimens taken from a garden or a wild habitat for identification. This is an excellent plan. A note as to the plant can be written on the envelope.

suited to delicate plants that soon fade, or whose flowers soon drop, such as Speedwells, Wood-sorrel, Mallows.

In order to procure the deep-seated tubers of the Earth nut, some Œnanthes, bulbous plants, etc., it is advisable, though not absolutely necessary, to carry a trowel, such as is used (though this is to be discouraged on a wholesale scale) for digging up ferns. It should be a long narrow one with the blade hafted, and may be carried in a sheath and slung at the waist. Equally useful, especially for batology, or the collection of brambles, is a good pair of pruning scissors which can be carried in the pocket. It is easier to cut through a stem

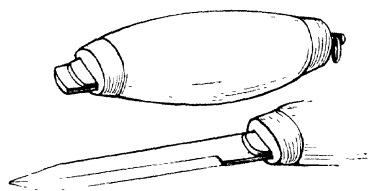


Fig. 6. Norwegian knife.
(E. M. Charters, *del.*)

armed with prickles with scissors than with a knife. Roses can be dealt with in the same way.

To cut the boughs of trees a knife is better, as scissors are only adapted for finer twigs; also a good stout Norwegian pocket-knife is needed, with a sheath (Fig. 6), but it should be seen that the spring is a good one, for it is often defective. The knife is admirably suitable for getting willow catkins and stem pieces, as well as for thick-stemmed aquatic plants like the Reed Mace. For this purpose also one can use pruning scissors (Fig. 7) * fitted to a telescopic walking-stick which may be carried, or attached to a bamboo fishing-rod, made to take to pieces. This is very necessary for procuring catkins of Poplars, etc.

It is a good plan to carry some string to attach to different willow catkins and leaves, or to connect brambles and rose stems and their panicles together, as well as some tagged labels on which to write numbers, etc., or localities for each.

For the press (or vasculum for that matter) slips of paper are needed to be filled in with place and date.

* *See* Appendix, where further details, prices, etc., are given.

All other data should be written down in a pocket-book, with details as to soil, altitude, meteorological data, etc., which must not be forgotten. The pencil may be tied to the book so that it is not mislaid ; for one of the experiences of the field botanist is the readiness with which the paraphernalia one carries about on these excursions can be left behind. At one time it is a knife, at another a lens. We have heard of entomologists searching for pupæ being taken for burglars unearthing their "swag," but not so far of like reputed delin-

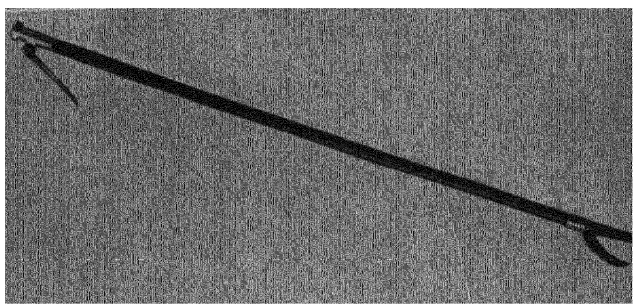


FIG. 7. Gripper or pruning scissors.
(Photo, A. Newton)

quencies amongst the botanical fraternity; though on the contrary the writer lost a very handy vasculum in a mysterious manner after leaving it for only a short period on a bank whilst searching elsewhere.

For aquatic work it is necessary to obtain the use of a punt, and to be able to search in midstream in the river, or elsewhere in the case of a lake. For this a drag or dredging apparatus is needed, made up of a three-hooked drag, carried on a long line, or a scoop-like shovel which does for smaller plants such as Duckweeds. The line is cast and drawn behind the punt and pulled in and examined and recast at intervals. Also a small muslin net is required, as used for pond-life, and a glass-stoppered bottle to carry back **Duckweed** or *Wolffia*, etc. (Fig 8). Work with aquatic plants is best done separately.

One important item of the impedimenta is the lens. A Cod-

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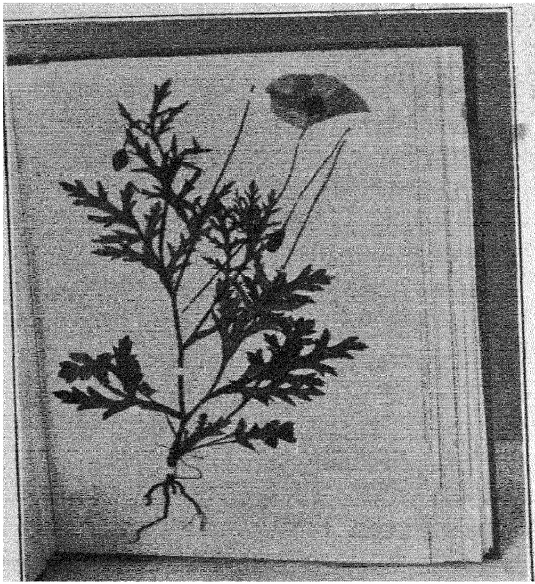


FIG. A A GOOD SPECIMEN

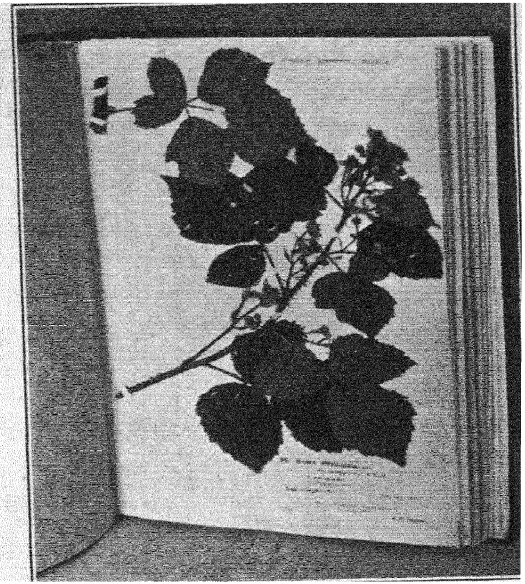


FIG. B HOW TO COLLECT BRAMBLES OR RUBI

Photo, A Newton

dington's lens is held to be the best, but for field-work a larger size of field is required, and a clear definition, rather than high powers of magnification and a small field. It is essential that a road or ordnance map be carried, and a time-table, if one is going far afield, as well as lunch, kept in a smaller tin by itself.

How to pluck a plant is an art only learnt by experience ; it damages some glandular plants to take hold of the stem or leaves, and this should be obviated by getting them up by the base of the stem or by digging them up. If the root is not

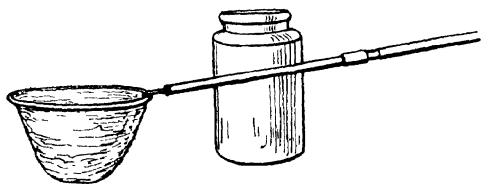


FIG. 8. Hand-net and glass-stoppered bottle.
(I. M. Charters, *del.*)

collected cut the stem of the plant off with a knife. Rooting up may lead to extermination, hence, except where especially required, the roots should be left intact.

The way to collect specimens is as important as the tools with which to collect them. All specimens should be good ones, and typical (Plate I, Fig. A), not freaks or malformed, though these also may be collected from a special point of view. Look at the specimen carefully in order to see if the leaves are eaten, discoloured, attacked by fungi, or infested by insect larvæ ; moths may often get into the herbarium by carelessness in these particulars. Scraps are of no use. In the old days just the tip of a plant with a flower, often only in bud, and a leaf or two were collected, giving no adequate or complete idea of the plant or its habit or characters. Not only is it necessary to know the form and size of the plant, but the radical leaves and roots as well are often required. All tubers should be dug up when needed.

Indeed a species must be represented by a series if need be, showing its characteristics from germination to seed formation, and due regard should be had to the requirements in each case. Brambles must be gathered in bloom and in fruit

(Plate I, Fig. B). Sedges should have fruit ripened, and Roses (Plate II, Fig. A) should be represented by fruit as well as flowers, and a piece of the stem as in the case of Brambles. Willows (Plate II, Fig. B) (and all trees) should have the flowers as well as the later leaves in each case. Water Buttercups should be collected when the achenes are ripe. In the case of some Grasses the roots and rhizomes must be collected (Fig. 9).

Moreover when the plants are monœcious, both pistils and stamens must be represented. Diœcious plants should have each sex collected even if they be gathered from different localities. Hermaphrodite flowers do not require this discrimination, as male and female flowers are in one inflorescence. But the male condition may be gathered with the later female stage, or *vice versa* in another flower.

Before starting to collect inspect the ground, and carefully and deliberately without any haste select the best material, having in view beforehand what is needed ; collect in sunshine. If specimens are wet leave them to dry before drying under the press, and only collect ripe material.

Inattention to these particulars is fruitful of much disappointment after the subsequent drying and preserving. Mr. J. Britten (formerly of the Botanical Department, British Museum) writes about this. " Anyone who has anything to do with the naming of plants . . . will be able to testify to the large number of persons who do not scruple to send for determination single leaves or a terminal shoot of a flowering plant, or a pinnule of a fern without fruit ; a proceeding which is unfair to those to whom they are submitted, inasmuch as they either have to risk their reputation for accuracy, or to appear uncourteous by refusing to have anything to do with such specimens."

It is well to collect enough at a time in case a subsequent visit may be useless. In the case of some common plants it is an excellent plan to collect a series to show the range of forms and variations, or to illustrate colour differences in the flowers, etc. A series of specimens collected at different periods is needed to illustrate trees and some other plants.

Collect when it is known that the plants are in flower (*see* Chap I, section 5), and as to localities *see* Chap. I, section 6. Also do not forget when collecting to make notes already advised regarding the plant's environment and associations.

2. Preserving and Drying Wild Flowers. For drying and keeping the specimens after having brought them home still further appliances are necessary.

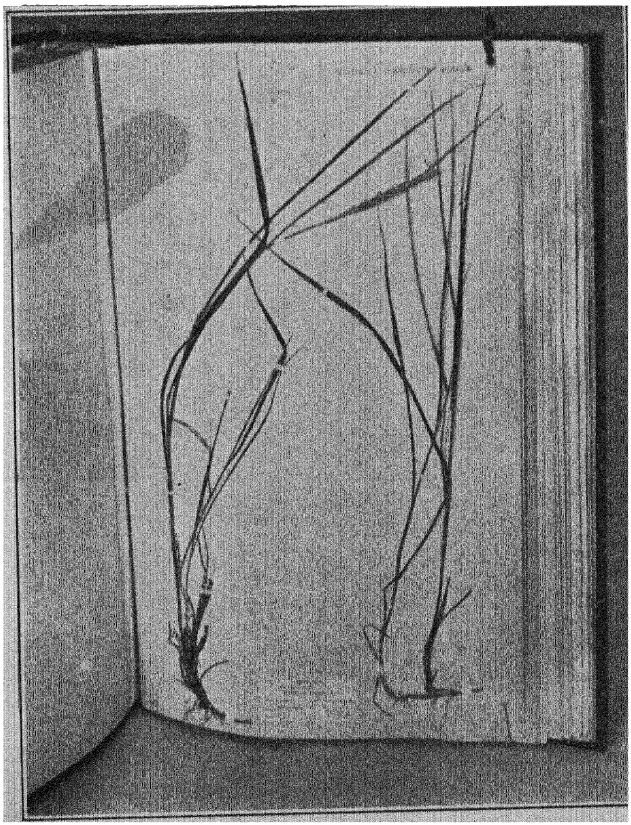


FIG. 9. How to collect grasses.
(Photo, A. Newton)

The first requisite is drying paper, which should be large and double. The Manilla paper is stiff and coarse and will scarcely suit delicate petals, which must be placed between tissue

paper; and flaccid land plants or aquatic plants must be floated into a bowl above such paper, then laid out upon the cap paper, and after arrangement dried between the Manilla. All delicate plants can be kept in these covers till both are

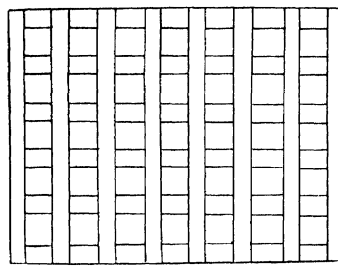


FIG. 10. Ventilator.
(I. M. Charters, *del.*)

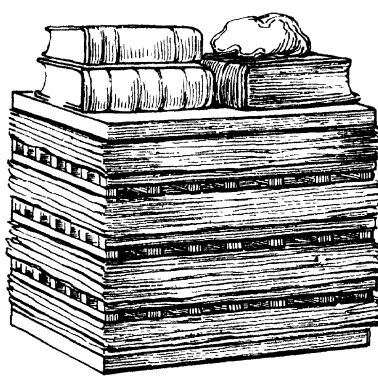


FIG. 11. Plants in press under weight with ventilators.
(I. M. Charters, *del.*)

dry. Newspapers do admirably.* A good stock of paper is necessary, say 24 in. by 20 in., or a similar size. Some ventilators are needed to place below and above and at

* A *Times* or *Daily Telegraph* folded once is just the right thing for this purpose, as there are eight pages at least, without supplements, between each contiguous sheet, and sixteen or more between each series of plants under press.

intervals between the papers to circulate air through them. These are small drying racks formed by thin slats of wood laid crosswise at intervals with open squares (Fig. 10). They not only accelerate drying but regulate the pressure. Frames of wire can also be used for top and bottom frames as they allow air to circulate freely.

To apply weights to the plants dried by pressure almost anything that is heavy can be employed (Fig. 11). If a press is used it is necessary to strap the boards together very

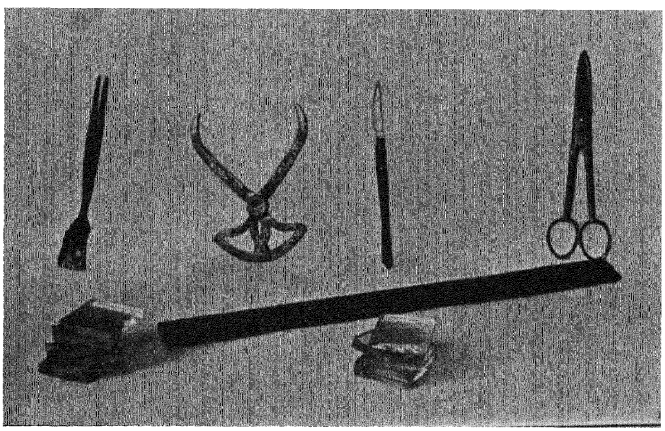


FIG. 12. Forceps, calipers, dissecting knife, scissors, glass squares. (Photo, A. Newton)

tightly, or to use pressure from above, *e.g.* by means of books, bricks, etc.

Sometimes it is necessary when arranging the plants between the papers to prune them to some extent, and scissors are required for this. Calipers can be employed to measure the length or size generally of the specimen to adjust it to the papers (Fig. 12). Formerly pressure was applied by means of a screw-press such as those used for taking impressions of letters before typewriting came into vogue. But such an appliance is quite a luxury.

For the arrangement of delicate petals a few squares of

glass are wanted. A pair of forceps enables the leaves, etc., to be put straight when arranging the plant (Fig. 12); it is well also to have some small folding packets like envelopes with four square flaps in which to put a flower for examination. Tissue paper and cap paper for fragile flowers and aquatic plants should also be procured.

In order to clean the roots, etc., it is advantageous to have a bowl of water, but if they are dry they can be simply brushed with a tooth-brush.

A good dissecting knife is useful for splitting down a thick stem or fruit, tubers, etc. When plants are succulent it is necessary to boil them or to place them in hot water to prevent growth during pressure; such plants should be killed with corrosive sublimate or alcohol, and if this is used before or after drying a wide porcelain dish such as is used in photography is required.

It is useful to have a supply of cotton-wool to be used for padding if the flower-heads require it. In the case of flower-heads with a spreading ray it is well to cut out a mount to take the thick disk, thus allowing the ray florets to rest on the upper surface of the mount.

A pair of forceps for lifting foliage, etc., during the drying process will be of service.

When arranging the plant in its position lead weights may be used (Fig. 13). These can be removed when the overlying sheet is placed upon the specimen.

Plants require some preliminary preparation before they are put under pressure. First remove all wool adhering to roses, brambles, etc., or hooked fruits or stiffly hairy stems; or mud attached to leaves or stems of plants growing on bare soil, which last is frequently found after a summer day's torrential rain. If the plant is a succulent one, such as *Sedum* or *Cakile*, let it be plunged in nearly boiling water for one minute and then dried on a towel; **Orchids** need this treatment to prevent fruit formation, and the same procedure is necessary for trees with needle-like leaves, as **Pine**, and other plants such as the **Heaths**, etc. The berries that are soft and liable to be squashed by pressure should be detached and the bunch hung up to dry, labelled, and numbered. If the fruits are hard they must be cut through, and the same applies to all thick-stemmed plants; large seed pods such as poppy-heads, if cut through, allow the seeds to tumble out, and should

therefore be cut off and dried by themselves, and, if too large to put in the collection, kept separate.

A water-lily flower should have a section cut through it and be dried in cotton-wool (Plate III, Fig. A).* Bell-flowers such as **Foxglove** should have a pad of wool placed in them to preserve the shape and prevent shrinkage. Such groups as **Epilobia** and **Compositæ** should be treated as in the case of

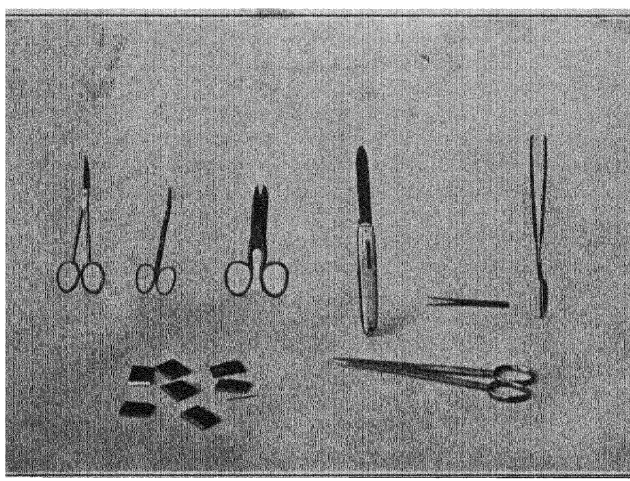


FIG. 13. Scissors, knife, forceps, lead weights for mounting.
(Photo, A. Newton)

succulents, where the flowers are beginning to go to seed, and the head be plunged in hot water to prevent pappus from forming. Before placing under pressure some delicate tinted flowers, it is sometimes advisable to apply a hot iron, placing tissue paper of course between the iron and the flower. Those plants that go black in drying, such as **Scrophulariaceæ, Labiatæ,** may be dealt with in a similar way, tissue paper being laid over the plants. Very large prickly plants, **Thistles,** etc., may be placed between boards and pressed down by heavy

* The leaf itself is an example of how not to collect. There is an art in the selection of good material.

weights or by standing on them. Bramble stems, for instance, need this, and also rose stems.

Batrachian Ranunculi should be well washed and all algæ removed, as well as larvæ of caddis flies, which often make their home upon the stems. Some gelatinous matter may often be found adhering to them which will be found to be ova of pond snails, and this should be cleared away.

When no roots are preserved the stem should be neatly cut through, at an angle, with the knife. Furthermore the specimen must be made flat for pressing, and projecting branches or roots must be cut off if in the way.

The plant now requires to be arranged for drying. Half a dozen sheets of the paper should be taken and laid in front of one on the table with the tools around one, and a pile of papers at one's side, the prepared specimens being put in the vasculum till required after preparation. Lay the specimen out flat on the paper, and if it is too large for the paper carefully bend it so that without destroying more of *the natural form and habit of the plant* than is avoidable, it may be got within the required compass. If then any parts are found to lie upon others, prune them away ; cut away any parts that are eaten, but do not do this more than is absolutely necessary. If delicate arrange the specimens on thin double paper which can be placed between the drying paper, and the plant can be kept in this till dry. Any parts that must be kept separate, such as seeds or fruits, or flowers dried by themselves, should be put in envelopes. They should have the data written on them, as is done for the plant itself : this is a point which must be carefully attended to, a small slip of paper with date and locality at least being put with each and a number with note as to habit, etc., referring to a diary. Place alternate plants on opposite sides of the papers ; it depends largely on the plants how many sheets must be placed between each specimen. When a plant is liable to stick to the drying papers put it between glossy paper.

The specimens will of course be dried the same day as they are gathered, but if they should be withered on return put them in water for a while, and cut the stem afresh under water to ensure imbibition freely in order to promote recovery. For this purpose warm water is recommended.

The lead weights come into use when arranging the plant for pressing by putting one here or there as the hand is

released in arranging. Instead of pruning away overlapping pieces, pieces of drying paper may be put between such projecting or thicker parts. Arrange some of the flowers to show the central parts, ovary surrounded by stamens, others in half section, and so on. Cut the fruit open in some cases to show cross and longitudinal sections.

Common writing paper placed above and below the petals prevents the drying paper from absorbing the colours, or, when damp, from discolouring them, and plants so dried keep their colours for some time. To arrange the petals use one of the glass squares, which can be worked round until the whole flower lies symmetrically, and then tissue paper can be slid in carefully underneath without disarranging the flower at all. Between each specimen put about 5–10 papers, and between each series of about five specimens put a drying rack for ventilation; having made the pile large enough, apply the necessary pressure. This may be done by the use of straps tightly tied across each pile with one of the wire frames below and above each pile, or a heavy weight may be used. For this it is possible to employ bricks, books, or any flat object which will communicate the pressure evenly, up to say 60 lb. (Fig. 11).

It should be added that drying is facilitated by several methods. The papers may be warmed in an oven or on a rack beforehand, or only one paper may be placed between each, *i.e.* two between consecutive plants, and ventilating boards may then be placed between each two specimens and the whole placed over a range. Or the pile may be placed where a good draught can circulate, and, in the summer, out of doors in the sun.

If the papers are placed directly on the floor and not changed soon enough the floor will absorb moisture, and communicate mould, when once it is set up, to the whole bundle of papers and plants. On this account it is necessary to change the papers regularly and often.* Good drying in fact depends on frequent renewal of the drying papers. At first this may be done every three hours; then as they become dry it may be done up to ten days or in some cases even three weeks.

* A ventilator should be placed below, resting on two bricks on their sides. This allows a good current of air to blow under the plants. They may be placed, however, on the grating of a hot-air trench without this precaution.

Sufficient care in this matter cannot be too strongly emphasized. It is always a good plan to warm the papers before changing the plants, laying them on a board in front of the fire for this purpose, or upright in an oven, and loosely arranged. To dry papers in the sun it has been found a good plan to clip them together and hang them on a line, using ordinary wooden clothes-pegs if wished. In order to prevent them from being blown away if laid on the grass in the sun, each of them may be eyeleted so that they can be quickly spread out on an extended string and as quickly drawn up again into a bunch by the opposite process if it should rain.

In order to change a plant from a damp paper into a dry one care must be exercised in taking the plant out of the old paper. First remove the top layers of paper, except the one just above the plant, then carefully turn back the top cover gradually, beginning at one end and curling it back bit by bit, releasing any part that adheres to the covering paper with the forceps, and when this is done place a fresh piece over it so that the inside of the double sheet (or sheets) is inverted. Then taking up the lower set of damp sheets, turn them upside down upon this inverted sheet, by this process now in its right position, and, if necessary, gradually peel away the plant where it adheres to the other side of the damp sheet ; this done, proceed as before in arranging the sheets in the press. It may be well, if many plants are dried and consequently several stacks of papers are under pressure, to keep a record in the form of a tabular sheet with the number of the stack and the date upon which it was first put under pressure, with subsequent changes noted upon it. It can be ascertained if a plant is dry by noting whether it adheres to the paper or not, and if it is rigid. If it feels cold when placed on the back of the hand it may be considered to require further drying. Always remember that a plant dries very quickly at first, but afterwards it regains about 12 per cent. of moisture from the atmosphere, and if left at first too long it will then go mouldy. But after this first period it again loses moisture continuously until it is quite dry. Fleshy plants contain some 90 per cent. of water, and it is easy to understand that continuous and regular drying is necessary to reduce this to practically nil. The modern use of calcium chloride in a dry form to prevent damp in cupboards may be applied here and small pieces placed in stacks of drying paper at intervals.

When dry remove the plants and put them for a short period (collecting being done in the summer, mounting in the winter) on sheets of paper of the same size as the drying paper, made of newspaper. On these place a plant, and with it the label (be very careful about this), and number each sheet in pencil with the order of the plant in, say, the "London Catalogue" (tenth edition), or Druce's "British Plants," or the British Museum List of Seed Plants. Put a cardboard mount between a number of sheets and put them away in a stack with ventilating boards above and below till needed, noting in a book what each bundle contains by means of a reference number (Plate III, Fig. B).

But there is perhaps one further process needed before they are put away, for there are two special enemies of dried plants from the herbarium standpoint, *i.e.* mould and mites. So it is well, as suggested, to poison the plant before or after drying, preferably after, with mercuric chloride, which is put in a flat dish and the plant immersed in it and allowed to dry. Or one may simply apply it to the plant in a 1 per cent. solution with a camel-hair brush, for it is very poisonous.

The best formula for this is :

Corrosive sublimate . .	1 oz.
Carbolic acid	1 oz.
Methylated spirits . . .	2 pints.

Another mode of poisoning plants before drying, and so retaining the colours by killing the protoplasm at once, is outlined in section 8.

3. Mounting Wild Flowers. The next operation is the mounting of the specimens upon sheets of paper for placing in the herbarium.

The necessary requisite for this is a supply of botanical mounting paper, of cartridge, fairly thick and of a fair size (Fig. 14). A common practice is to have it cut 16 in. by 10 in., others use 17 in. by 11 in., the size of the Kew sheets, those of the British Museum being rather larger ($\frac{1}{2}$ in. each way). This can be had in parts of a ream (480 sheets full size, cut to 960) or by the 100. It is better to use good stiff paper than cheap limp paper, and one can only put the useless scraps of a bygone generation on foolscap or smaller sheets. As paper varies so much it is necessary to get a good supply to begin with,

An important adjunct is the adhesive material ; this may be made by gumming sheets of paper and having it cut up into strips $\frac{1}{16}$, $\frac{1}{8}$, or $\frac{1}{4}$ in. wide, or stamp edging may be used ; but by far the best is the transparent music mending paper sold in rolls an inch wide at 1*d.* or 2*d.* a roll. It is less unsightly than

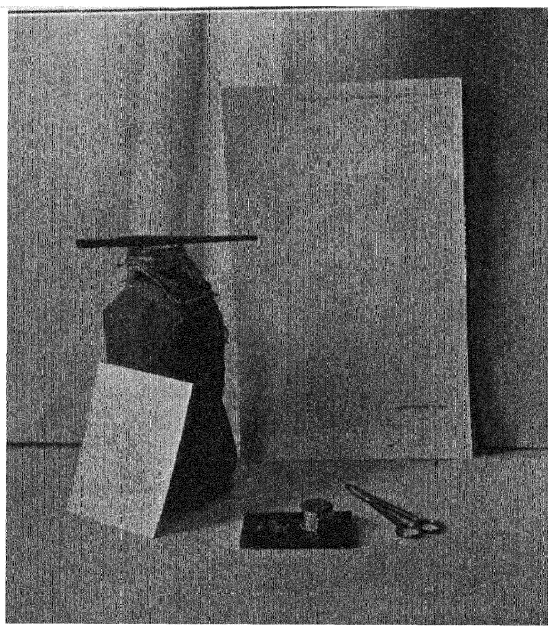


FIG. 14. Mounting materials, etc., paper, adhesive paper, gum, brush, scissors, moth-paper.
(Photo, A. Newton)

the white strips of stamp selvage. Some people prefer to gum or glue the specimens down. This is a disadvantage for most specimens, as they crack when aged if the sheet is bent, and only one side of the plant can be seen. But in the case of delicate water **Batrachia** or *Chara* or *Nitella*, all dried by floating out, this may be done with advantage. Take the plant and lay a sheet of newspaper on it, invert it and paste the

plant all over with the glue, gum, or flour paste (tinctured with oil of cloves to preserve it). Next take the mounting sheet and place it carefully on the plant, and move the hand over the sheet so that it adheres at every point ; then turn it over and peel the newspaper away, and blot the sheet so that no excess of paste or other adhesive remains. Perhaps gum tragacanth is best for this purpose (and for the labels for the sheets) ; dissolve it in water or methylated spirits and add if desired a quarter part gum arabic. Gum tragacanth goes mouldy if camphor is not kept in the bottle in which it is made up. However, we advise strips to be used wherever possible. Fish-glue or seccotine is necessary for sticking down larger stems, fruits, etc. To apply the gum a fine camel-hair brush is required.

Have ready also scissors for cutting strips, forceps for arranging, lead weights for keeping in place, a knife (Fig. 14), water for moistening the adhesive papers, and a duster or handkerchief for pressing down the strips and the labels. It is well to have a card mount on which to place the paper ; for mounting one requires a good wide table, with plenty of room. On the left place the pile of plants to be mounted, and reserve a place on the right or in front for the sheets when finished. Take the specimen and lay it out so that it is central, if large, upon the paper, and if too large bend the top over, placing the root at the bottom. Leave a space of, say, 4 in. by 3 in. for the label in the bottom right-hand corner. Now proceed from below upwards to apply the straps where necessary, making them broad or narrow as the case may be and about ½ in. to 1 in. long. At least three or four are necessary for an average-size unbranched plant. If a plant is small and several are needed to illustrate the species, place them in rows one above the other. If specimens from more than one place are placed on the same sheet, indicate the locality by writing, etc., below it, or by number referring to the general label. If there is only one small specimen put it in the top left-hand corner, for additions to be made later.

Some plants may need a little further pruning with scissors or knife. Thick-stemmed plants should be mounted so that the stems are not near the edge. In mounting a series show the seed, cotyledons, leafy stem, flowers, fruit, barren stem in roses and brambles, leaf buds, suckers, scales, and stipules in trees. Seeds and capsules or other fruits, tubers, and roots

should be shown. If too bulky they will already have been sectioned. Seeds can be kept in small glass tubes or packets (as also can flowers), as they often tumble out of follicles, etc., when over-ripe, and it is important to have them for the characters they show. When a series of seeds or other parts is kept apart reference to the parent plant and place in the herbarium, and *vice versa*, should be made on each.

It is important that the label * should bear the important particulars and no others. Let it have the name in Latin, a number, following the London Catalogue, for arrangement, the locality and details of habitat, altitude, soil, date, day of the month, collector's name, and any additional note of importance. One may go further and enclose with each sheet a photograph of the plant in its natural habitat, or even a coloured drawing of this or of the flower or other parts.

To arrange the species, mounted on separate sheets under each genus, a thick brown-paper cover is needed which will include all the known species of each genus. It will depend much upon how the specimens stand in the cupboard holding the herbarium as to where to place the genus label. If these are laid flat it is wiser to put the label in the same place as the species label on the upper cover. A few people mount the species on a double sheet, thus having a cover for the species at once, and no generic sheet is needed unless it be for ready reference. If the sheets stand vertically in the cupboard in covers, then the genus label is best placed at either the top or bottom left-hand corner nearest to the out-

* The subjoined is a fair example of what may be done in regard to the extraction of data from a specimen. But they must be made on the spot.

Plant..... L.C.X. No.....
Folk-name .....
Habitat ..... State .....
Locality .....
..... Co. Dn.....
Frequency .....
Formation ..... Altitude.....ft.
Remarks .....
.....
Observer ..... Date.....

side (Plate IV, Fig. A). It may further be advisable to have larger and more comprehensive order covers which can be used in the same way to include all the genera. But in a genus like *Hieracium* or *Rubus* several covers are required for convenience in order to arrange one genus.

As the question of accumulating information about the specimens on the spot is so important, a few further instructions may be noted. It is advisable to make notes at once in the note-book, and not to wait till one gets home. This can be done continuously in the field by shorthand or some *aide-mémoire*, and extended at home, and then information about each plant can be written on separate slips or sheets, numbered like the specimens. It is a good plan to have note-books in addition, with numbered tear-out leaves for use in the field. Take also some eyeleted labels (Fig. 15) to tie upon the shrub-like plants that are liable to be mixed, *e.g.* brambles, and number them so as to correspond with the entry in the note-book. Observations must be accurate and not fanciful. To the notes add maps, drawings, photographs, as already suggested in Chap. I.

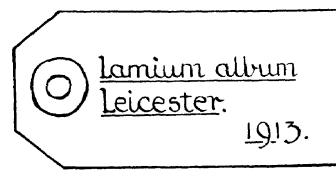


FIG. 15. Eyeleted label.
(I. M. Charters, *del*.)

The habit and type of vegetation can be photographed or sketched, and the parts of the picture or negative numbered (by picturing or tracing image on focussing screen or transparent paper), describing each on the spot.

It is well to give on the tickets* not only altitude and soil, but habit, colour of flower, and fruit (especially in the case of brambles, roses, etc.), scent, honey, floral mechanism, and details as to insect visitors, mode of seed dispersal. State whether common or rare, and give the associated plants as well as the chief type of formation or association. These details may be supplemented by others obtained by definite survey work as described in Chap. I.† Labels printed to paste

* Similar to the form on p. 56.

† *See also* sec. 11. The methods given are only a few. Many others may be devised; and home-made apparatus and self-evolved methods are frequently better than the ones with which everyone is familiar.

on the mounted sheets, giving a sort of blank form for filling in details, can be had for 4*s*. or less a thousand (*vide* p. 56).

4. The Arrangement to be Adopted in the Herbarium. It is essential before the plants are arranged in a herbarium to settle beforehand what plan is to be followed in arranging the plants.

Mr. E. M. Holmes in an excellent paper defines the object of a herbarium thus :

" In large or national Herbaria the principal object is to have in the collection every known species of plant, so that travellers, curators of botanical gardens, horticulturists, systematic botanists, and others may be able to identify any unnamed plant, or, if unknown, may be able to describe it. Other objects are (1) to afford a knowledge of the distribution of plants in different countries; (2) of the variation of species; (3) the preparation of floras."

A herbarium is not intended to teach botany, but " is, in fact, a dictionary of plants, and the arrangement that permits of finding a plant in it as promptly as possible is the best."

This last is complicated by the aims of a museum, which may be extended, as in a national museum, or merely local. There is the initial difficulty of discovering on visiting a museum, or other herbarium, by what method the orders are arranged. It may be by Bentham and Hooker's " Genera Plantarum," as followed in the British Museum, Kew, Edinburgh, Glasgow, Oxford, and Cambridge; or by Engler and Prantl's " Naturalichen Pflanzen-Familien," as in Germany and elsewhere; or alphabetically under Monocotyledons, Dicotyledons, etc., as in some foreign herbaria; or the natural orders and genera may be arranged like books in a library, the cabinets numbered and the shelves lettered, with an alphabetical index with corresponding letters and numbers. To save time it is suggested that cabinets be numbered consecutively from left to right with an alphabetical list of natural orders on each floor, the number of the cabinet containing the order being placed against each name on the list.

The second difficulty is to discover the position of the genus, arranged in this country by Durand's Index to Bentham and Hooker, but by Engler and Prantl's system on the Continent. To avoid delay it might be possible to have an alphabetical list of genera nailed outside the cabinet, where it begins, with the number of each in the sequence.

Then there is, lastly, a difficulty in finding the species. This may be solved by several methods. The geographical method arranges plants by definite regions of the globe, in covers of different colour, or with labels of different colour.

At Kew they run as follows :

Yellow, 1–3 : (1) Europe ; (2) N. Africa and Orient ; (3) N. Asia.

Green, 4–6 : (4) China and Japan ; (5) India ; (6) Malaya.

Buff, 7–9 : (7) Australia ; (8) New Zealand ; (9) Polynesia.

Grey, 10–12 : (10) Tropical Africa ; (11) Mascarene Island ; (12) South Africa.

Pink, 13–18 : (13) North America ; (14) Central America ; (15) West Indies ; (16) East Tropical S. America ; (17) West Tropical S. America ; (18) Temperate S. America.

By the natural sequence method the arrangement of De Candolle's " Prodromus " has been used, but this is out of date, and needs supplementing by new monographs. By the natural sequence, geographical, and special flora method, the species are first arranged geographically, and then by the flora of each region, but when range is extended or new species are named this is found to fail.

The library method is to follow De Candolle's " Prodromus," and to place all additions alphabetically at the end, and there is also the method where species are arranged alphabetically.

It is best to follow the " Index Kewensis " and " Durand's Continuation up to 1895," corrected by recent work. Nearly allied species are separated, but this method does away with any need for separate covers, or reference to books, and when the " London Catalogue of British Plants," usually followed by British botanists, is republished and the numbers are altered this makes no difference.

The alphabetical method is best adopted within limits of large groups such as Monocotyledons, Dicotyledons, etc.

There are some other modes by which reference can be facilitated, such as :

(1) The preparation of a list of all separate collections of plants.

(2) A list of all published genera since 1895 (to supplement Durand's Index).

(3) A printed list of all illustrations of plants published since the issue of Pritzel's " Icones Plantarum," as at Kew.

(4) A printed list of all the species published since the year 1895, when the "Index Kewensis" and Durand's "Appendix" brought things up to date.

This has been done imperfectly so far by Just's "Botanischer Jahresbericht."

(5) The placing at the entrance of each room or floor of an alphabetical list of the 200 or so natural orders with numbers attached indicating their position in the rooms of the herbarium; and of

(6) An alphabetical list of genera with numbers attached outside the cabinet at the commencement of each natural order; and of

(7) An alphabetical list of species and the number of their sequence at the commencement of each genus.

A few other methods are of advantage in the regulating of a herbarium:

(*a*) A reference may be placed on the outside of the species cover of the monograph or flora that has been followed, and to the page in it on which the species is described; (*b*) the indication of type-specimens by the word type-specimen and a reference to the work in which it is described; (*c*) the use of a distinctive printed label for all plants quoted in Floras; (*d*) the use of envelopes on each sheet containing a loose leaf and flowers and fruit when possible, enabling one to examine both sides of the leaf and hold it up to the light for oil cells, mucilage cells, resin cavities, and to examine the structure of the flower and the microscopic structure of the seed; (*e*) cross references on the genus cover to species separated and placed in other genera.

In Mr. Druce's "List of British Plants" he includes 734 genera and 2958 species of plants, besides a large number of varieties; the "London Catalogue of British Plants" includes fewer, but even so it is obvious that any cabinet to hold a complete collection must be of a large size.

It is unnecessary to describe the details of make of a typical herbarium cabinet, but the general plan may be mentioned. It is usual to have a double row of plants, the cupboard being partitioned in the middle, and usually about 6 ft. high. Mahogany is a good wood to employ. The width will depend upon whether the plants are arranged (*a*) flat or (*b*) upright. If flat they can be laid lengthwise, or the other way, making the inside of the divisions either a foot or eighteen inches

wide (Fig. 16). If they are vertical then the cupboard can be made a foot wide from front to back. The sides as well as the partition, if the specimens are laid flat, should have runners

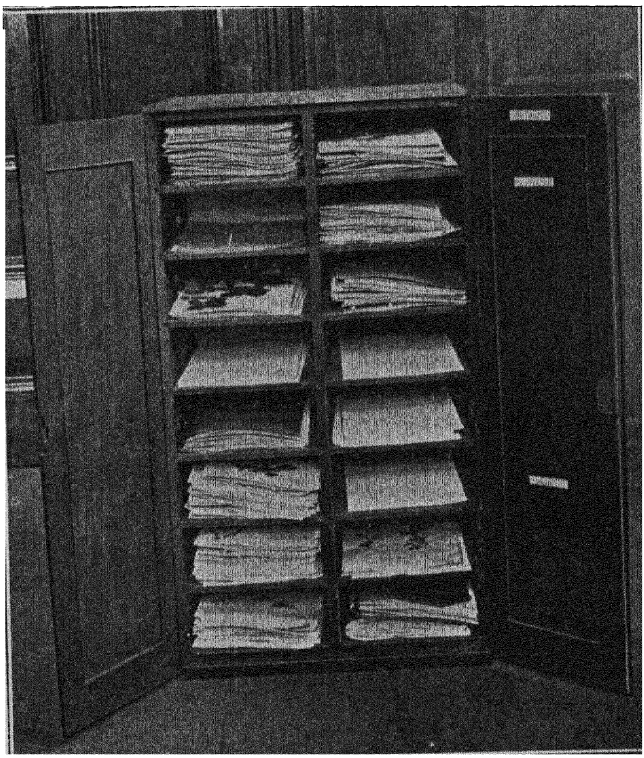


FIG. 16. Herbarium, with shelves adapted for horizontal arrangement. (Photo, A. Newton)

at intervals of half an inch, and there should be divisions to slide in and out of these where required. In the cabinet in which the plants are placed in an upright position one may have a couple of vertical divisions and a horizontal, the latter at distances of 18 in., the former at equal intervals, three in

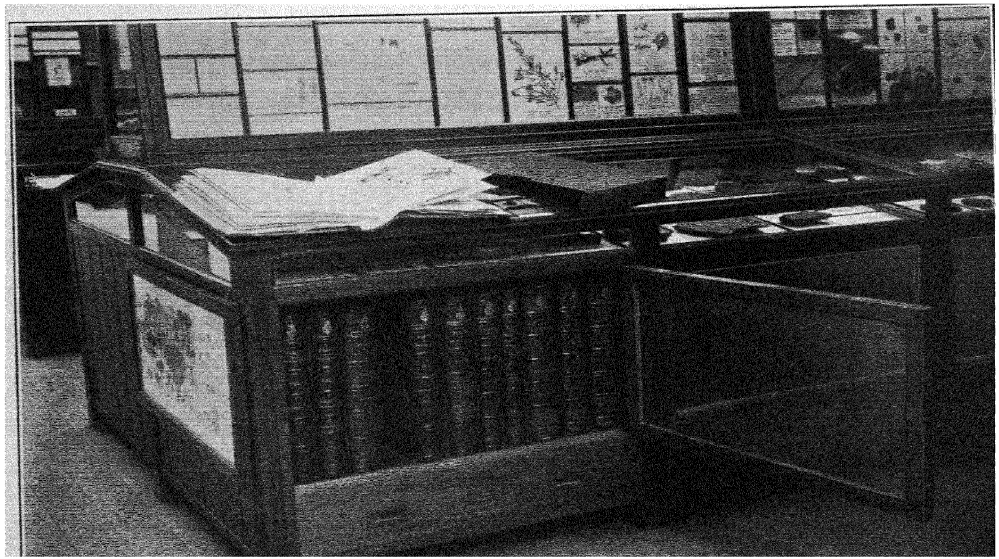
a width of, say, 15 in. (Fig. 17). In each division or compartment have naphthalene to drive away moths ; the naphthalene pads may be placed in the covers at intervals. On the front edge of each division have fastened a note of the contents, say orders or genera, in large type. This will be an aid to reference, and the first and last numbers of each series can also be given, according to the London Catalogue, or else the alphabetical arrangement may be used as above. One other method of arrangement in loose sheets is to have each set of species in a genus (or each genus) tied up in a cover which overlaps all the sides, the cover being 3 ft. in width and at least 20 in. in length. The contents are labelled conspicuously outside and portfolios may be placed in a similar kind of cabinet.

Another method of my own invention is to have a limp cardboard case open one side to insert a sufficient number of genera in their covers, with tapes to tie it up, which is placed in telescope fashion within another stiff case. This is shouldered, and a deep lid fits over it and completely encloses the inner case (Fig. 18). This is absolutely dust- and moth-proof, and if kept, like file boxes in library shelves, labelled across the back, they serve as books of reference, and are not liable to exceed one's needs as regards space. The only objection is that it takes a little longer to look at a specimen so stored than in a cupboard. The looped strings serve as a handle to draw out the inner case. At Leicester Museum the novel plan is adopted of having the sheets bound up in book form inserted on guards with extra ones allowing for additions, the book being enclosed in a case, making it nearly dustproof (Plate IV, Fig. B). These books or volumes of plants are labelled as far as orders go on the outside, and are exhibited in the museum in glazed cupboards (Plate V) below the botanical exhibits, so that they can be seen and inspected on application to the attendant. The method is satisfactory, but one cannot determine whether future additions may or may not swell out the case and cause the pressure to crush the contents.

In my own portfolio arrangement the elasticity within the boxes allows for expansion, and the contents of each file box can be changed from time to time.

5. Various Methods for Preserving Plants or their Parts. How to skeletonize leaves is often asked by the wanderer who finds this beautifully done already in winter by nature out of

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LEICESTER MUSEUM HERBARIUM
Showing plants arranged in bound volumes, with one open above

Photo, A. Newton



FIG. 17. Herbarium cupboard with sheets arranged vertically. (Photo, A. Newton)

doors (Plate VI). To do this a little apparatus is needed, and the following solution :

Chloride of lime . . .	5 oz.
Washing soda . . .	6 ,,
Water	2 ,,

This can be strained, when the soda has been dissolved in

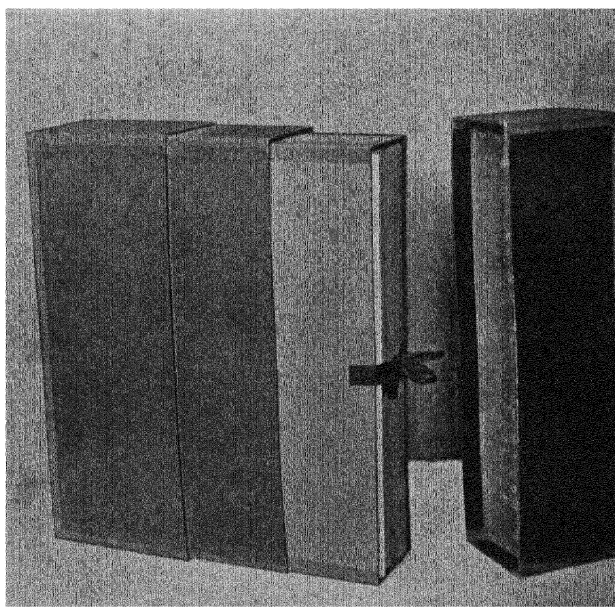
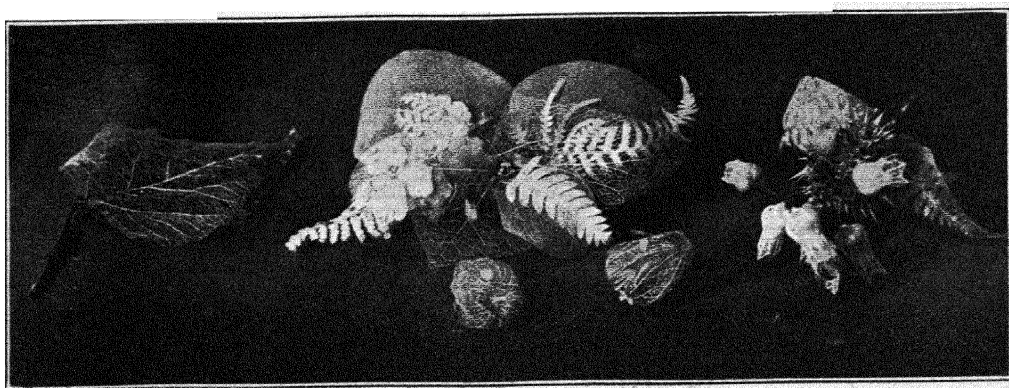


FIG. 18. Portfolio arrangement showing inner and outer case (Photo, A. Newton)

warm water, into a jar through muslin, and lime added. The leaf is boiled in this solution when filtered until it is devoid of anything but the midrib and veins. It is well to take out the leaves and remove the dissolved chlorophyll and leaf cells, or dry it between blotting paper and wash it in clean water. An improved solution is obtained by adding chlorine gas to the lime water and adding the soda afterwards.

PLATE VI

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NATURAL AND ARTIFICIAL SKELETON-LEAVES, ETC

Photo, A. Newton

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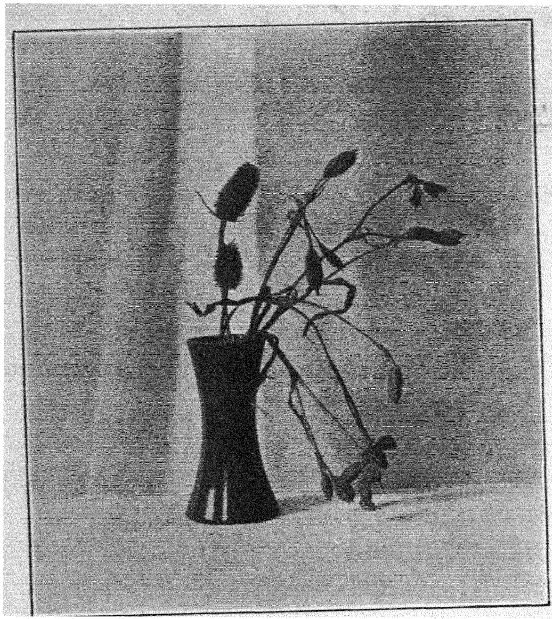


FIG. A. FRUITS AND SEEDS FOR FRUIT AND SEED COLLECTION



FIG. B. MODEL OF POTATO PLANT

Photo, A Newton

To mount the leaves take some fish glue or gum tragacanth. They should be mounted on black paper to show well. Let a sheet of thin paper be used as a cover to the mount and pasted to the back of it to overlap. It is recommended that only the stiffer, coarser textured leaves be boiled and that finer textured leaves be macerated ; the boiling takes ten minutes, while the macerating process lasts from days to weeks. Leaves containing tannin cannot be treated thus.

It is often necessary to collect and preserve fruits and seeds (Plate VII, Fig. A). For this purpose they must be quite ripe and can be collected out of doors in chip boxes. They can be secured by sweeping with a net as for insects, or by using a telescopic walking-stick with pruning-knife, or a bamboo fishing-rod (collapsible) to reach those that grow (like those of White Beam) at some height. It is important to show the seeds and the structure of the seed-vessel and the mode of seed attachment, as well as their contrivances for dispersal. For this some packets are required to enclose the seed capsules before they shoot their catapults, *e.g.* **Wood Sorrel, Violet,** etc., but drupes, pomes, berries, achenes, and nuts can be carried home loose. These need different treatment in preserving, and should be put in tubes in a solution such as the following :

Salt	1 lb.
Potash alum	8 oz.
Corrosive sublimate . .	10 gr.
Distilled water . . .	1 gal.

The " kernels " of drupes may be dried separately. To use them they may be floated out in water afterwards, having been sectioned and dried in air, assuming their natural position. For a series one needs the bunch of fruit, a single one by itself, vertical and horizontal sections, and seeds. These can be gummed to thick cards, and may be stored like negatives or lantern slides in grooved boxes.

Trees and shrubs are now becoming popular for teaching and pictorial purposes, and to make a collection of these may be one's special hobby. Remember that the flowers appear before leaves in many trees, and to collect a series several visits are necessary. Male and female catkins must be collected, often from separate trees. Get the leaves later and see they are free from holes or blemishes and quite mature ; a skeleton leaf may be made as well for the series (*see above*).

A twig, a bit of the branch, and suckers should also be shown. Gather the seeds ripe with the fruit ; photographs of winter and summer states may be made, as well as of the bole, and the flowering twigs. Seeds, etc., may be dried by pressure like the other parts of plants ; it is advantageous in the case of seeds to put a layer of cotton-wool between the drying papers, and to dry with a weight or by means of straps. Dried in this way they may afterwards be mounted as a series on thick white card, the heavy parts attached with fish glue, the lighter with gum ; they can be stored as in the last case in grooved boxes. The seeds may also be dried in sand as by the process mentioned later (*see* Section 7). In this case they can be mounted and stored in glass-topped boxes, and the size here will not count. To paint over the specimens make a mixture like that given on p. 53, and apply with a camel-hair brush.

6. Glass Models of Plants. To obviate the difficulty of preparing or preserving plants in their natural colours, it has been found of value to reproduce them by means of models in glass.* The celebrated Leopold and Rudolph Blaschka, renowned the world over for the models of invertebrates, held the secret for this method of working and colouring in glass. The elder one died in 1895, and there now remains only the son Rudolph. They were commissioned in 1891 to make a series of models of the American flora for Harvard University. Up to recently 147 natural orders, 520 genera, and 687 species of flowering plants had been executed, and 2500 models to illustrate details of morphology have also been made.

The plant models are arranged after Engler's " Planzen Familien." There are plants in their relation to light, heat, insects, etc. Other models illustrate useful plants with their economic products, *e.g.* flax, cotton, tobacco, coffee, tea, chocolate. Cryptogams are also represented in this exhibit.

The models are botanically exact in structure, form, size, colour, spines, hairs, etc., and it is only to be regretted we have nothing of the kind in this country (Plate VII, Fig. B).

7. Drying Plants without Pressure. Plants can be dried without pressure to retain their natural colours in two ways.

The first is by placing them in silver sand, which should first be finely sifted and baked in an oven to kill all germs. The

* *See also* Appendix as to the methods used in making models in wax. Excellent results are obtained in the case of plants by this means, and the colours used in the waxes are more or less natural.

sand is placed in a box, and the plant arranged in the box in its natural position, and it should not be laid horizontally unless that is its natural position as a trailer or procumbent species. When the plant is laid in the sand on a bed of the requisite depth, the sand to be laid upon it or around it should be carefully put in the box, gradually and evenly letting it fall from above on to the plant to fill up little cavities. When filled the box should be placed where air can freely reach it. Opinions differ as to whether the sand should be warmed. One method advises the placing of the drying boxes in a cellar an hour before emptying and allowing the sand to flow out at the bottom by withdrawing a cork. As the plants are afterwards affected by moisture, a thin coat of shellac* may prevent this absorption, or chloride of lime may be used. Ten days is a usual period taken in drying by this method.

Another method is to use boxwood sawdust instead of silver sand as a drying medium; goldsmiths use this for drying gold and silver after washing, as it is more absorbent than sand and dries more quickly. It is used in the same way as the sand, but not allowed to fall in a spray on the plant, being carefully placed round the plant with a spoon. As this is a poisonous medium it must be used very carefully and not allowed to create a dust. It is well to wear a mask to prevent it from entering the mouth or nostrils. In spite of its disadvantages the results obtained have been good. It is not possible to dry all plants alike; succulent plants need plunging in boiling water to prevent growth, and are not so successfully treated.

Instead of using either sand or boxwood sawdust, sulphate of calcium or plaster of Paris has been used, employed in the same way; the plaster of Paris has a great affinity for water.

The colours are well retained and the shape and form if desired. The plaster requires heating to remove the moisture after being used, and it is best to use it when warm; for storing keep it in stoppered bottles.

8. The Preservation of Natural Colours in Dried Plants. Some plants retain colour better than others. The best method is to dry quickly, using drying paper while still warm from oven or stove, and to change it repeatedly. But *Sedum* and

* White shellac dissolved in wood naphtha — permanent ground colours may be worked in with it—applied with a fine brush, not to impart a polished appearance.

the orchids retain moisture a long time under pressure, and unless boiled continue to grow and form seed. The **Red Poppy** absorbs ammonia and so loses its colour unless brushed with acid. The change in colour is due to oxidation, for sulphurous acid, which deoxidizes plants, deprives them of colour temporarily; but their colour returns on exposure to the air. The oxidation takes place under the influence of moisture, for flowers dried over quicklime keep their colour. It is not the action of sunlight that destroys the colour, but damp, germs, etc., as when kept in stoppered bottles they become gelatinized owing to an oxidizing ferment in the presence of moisture, hence the value of placing quicklime with them for a short period to absorb this moisture. If this is done they will be found to retain their natural colours. The amount of moisture necessary for the action of oxydases varies in different plants.

Quite recently the retention of colours, more especially green, of botanical specimens exposed to light has been secured by treating them with acetate of copper dissolved in acetic acid diluted with an equal volume of water.* This is done by boiling as soon as the plant is collected, a copper chlorophyll compound being formed, and the protoplasm is killed before decay sets in. After this the plants are washed and dried in the ordinary way or mounted in preservatives, *e.g.* ¼ per cent. formol.

Drying in hot sand with paraffin wax has the result of retaining the flexibility of the plant, and the excess of wax can be removed by benzol or some other solvent of paraffin. †

9. Water Cultures. It is interesting and instructive, whether as part of a general course of practical botany or not, to make water and soil cultures of seeds. For this are required some wide-necked jars and a solution made up of potassium nitrate 1 gramme, and sodium chloride, calcium sulphate, magnesium sulphate, calcium phosphate, of each half a gramme, in 1 litre of water.

The plant may be started in soil and then removed to the water culture supported in the neck by soft asbestos or placed in a cardboard disk, with a radial slit. The rate of growth may be noted by drying the plant and weighing it with a chemical balance. Any rise of temperature may be found by means of

* On this point *see* Appendix, where a fuller account of the method is given.

† *See also* Appendix for English's process.

a thermometer. In the water culture see that the cork is dry, or the seed will show "damping off." The roots may be shaded from light by wrapping black paper round the jar. As the water evaporates daily renew it with a funnel, in order not to wet the cork. The plant should be taken out periodically, washed in water, and the solution poured out, leaving the roots in water for two days ; then refill as before. It is well for comparison to obtain seedlings of the same size. To note the effect of deprivation of potassium omit the potassium nitrate and use sodium nitrate, or calcium phosphate instead of potassium phosphate, and so on. The solution should be acid, and air must be admitted to the roots by a condenser.

Then compare results and also compare results obtained by growing in distilled water, ordinary water, and in different combinations of the solution. Dry and weigh the plants, or burn to find the increase in amount of ash or relative amount of each.

To watch the germination of seeds in soil have boxes made with one side omitted, and the fourth side instead fitted with a sheet of glass running in a groove. The seeds are placed touching the glass and the growth can be watched without any trouble ; wet sand does equally well. One may compare the influence of different kinds of soil upon the plant, as well as note the mode of germination, by growing the same type of seed in different soil samples in separate boxes. Similarly the influence of given proportions of water to a given weight of soil can be tested by growing a number of seeds in several of these boxes. Again, influence of numbers on rate of growth may be determined by placing several seeds in these boxes, which are readily made and should be 6–8 in. by 5 in. by 5 in. Screening from sun should be arranged for.

10. Preserving in Liquid or other Media. We have assumed so far that the plants are preserved dry as herbarium specimens. But it may be necessary and advisable to preserve them in other ways, to preserve form and other details. To preserve colour the specimens must be kept in a dry state ; to retain form they may be preserved in liquids. Some plants become flaccid in aqueous solutions and they are best preserved in 90 per cent. alcohol, which should be cleared by distilling when it becomes 91–95 per cent. The specimens should be put in at once, as soon as gathered ; this both bleaches and hardens the specimen. Chlorophyll is discharged and the spirit must be changed. This is suitable for pulpy as well as

woody plants, but the former in the process of dehydration are liable to shrink.

Formol is used in a 4 per cent. solution for preserving plants or, as the commercial liquid is 40 per cent., 10 parts formol to 90 parts water. Of the two, alcohol hardens more quickly and preserves the form better, while formol is a clear liquid and colours are long preserved in it. In either case jars or tanks in which specimens are preserved are to be carefully sealed down with bichromated gelatine (Plate VIII).

A whole text-book might be written upon these and other methods for preservation of plants in liquids. It is sufficient here merely to indicate a selection.

As an appendix to this section some further notes on observing and survey work are subjoined.

11. Other Methods of Survey, etc.

Floristic Botanical Work. Systematic work comprises :

Field-work and herbarium work, observations in the field or at home.

Field-work comprises :

Collecting.

Note-making or observations.

Herbarium work includes :

Preservation of material collected, by

Drying
Mounting } of specimens, *see ante.*
Storing

Observations are made in the field by the making of lists of species observed—by marking lists, or by making a MS. list ; and, at home, by the filling in of data upon tickets, on the card system, for reference and further arrangement on various bases.

Note-making. *Data tickets* are used in the compilation of the floristic portion of a flora, and used for recording the rock-soil notes furnished by an ecological survey of the area, with blanks for the inclusion of status (whether flowering or not), county hydrographic division,* altitude, rock-soil, locality,

* If this be adopted, these divisions have no connexion with plant distribution, except for convenience of reference, by subdivision of a large into smaller areas. The influence of river development, however, has an indirect bearing on the question.

date, collector's name, etc. These are made out as a card series from published records, existing specimens, and notes made in the field.

Delineation of Boundaries of Squares or Gridirons. In order to make optical observations readily it is necessary to have salient marks along the boundaries of the squares to be mapped, in the form of stakes, pegs, or holes in the turf, if permanent work is to be carried on. Ordinary bamboo canes will do, and these may be longer at the ultimate corners and have a small flag attached. The intermediate pegs or sticks may bear letters or numbers on cards for reference.

Surveying Vegetation on a Small Scale. *By the Gridiron Method.* In some cases it is necessary to map the vegetation more minutely, by indicating the exact position on squared paper to a selected scale, noting the contour lines and other features. Parenthetically it should be said that not only are the physical features and plant community boundaries put in (the latter by symbols), but notes are made in the note-book of the plant species, their frequency, and other details, whilst specimens are also collected and labelled for drying, etc. The soil is sampled, tested for water-content and texture, etc., photographs are taken—apart from the operations involved in taking levels, mapping, etc.

The gridiron method consists of taking a square area of 25 ft. and running four parallels down, 5 ft. apart, thus forming rectangles of 5 ft. by 25 ft. Across these bars may be run at right angles, making smaller squares of 5 ft. by 5 ft. This method applies only to very special cases, *e.g.* in salt marshes or on the new ground of a reservoir or some open spots as heaths and alpine habitats.

Surveying Vegetation on a Large Scale by the Square Method. Where a region is not divided up into small areas, as in the case of fields, etc., a method in general use is to take a long base line, and to divide it up into lengths 100 ft. apart, posts being planted at each point. From these perpendiculars are made at intervals of, say, 800 ft., and posts put down at 100 ft. intervals. At the tenth post parallels are run. Posts are marked out from the lateral posts, dividing the area into 100 ft. squares.

By this means and by indicating the parallels by numbers and the perpendiculars by letters, the position of any point can be referred to in terms of both, *e.g.* 14a.

Method of Survey. For general work it has been found

convenient to use the 6 in. maps in which the areas are marked out as fields, woods, etc. Each of these is numbered (except the marginal incomplete plots, which are reserved for treatment when the four surrounding maps of each sheet are surveyed) for reference.

Each area is studied in detail on a systematic plan, and the observations made upon each area bear the same number as the number of the area. Each area is treated as a separate unit at first, but in studying a whole sheet, or a series of sheets, the relationship which exists between a series of contiguous areas (the boundaries being artificial in the case of fields), brought out by actual survey, is recognized by a comparison between the data offered by the observations made, these being arranged in the order and position of the numbered units.

Individual differences between adjacent areas are also noted by the same means. Charting the extent of a local association on squared paper by actual survey on the spot is the method most recommended.

Vegetation Maps. In order to define the types of vegetation in any given area it is necessary to adopt some mode of representation of the different units, *e.g.* woodland, heath, pasture, etc., depending on different soils, etc. The most convenient method is by means of colour, and by symbols or letters ; thus an oakwood is coloured green, with the letters O for oakwood, A for ashwood, etc.

These maps are constructed from those on the 1 in. scale, reduced from observations made on the 6 in. scale. Such maps, based on a soil and vegetation survey (apart from other ecological aspects), are invaluable to the agriculturist, and correspond to the geological maps of the geologist.

Tapes for Measurement of Distances for Survey Work, by the "Square" or "Gridiron" Method, or in Making Quadrats. The scale of distance used in survey work is the metre (= 39·37 in.).

For the square or quadrat it is useful to have a 100 metre tape, and a 10 metre tape (for measuring distances of 10 metre intervals), and a 1 metre tape. For convenience a steel pocket tape may be carried.

Determination of Contours, Construction of a Map or Plan, to ascertain the Height or Distance of an Object. *Use of the Anglemeter,* a Substitute for the Theodolite.* The anglemeter

* To be obtained from Messrs. Becker, Hatton Wall, London, E.C.

may be used to measure the distance of an inaccessible object (A). A base-line BC on the level is measured by tape. Angles ABC, BCA are measured by the anglemeter. On squared paper a line BC is drawn on scale $\frac{1}{8}$ in. to 1 ft., and with a protractor the above angles are made, and the triangle completed (producing BA and CA).

The sides BA, CA are measured with a rule, and the distance of these is then found by reference to the scale used. In place of scale drawing, trigonometrical formulæ may be employed.

The height of a building, hill, etc., can be found by the anglemeter. From the base of the object walk outwards till the line between a point B, on a level with the eye, and the point C makes with the top of the hill, etc., an angle of 45 degrees found with the anglemeter. Measure BC, and to this add the height of the eye from the ground, and this gives the height of the object.

The same principles regulate the measuring of the width of a river or distance across inaccessible ground from one point to another. Set the anglemeter at 90 degrees. Through it at point B sight an object A on the opposite bank, and note an object X on the side of the river on which you are standing. Set the anglemeter at 45 degrees, and pace till a point at B is seen directly and coincides in the mirror (C), then BA = BC, *i.e.* the distance paced.

The anglemeter can be used as a clinometer. In measuring a slope a level must be obtained, either by the horizon, or by a spirit-level placed on a camera stand. One end of this is sighted as one point, the top of the hill in the mirror, which gives the angle of slope.

For contouring, a series of angles is obtained on the same base, and a plan is drawn, others at a different level.

The Chemical Balance. This is used to weigh soil samples when first obtained, and before they have been desiccated or dried to obtain the water content, as well as when dried.

To find the *water content* the weight of the dried sample and pan, W_1, is subtracted from the first weight (W) of the original sample and pan. The weight of the pan W_2 is taken from the dried weight W_1. The first result is then divided by the second and multiplied by 100, and the result is per cent. of total water content (holard), taking the dry soil as a basis.

$$\frac{(W - W_1) \times 100}{W_1 - W_2} = \text{water content per cent.}$$

The balance is also used in making an analysis of the soil for *texture*, or physical structure, the material which passes through each sieve being respectively weighed, and a percentage of the whole sample is thus found.

It is also used to weigh samples obtained by the *elutriation* of clay.

Water Bath. The soil sample is dried in a water bath or water oven to remove the available water as vapour. The water bath is so regulated by the water being kept at a constant level, with continuous inflow and overflow, that the process of drying is rendered much more thorough and uniform, and can be left for hours together. The soil can be dried in twenty-four hours at a temperature of 100 degrees C., though if the clay is stiff even longer is required. In the absence of a water bath or oven the soil can be dried in the sun, but this may take from two to three days.

Geotome. *For Soil Samples.* For taking soil cores or samples an instrument is required which will cut through the soil to a depth of 8–12 in. and bring up a solid core, to keep intact, or to utilize for examination of physical structure, chemical analysis, or water-content.

The geotome serves in place of a hand borer or auger. To extract the core a plunger is used, which pushes the core out without breaking it unless the soil is very soft and friable. A tin is used to carry the soil home, and may for convenience be one made to hold exactly a pound if it is not intended to keep the soil core intact.

Texture of the Soil. *Use of Sieves.* By breaking up a soil into a loose mass, it is possible to obtain an idea of the texture of the soil (in order to estimate water capacity and air content) by sifting this through a series of sieves of different degrees of coarseness. Three different sets of sieves are taken with 30, 60, 90 meshes to the inch, and through the first all but gravel will pass, through the second all but the coarsest sand, and the third retains only the finest sand or silt. Thus two sieves will generally do. The result will be usually about

10 per cent. gravel
15 per cent. sand
75 per cent. silt-clay.

To supplement this result a series of soil cores may be taken and the rate at which water moves up or down in a given time

noted. This gives the porosity and capillarity, the latter varying inversely as the former.

Test for Acid or Alkaline Matter in Soil or Soil-water. By using blue or pink litmus, which can be carried in the pocket in the field, to make rough tests for acid or alkaline matter, a qualitative result is obtained. For quantitative purposes the sample may be collected and chemically treated later. The determination of the existence of these in the soil is important, for they, more than other chemical constituents, regulate the presence or absence of certain plants on a particular soil. Alkalies reduce the amount of available water, acids increase it.

Measurement of Rainfall. *Rain-gauge.* The amount of rainfall is measured by means of a rain-gauge. The form recommended consists of a glass bottle fitted with a copper funnel with a conical receiving area and a narrow tube or stem fitting into the neck below. The ratio of the surface of the receiving area to the tube is 10 : 1. The diameter of the funnel is 5 in. The rain-gauge should be placed in the open, away from trees, on level ground, and sunk in so that the rim is 1 ft. above the surface. The top of the funnel must be level, and the rim quite circular.

The water collected should be examined at 9 A.M. every morning (even if there is only dew precipitation). It is poured into the measure, which holds $\frac{1}{2}$ in. of rainfall, with the 5 in. gauge, equal to 5·67 oz. avoirdupois.

Slope and Direction. *Use of Clinometer and Compass.* The slope of a piece of ground has an important effect upon the vegetation. The amount of slope, or of the inclination (or dip of the beds where the soil is directly derived from the underlying rock), is measured by means of a clinometer. This may be estimated by line and plummet, which measures the angle on a semicircle graduated in degrees. A basing strip is laid on the ground, the clinometer is moved gently along the upper edge, and the marker is allowed to swing freely. When at rest it is turned on its back and the degrees read off.

The compass is used to denote the direction of a ridge or other landmark, or of the wind or cloud, or direction of dip (= strike). The directions are quoted in terms of the number of degrees (360 in a circle) from E = 90°, W = 270°, etc.

By means of the prismatic compass fitted with a camera lucida and sight line, not only can the dip be ascertained but also the correct direction, and the true geographical north is found

by taking into account the magnetic declination, about 17° as a rule.

Psychrometer, or Wet and Dry Bulb Thermometer. *Measurement of Dew Point or Humidity.* Tables have been drawn up showing the amount of moisture present in each cubic foot of atmosphere at all possible dew points. To determine humidity therefore it is necessary to ascertain the dew point. This is done by means of a psychrometer or hygrometer, consisting of two thermometers, a dry and wet bulb. The latter has threads of wool attached to the bulb which are wetted by immersion in a receptacle placed below and kept moist. When the air is saturated the moisture on the wet bulb cannot evaporate, and the dry and wet thermometers register the same temperature.

If evaporation takes place the humidity is determined by the difference between the readings of the wet and dry bulb thermometers, and this with the dry bulb thermometer reading is referred to Glaisher's tables, and the dew point ascertained by the formula :

$$(t_1 - d) = A\,(t_1 - t_2)$$

where t_1 is temperature of dry bulb,

t_2 is temperature of wet bulb,

d is temperature of dew point,

A is a factor which depends on the temperature of the dry bulb.

Barometer. *Measurement of Pressure of the Atmosphere.* The pressure of the atmosphere, due to the weight of the air, which at sea-level is 15½ lb. to the square inch, is measured by the aid of the barometer. In this instrument the column of mercury balances the pressure exerted by the air. This column varies with the state of the atmosphere, and the reading indicates the height of the column in centimetres or inches, it being normally 29·92 in. The pressure decreases at high altitudes. When we say the glass is high the weather is likely to be fine ; if low it is the reverse. In the British Isles the barometer varies between 28 in. and 31 in. To make an accurate observation a vernier scale is fixed to the barometer, and a thermometer is attached to reduce all readings to the same standard temperature.

Measurement of Light Intensity. *Use of the Photometer.* In order to ascertain variation in the intensity of light, a factor of supreme importance in its effect upon vegetation, a photo-

meter is used. This consists of a metal box (like a steel tape measure) with a wheel to which photographic paper (solio) is fastened. There is a 6 mm. square in the side with a slide between two flanges which is used to expose the paper.

There are lines on the side which indicate the number of exposure, the wheel being regulated by a click, and a line just below the opening coincides with the successive lines on the disk. The length of exposure is determined by the watch and the slide is opened the full length.

In place of the photometer an ordinary photographic exposure-meter may be used, as this kind of photometer is difficult to obtain in this country.

Measurement of Altitude. *Use of the Aneroid.* In order to obtain a series of observations of the altitude of any points above sea-level reference may be made to the 1 in. or 6 in. ordnance maps whereon the contours are marked at every 100 ft. In addition to these determinations there is given the altitude of particular points used in triangulation or as offsets, and known as bench marks, where the altitude is marked with a broad arrow on a wall, gate, or other object. The altitude of particular points, hills, etc., is also given.

If it is required to obtain between any series of contour lines an exact altitude, use is made of an aneroid barometer. The instrument is set, and the nearest bench mark forms a convenient starting-point. As an ascent is made the needle indicates the increase in altitude, and this, after computation, is added to the altitude at the starting-point.

Measurement of Temperature. *Thermometer.* The thermometer is used to measure the temperature of the atmosphere. It should be placed away from the earth, and is generally exposed in a Stevenson screen where the sun cannot shine on it, and so cause an unusual rise of temperature, which may fluctuate as clouds obscure the solar rays, whereas the temperature will really remain much the same.

An earth thermometer for measuring the temperature of the soil is placed in a case and the bulb embedded in paraffin wax.

Maximum and Minimum Thermometers. Temperature depends largely upon the radiant energy received from the sun. At night the surface is cooled owing to loss of heat by radiation. An ordinary thermometer measures the temperature at the time. In order to obtain some idea of the range of variation during any period, a maximum and a minimum

thermometer are needed. The former reads like the ordinary thermometer, but has a constriction which causes a break in the thread.

In the latter is an index, and the reading is taken at the top of the index which indicates the lowest reading, the index returning to the bulb end as the temperature falls; but if the spirit expands with a rise of temperature the index is left in place and indicates the lowest temperature.

CHAPTER III

THE NECESSITY FOR ENCOURAGING THE STUDY OF BOTANY ON ECOLOGICAL LINES, BY THE POPULARIZATION OF PURE LIFE-HISTORIES OF PLANTS, THROUGH NATURE STUDY, MUSEUMS, SCIENTIFIC SOCIETIES, AND OTHER ASSOCIATIONS, AND IN THE UNIVERSITY.

1. The popularization of Botany in schools, and the application of it to the teaching of Nature Study. 2. Museums and the exhibition of wild flowers, the interrelation of museums and schools. 3. How Scientific Societies may advance the study of Botany. 4. The University. 5. Agriculture and economic relations to the advancement of botanical study and knowledge. 6. Various ways in which Botany is, and can be, encouraged in Great Britain. 7. The preservation of plants.

1. The Popularization of Botany in Schools, and the Application of it to the Teaching of Nature Study. The popularization of Nature Study is relatively a growth of not more than the last thirty years; it grew out of the old object-lessons. But they were often so meaningless because, though describing or concentrating attention upon a single object, and trying to give by the heuristic method the whole life-history of, say, a bean or potato, they were deficient in the art of compelling attention and interest, the objects of which they treated, by a strange paradox, not being forthcoming.

But now this is very much altered, for the very idea of Nature Study is to take the mind away from the teacher as it were and to give the *pupil* something to do. Children in schools now take a delight in nature knowledge because the objects around them appeal to their powers of observation; and because, intuitively, observation is gradually employed in a chain of reasoning which follows after the question what?

has been answered, and when the questions how ? and why ? come to be asked. In this way children learn for themselves the art of thinking. Collecting in this way is a useful means to an end, which need not be overdone by children if engaged in a wild flower competition, as they may be, without running any risk of diminishing appreciably the numbers of a plant. Children moreover like to study wild flowers out of doors in the open air without necessarily plucking them. This brings into school-work that reality and depth which are only possible when we study nature itself first-hand. The round of the seasons, peculiar as it is to the temperate countries, gives the young mind an idea of the force of life and the unity of things. The interchange of ideas and specimens by means of such a body as the Schools Mutual Aid Association, so ably conducted by the Hon. Cordelia Leigh, cannot fail to foster a healthy comradeship too between those who are mutually engaged in Nature Study, and help to promote it.

So many ways of creating interest can be found if trouble is taken to interest. Thus there is the study of the life-history of each thing observed, plant or animal. Here wild flowers are of use, and it is important to study them fresh, not from dried material. It is indeed a common practice for schools to have exhibitions of wild flowers in vases for school-work. The children learn not only their names but many other things, such as their adaptations and contrivances for various purposes. From the field-work they learn enough to construct a map of the district, on which the occurrence of wild flowers, etc., can be noted, fields, lanes, woods, etc., also being marked thereon. For the school itself they can collect and preserve a set of fruits and seeds to illustrate form (Fig. 19). A scrap-book may be kept to record information obtained to illustrate the subjects, and to paste in photographs that may be taken of the plants in their locality. There is also a great deal of interest in the keeping of a Nature diary by the children in which they can enter records of plants. Water-plants can be kept in an aquarium where, however, there must not be overcrowding, and easy water cultures may be made by the more advanced pupils. Nothing can be more instructive to the children than to have the flowers arranged on the ecological plan. It helps them to study the why and wherefore of the numerous associations of plants. In these and many other ways the study of

botany is encouraged by Nature Study in the schools, and this is only an introductory phase to the diffusion of its subject-matter through museums and other means, discussed hereafter.

There are some other subsidiary methods which help to promote this end. Scattered up and down the country

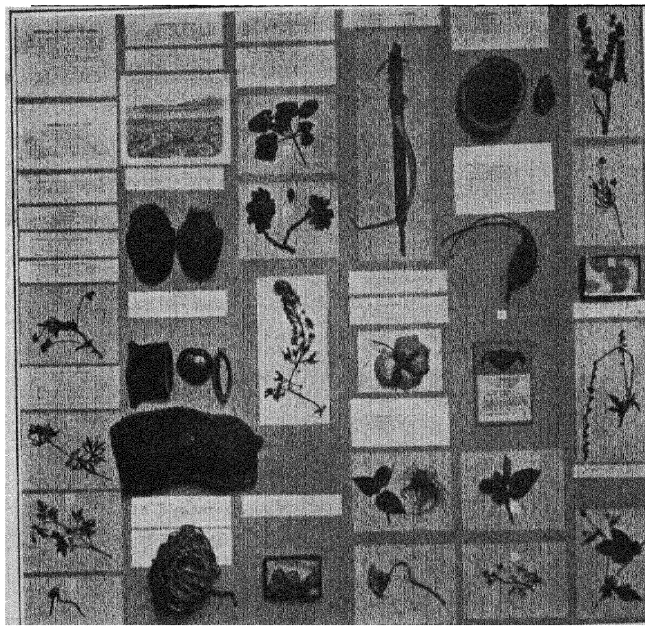


FIG. 19. Collection illustrating the means of dispersal of fruits and seeds (Photo, A. Newton)

are numerous branches of the Kyrle Society, one of the objects of which is to distribute wild flowers to schools. This also is done by the London Flower Fund and, as we have mentioned already, by the Schools Mutual Aid Association. The town children in default of specimens send cuttings, photographs, etc., to their country friends.

The encouragement museums may give to schools is again

equally useful in disseminating the study of botany and giving it an impetus.

2. Museums and the Exhibition of Wild Flowers, the Interrelation of Museums and Schools. It has been stated that the first exhibition of wild flowers in a museum was made at the Brighton Museum in 1872 when the British Association met there; plants from every part of Sussex were sent in, exhibited in troughs filled with wet sand, in three tiers, in a suite of three rooms. They lasted three days, and the affair was forgotten. Dr. F. A. Bather, of the British Museum, says that Miss J. H. Maiden, of the Technological Museum, had an exhibition of cut flowers for some time. Later Mr. H. Willett commenced a series of Wild Flowers about 1894 at Brighton, following the example of the Tunbridge Wells Natural History Society, the members of which placed flowers in vases after their excursions, and the museum, aided by outside helpers, continued to keep up this supply.

The specimens were first arranged in tumblers, then in glass jam-jars placed on a tier of shelves, or rather under the shelves, an overhanging piece of cloth concealing the jar, and the shelves opened down the middle and were fitted with perforated zinc with $\frac{3}{4}$ in. perforations for test-tubes for small specimens. The orders were arranged alphabetically. The names were written on cards with habitat, remarks, number, etc. As many as 125 species were exhibited at a time and over 600 in a season. Rare plants could be seen by students from a distance and the collection was valued by the schools. The method has been in force in Plymouth Museum for some time. In criticizing this arrangement Dr. Bather suggested that the Japanese mode of fixing cut flowers was often superior to test-tubes and jam-jars. Mr. E. M. Holmes has suggested that a plot of land should be reserved to cultivate plants to supply the table, and in this way their soil requirements would be found out.

In the arrangement of the flowers in the museum, attention has to be paid to the situation of the flower-table and the mode of arrangement of the flowers. It is well to arrange them alphabetically under each natural order. This facilitates reference (Plate IX). The flowers should be carefully selected, and characteristic (Fig. 20). Basal leaves should be exhibited where they are different, and also all the other parts required for specific identification if the arrangement is systematic. In the case of climbing and twining plants these characteristics

are illustrated by training the plants upon a stick. It is necessary that the labelling should convey more than the mere name. Some details should be given as to habitat, status, degree of occurrence, and the difference between allied species, of which a number should be gathered. It is not well

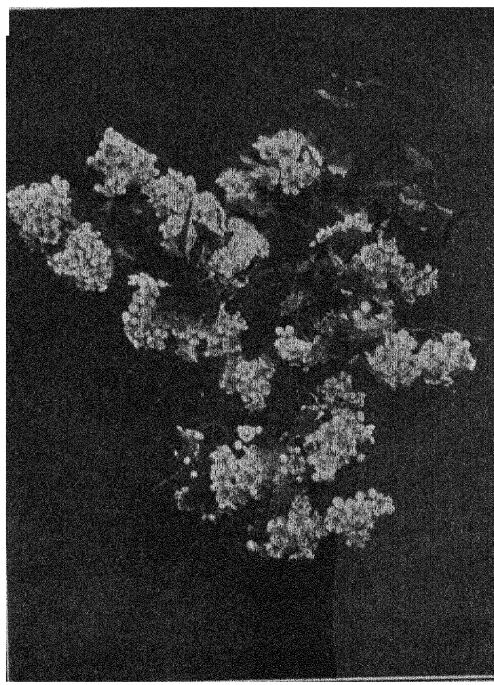


FIG. 20. Wild flower exhibit, a characteristic specimen.
(Photo, T. R. Goddard)

to give localities ; these are known to the staff which collects the flowers, or outside workers who assist in the collection. Perhaps the most useful way—or a supplementary method—is to arrange the flowers in groups upon an ecological plan—flowers of the meadows, bogs, sea-coast, etc., with special reference to the flora of the district.

Not only does the Wild Flower Exhibit in a museum (most museums have one nowadays) encourage the school-children in their work, but it is also eagerly inspected by that large body of private students connected or not with other institutions, who, one and all, take an interest in wild flowers. This body, like the schools who visit museums, has increased by leaps and bounds during the last decade, and on this account we have good reason for detailing the functions of a botanical museum to follow it up. In other ways, besides this exhibition of current life in the case of the plant-table, museums can assist schools in the encouragement of natural history.

As is shown in the remarks on the organization of a botanical museum, much may be done besides the illustration of systematic botany, or the formation of a herbarium, the latter of which need not even be on view. It is possible to make the ecological collections of such interest that the student or learner will go on from their study to a serious study of the series designed to illustrate morphology and anatomy. Moreover the mere knowledge that a herbarium exists in a town may be in itself a great impetus to the study of plants from the pure collector's point of view. But it is necessary that the herbarium making or studying be only a part of the botanical education of the student, and Professor Oliver's views in his York address and "New Phytologist" (under "Botany in England: A Reply") are much to the point in this connexion.

Next let us consider for a moment the organization of a botanical museum. Prof. F. E. Weiss, whose views we follow here, has given an excellent idea of what such a museum should be like. A museum should always be a teaching museum (whether connected or not with a university or other body whose function it is solely to teach the subject a museum can illustrate), to supplement what is gained by the sense of hearing in a lecture-room, by exercising through the media of exhibits the sense of sight. A museum must indeed have a plan and ideal, and this applies to its being mapped out into departments, like the botanical one at Leicester, as well as more especially to the details of the arrangement, aim, and scope of that individual department. A botanical museum should more or less be guided in its exhibits by the tendency of the professors of the day or their plan; they should work in unison.

It has been recognized that it is better not to start with the supposition that a student has no knowledge of botany and to begin with the lower forms and go to the higher, but rather to assume some knowledge, and to illustrate and describe accurately (and so correct some probable mistakes) a single flowering plant (or a series of them). Thus it is advisable to arrange a more or less distinct and complete series of specimens illustrating the systematic arrangement from lowest to highest (and thus illustrate the forms of plants). This would, moreover, explain the phylogeny of plants.

The second series should be arranged to illustrate the morphology and anatomy, or external and internal structure of plants, and the physiological functions wrapped up with the various organs. A series of root-forms, leaf-forms, stems, flowers, seeds, etc., should be shown for comparison, and the relative significance of each of the parts should be outlined.

A third or supplementary series should illustrate the divisions of plants according to environment, with such classes as Parasites, Epiphytes, Insectivorous, Sensitive, Succulent Plants, Climbers, etc. The influence of surroundings in moulding the plant's form would thus be further shown, and the interrelationship with the parts or organs in the second series should be pointed out.

The herbarium performs the function of illustrating, by actual specimens, in the same way as the pictures of a book, arranged systematically, and should be kept separate from the above, and, if it be included in the museum, kept for reference. Moreover the herbarium is only a partial record, for large and succulent fruits and nuts cannot for convenience find a place there; fungi, too, cannot largely be represented in a herbarium. It serves thus chiefly for a section of students or the pure systematist.

In the systematic part of the museum only the most important and representative genera are shown to illustrate the chief orders, thus preventing the beginner from becoming fatigued with too much detail at once. In addition to dried material, there is also spirit material exhibited and labelled in glass tanks. Some things are best shown in the dry form, as Red Seaweeds, for sooner or later spirit material more or less loses colour and form. Brown Seaweeds, on the contrary, keep better in liquid than in the dry form, and this applies to Green Seaweeds.

Fungi, as a rule, are difficult to preserve, except the microscopic forms parasitic on flowering plants. Indeed, they are best represented by models. Some flowering plants, particularly Orchids, are better preserved in spirit or formol, and show well with a background of blue, black, or red opaque glass.

But specimens have here and there to be supplemented by drawings and illustrations, and for this purpose to show

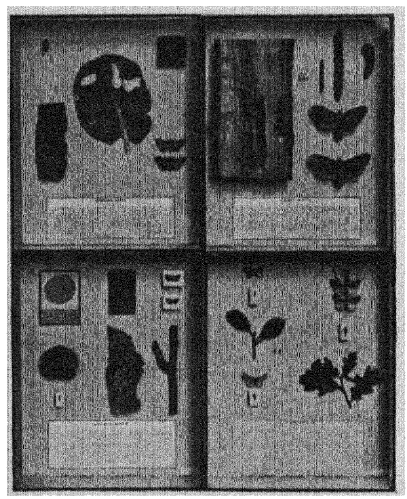


FIG. 21. Economic exhibits—insect pests upon plants.
(Photo, A. Newton)

structure or form, to explain function, minute tissue, or to illustrate habitat, no better work can be used to cut up and mount under glass for this purpose than Kerner and Oliver's "Natural History of Plants,"* which throughout is written in a thoroughly modern ecological and biological manner.

Models also should be used where they can judiciously be employed, but they should be good and not clumsy or wooden, much less inaccurate. Those in glass by Blaschka and in composition by Smedley are of permanent value. They are

* Messrs Blackie and Son, London and Glasgow.

especially necessary where enlargements of microscopical structure are required.

Nothing is more likely, especially in an index collection or general hall, to arouse interest, which is the first desideratum in the uninitiated, than to show photographs of plants growing in their natural habitats, or the entire plant, to give an idea as to its habit and form.

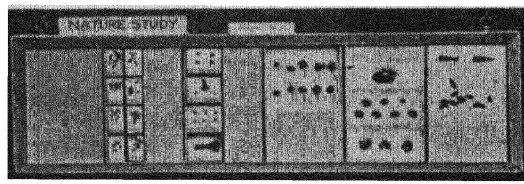
The economic side of the museum (Fig. 21) should not be neglected, for the advance of agriculture in all its aspects, pure farming, gardening, fruit-growing, forestry, etc., has made this to-day more than ever necessary.

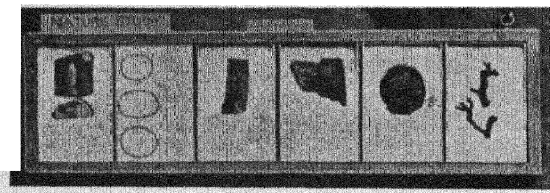
The morphological portion of the museum will be illustrated by specimens and drawings of germinating seeds, roots, stems, leaves, and their adaptations (protective, etc.); the flowers, pollination and fertilization requirements, their fruits and the dispersal of fruits and seeds, etc.

Moreover there are other ways in which the museum can advance teaching or encourage the study of a subject such as this. From time to time demonstrations can be given in the museum bearing upon some special exhibits and illustrating such subjects as "How and why plants are associated" in such and such groups. For the benefit of the teacher or others a series of lectures, dealing definitely in some detail with the ecological or other sides of botany, can be given and illustrated by lantern slides or specimens. In addition any definite sides of the question, such as the economic, or questions of fungal or insect pests, can be illustrated by preparations bearing upon injurious or non-injurious plants or insects, and so while dealing with life-histories, at the same time give preventive remedies for the stamping out of disease, etc., in a district, thereby also aiding industry. For schools, or even for other purposes, one may organize a circulating series* (Figs. 22, 23, 24, 25) whereby one is able to bring the museum to the school or individual where it is impossible to bring the school or individual (as is preferable) to the museum. In these and other ways museums can make for great progress.

3. How Scientific Societies may Advance the Study of Botany. In the local or district character of most of our Scientific Societies, Field Clubs, etc., lies a great part of their value; they are, as it were, the veins which lead to the main arteries of scientific work carried on by universities, museums,

* *See* Appendix for further details.





FIGS. 22, 23. Travelling exhibits—type collections for school Nature Study.
(By kind permission of W. M. Webb)

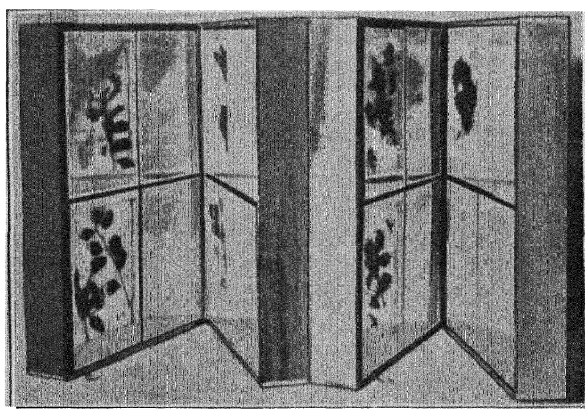


FIG. 24. Simple travelling museum case partly open.
(By kind permission of W. M. Webb)

and schools. Professor Boulger has well remarked that among the chief functions of local societies would seem to be: "(i) The education of a neighbourhood to some appreciation of science; (ii) the encouragement of beginners or of diffident and otherwise isolated students by the stimulus of rivalry, discussion, or co-operation; and (iii) the corporate record of local observations undertaken perhaps by many members. As a good illustration of this last function, the twenty years' record of the Marlborough College Natural History Society in botany, ornithology, entomology, and meteorology, or rather in meteorology

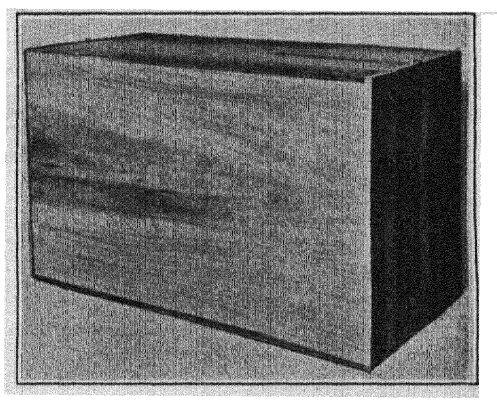


FIG. 25. Travelling case closed.
(By kind permission of W. M. Webb)

and in the phenology of plants, birds, and insects, may be instanced. Though contributed to by many generations, we may say, in a scholastic sense, we owe this valuable scheme in its entirety to the Rev. T. A. Preston."

In a sheet I have before me used for these purposes 79 plants were enumerated, some of the most common, such as **Wood Anemone, Pile Wort, Marsh Marigold, Mallow, Herb Robert,** being printed in larger type, 11 insects, 21 birds, and a concluding item "Frog Spawn"; and columns were ruled with a locality as a heading, and a number was inserted under it referring to some observation made in a diary or other record by different observers, giving details of time, date, and so on. It is only to be regretted that the example of Mr. Preston has

not been followed in most schools, though there are several school Natural History Societies with museums of their own which are doing similar work, such as the Rugby Natural History Society, which publishes its own Transactions or Reports and has done so since about 1860.

One of the chief methods by which societies can advance the progress of any subject is by the establishment of sections devoted to, say, botany, and the concentration of activities, therefore, in a definite direction by all those interested in a kindred work. By means of such sections a society can band together all its workers in a given subject and plan or work out some definite problems, such as, for example, the working out of a flora on ecological lines. For this purpose it will confine its work to a definite area also, usually the county. This restriction of place in itself is a motive for specialization, by which this age is so universally marked. But beyond this there is the far more important work of stimulating and arousing interest in the beginner, of encouraging him by assistance and mutual co-operation, and of generally discovering and bringing together all those who are beginning to be, or have long been, interested in plant-life, whether they have been isolated observers or not. It brings the town to the country and the country to the town as it were.

Furthermore, it should, if it does not, create an *esprit de corps* among all those equally interested in one branch of work or between those interested in different work. It must not be organized or managed by individuals who want to "run the show" for their own advantage and treat the members as puppets, nor should there be any hesitation on the part of the advanced worker and the beginner to mix together and exchange intercourse; an intellectual snobbishness is one of the worst forms of its kind.

The sections, moreover, are only the initial stage of the society's influence, or rather their winter evening meetings when papers are read and discussed, lantern slides shown and explained, specimens exhibited and described. There are the summer excursions into the field, organized in the same manner. Here the more formal acquaintanceship in the lecture hall or council room may develop into a real and living friendship or association, ripened by the more genial influence gained by walks under the open sky amid meadows full of flowers,

to the accompaniment, it may be, of the numerous bird-songs around one. Here the practical work in the laboratory again is sweetened by a foretaste of Nature in the field in its pure beauty. Connected with or arising from such excursions are exhibitions of objects collected during joint rambles or personal researches, and there may be emulation by the subjecting of exhibits to competition. In these ways a considerable amount of encouragement is given to botany, whether in the field or at home.

4. The University. As the Alma Mater in the education of each student who seeks the highest aids to learning, the university plays an important part in the teaching and dissemination of scientific knowledge, for the natural sciences take a greater share in education to-day than law and logic. Indeed, there is rather a danger of their assuming too great a prominence, especially technologically, and in some measure encouraging that materialistic nightmare which so long hung over the world after the publication of Darwin's "Origin of Species," owing mainly to the misconceptions of the theologian of the sixties and perhaps to some extent to science, then but groping towards the light.

Referring to this tendency, Prof. F. O. Bower, of Glasgow University, has said: "The public mind is becoming accustomed to this title 'technical college,' and is disposed to consider such establishments as something quite distinct from universities, and to regard them as places where the public demand is really met, while the universities are mere ornaments." As to their distinctness he would say: "There is nothing but tradition or convenience to prevent the retail dealer in ordinary life being his own importer, or the importer entering the sphere of retail trade. Similarly, there is nothing beyond tradition and convenience to prevent the technical colleges carrying out investigations in pure science, nor universities engaging in its technical application. This we may admit, provided always that the advance of pure science shall take place; this is the prime necessity, but it seems immaterial whether it be carried out within the walls of the university or elsewhere. Geographical position, tradition, and personnel may be the determining factors how far pure science shall be pursued in any given technical college. Conversely, the near proximity of a technical college, and the character and traditions of the neighbourhood which it serves, will be among the chief deter-

mining factors how far the practical application of science is to be carried in any university. There should be no absolute rule laid down in such cases, nor any jealousy between such institutions."

As to the supposed uselessness of botany from the public point of view, which Professor Bower refers to from his own or the university standpoint, he writes :

" I cannot help thinking that the botanists are in a measure to blame. In the past perhaps more than now, they have entrenched themselves behind a barrier of terminology, and made little endeavour to show that many of the terms are in themselves an evil. Accordingly the conclusion is that the botanist sets store by repulsive trifles, and is, therefore, worthy of contempt. But further, in this country we have been slow to adopt the practical applications of botany to agriculture, forestry, manufactures, and the arts ; this is, perhaps, the chief reason why the average man has not yet consented to take the science of botany quite seriously."

Furthermore, in regard to the Middle Ages of botany and its succeeding barren stages he writes : " The memory of this period dies hard, and the public are still slow to learn that a botanist is not a mere expert in terminology, but primarily a student of life, and that that life exists in phases which affect human well-being in the most various ways. It is only when this has been apprehended by the average man that the botanist will be properly understood by him."

Indeed the use of experiment in botany, as in biology generally, is the greatest advance of this age. " Experiment is observation ; but it is observation performed under artificial conditions ; and in scientific experiment these conditions are accurately known."

Such is the summary given by Professor Boulger, who writes as to the status of physiology in this connexion :

" Abundant new light has, however, been thrown upon the question of the essential character of the various elements found in plants, and the use to which they are put in the plant by ' water culture,' the growing of plants in distilled water to which certain known chemical substances are added. This method of experiment, with many others bearing upon plant-nutrition, which I cannot now touch upon, we owe to Julius Sachs (1860–95). In spite of his work, and that of Darwin on Insectivorous Plants and on Movements in Plants,

there is an immense variety of questions in vegetable physiology in which further experiments on movement are highly desirable. The rate of movement of water in the plant, the presence of nitrogenous ferments in the leaf and in other parts where metabolic changes—changes, that is, of mere plastic food material into organized tissue—are going on, and the entire subject of the chemistry of special secretions, such as the colouring matters, are among these subjects; many of which can be investigated with simple apparatus and trench upon the deepest physiological problems."

So much then for the technical importance or functions of a university and the value of experiment as a factor in practical courses of instruction or research work. Both come into direct contact with aspects of botany here advocated; that is to say, economics and the investigation of function as a result of field study or ecology, and its connexion with physiology. In either case the university can, and does, do much to stimulate non-collegiate students in their pursuit of botanical knowledge, and the general public is thus reached.

There are other ways in which a university is connected with botany outside its own sphere, and it is here that we approach the question. Most universities have herbaria whereby systematic botany can be illustrated. But on this head Professor F. W. Oliver says: "The position seems to be this: rightly or wrongly, and in spite of warnings, we are permitting the herbaria to become stranded; the universities, schools, and other institutions which diffuse and stimulate an interest in botany are not laid under contribution as they might be. Systematic botany hardly gets its fair proportion of the best that is available."

So he proceeds: "Hence, if the great school of systematic botany is to be revived in this country, the systematists themselves, *i.e.* those with the equipment of the great herbaria behind them, must take the leading share in the campaign." Again he writes: "I should like to see members of Herbarium staffs, in fact, members of the neighbouring university, or, at any rate, a selection from among them."

What we especially wish to emphasize is more or less illustrated by the following paragraph: "If ever there was a time when the future of systematic botany was full of promise, it should be the present. The perfecting of cytological and

anatomical technique, and the improvement in breeding methods place new implements at its disposal for broadening and deepening its work. Botanists should pull together with a view to so modifying the system that we in this country may take our proper place in the general advance. If we look abroad to centres of activity in systematic work, I think we shall find the relation between the university, the herbarium, and the garden to be an important factor in the case."

These remarks apply well to the old style of herbarium in university and museum alike. Not so, however, to the modern type of herbarium such as that of the United States National Museum, where monographs are prepared dealing with many other aspects of botany in addition to admirable systematic accounts of important groups. In our own country the Botany School, Cambridge, fitting memorial to the work of so eminent a botanist as Babington, though started by a different school on an ecological basis, bids fair to take the foremost rank so far as influence goes.

But in addition to the university herbarium there are other ways and means by which interest can be aroused through the agency of university teaching or methods. There are popular lectures that can be given from time to time on subjects of interest to the general public. The training of undergraduates in the subject on sound lines is moreover likely to be influential indirectly in encouraging this work by the introduction of university principles and methods into scientific societies with which they are often in touch when they leave the "'varsity."

In this connexion the popular lectures given at the British Association meetings and at the Royal Institution and elsewhere, largely given by university men, are capable of moulding opinions and views in definite directions. Extremely useful in provincial towns are those Cambridge and other University Extension Lectures which are given on botany and other subjects, often consisting of twelve lectures and a series of classes connected with them of a more or less practical nature.

5. Agriculture and Economic Relations to the Advancement of Botanical Study and Knowledge. *Why not a National Museum of Agriculture?* "The English visitor to the Berlin Museum of Agriculture has perhaps asked himself this question. He has seen the attempt of the Germans to group together a series of objects illustrating the history and present position of agriculture and fisheries. The centre of the large hall is

occupied by innumerable models and actual machines and implements. In the galleries every corner is occupied by zoological, botanical, geological, and chemical specimens. The birds, their nests and eggs, fill a large number of cases, and readable labels indicate their agricultural importance. Suitable traps are shown for dealing with those that might prove harmful. The mammals are shown in like manner. A set of Dr. Anzona's models indicate the changes produced in horses' teeth by age. Models and specimens illustrate the important breeds of farm animals. There are splendid models and diagrams of Farm Insects, as we might call them ; and their life-histories are given in neat cases showing also the plant attacked. Dried specimens of plants are exhibited in shallow wall cases. The large series of seeds, models of roots, the various woods, fungi, and many other exhibits still further indicate the botanical side of agriculture. A good microscope occurs here and there in this gallery, so arranged that a number of sections may be seen under each. An interesting row of bottles indicates the chemical analysis of peas, lucerne, potatoes, and even flesh.

"The minerals are arranged in chemical order. Ideal pictures indicate different palæontological eras. But here the most striking object is a horizontal model of Berlin in semi-transparent material.

"Glass uprights seen through the model of these are coloured to indicate geological formation of the district.

"An attempt is made also by models and pictures to teach the various kinds of fisheries.

"In Germany, where education in agriculture has been carried further than we have been able to do yet in Britain, every agricultural school has at least a series of models illustrating the more important breeds, and specimens of soils, rocks, and birds.

"The large institutions provide what agriculturists would term an interesting museum. At Hohenheim, for example, we may see a very similar exhibition to that in Berlin. Implements used at successive periods and in different countries are shown by specimens and models.

"Manures, soils, rocks, minerals, fossils, herbaria, models of plants, form extensive collections. The structure and divisions of the farm animals are illustrated by specimens, and all this in addition to the equipment of a large farm."

Such are the remarks of one who was desirous of introducing similar methods into this country. At the present time agricultural colleges and departments of colleges have to supply their own material and there is no attempt in any one museum to illustrate the history and present state of agriculture here. The museum needed would have to be a working institution for advancing agriculture and preserving collections illustrative of it. There is a demand for this museum which is felt, and plenty of scope for the exercise of special knowledge in botany, zoology, anatomy, and pathology to explain the interrelation of agriculture with these subjects. A collection of animals, plants, and preparations illustrating structure, pathology, and analysis (soils, etc.) would be of great value to the agriculturist and also to the naturalist, as such a knowledge is of constant value. It would be possible again to illustrate the various industries that make up agriculture, and their mode of working, etc., as bee-keeping. It would also be necessary to exhibit machines and appliances and to have working models as in other technological collections.

These are only a few of the ways in which, in connexion with and as a means of promoting the subject, botany may be encouraged by means of the necessity for making agriculture a scientific study.

In treating of economic botany as a museum subject it has been proposed that such a museum should deal with the source, geographical distribution, collection, manufacture, properties, and uses of vegetable products, and the conditions controlling their production and utilization. This can be illustrated by means of specimens, photographs, maps, descriptive information, and commercial data. The products may be arranged according to their botanical relationships, their uses, and their country of origin. It is best to arrange the products according to their uses when only one area is being dealt with such as the British Isles ; where the scope is wider the museum can best arrange them according to their botanical relationships. In the case of commercial needs the best method may either be by arrangement according to use or origin, which will depend on whether the museum is used from either of those points of view.

Samples of different kinds of wood with sections may very usefully be shown in a museum (Fig. 26). Though there is a Woods and Forests Department, at the present time there is really little scope in England for the exercise of its functions, in

the same way as in India and Canada. The present movement, however, towards afforestation, even if it is so far largely managed by private enterprise, cannot fail to have a healthy stimulus in the direction of causing forestry to be resuscitated as an important adjunct of Statecraft. There are, moreover, now some score of State forests where forestry is being carried out scientifically. Allied to forestry is the activity of the Board of Agriculture ; this body gives advice to farmers and others directly, reporting on various matters, giving information

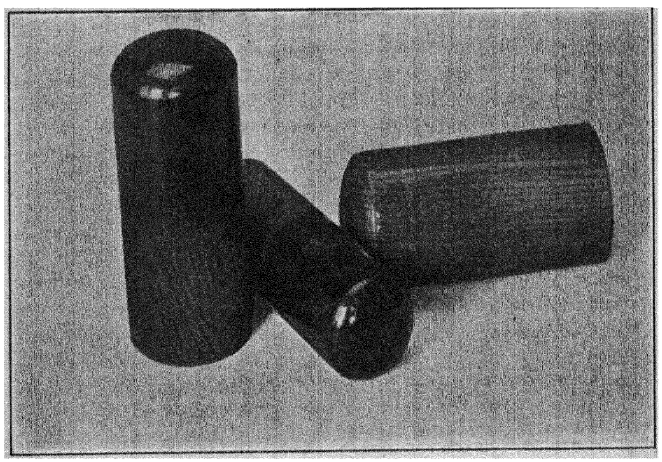


FIG. 26. Wood samples for forestry work, etc.
(Photo, A. Newton)

through its inspectors, and so forth. Moreover it disburses much money annually to encourage research and education in colleges and other centres.

Agricultural colleges * in this way are fertile aids to the spread of knowledge of a technical character, and may at the same time encourage pure, as they undertake to do applied, botany. They publish statistics as to the state of agriculture, cultivation, stock, and so on.

* The work of the experimental station at Rothamsted is in itself a remarkable case of the strides which this science (agricultural botany) is making in this country.

But the most influential aids are the publications of the Board of Agriculture, including the *Journal* and the leaflets, some 239 of which have been published. These deal with Acts of Parliament, Farm Animals and Dairying, Diseases and Insect Pests of Farm Animals, Cultivation of Fruit Trees and Farm and Garden Crops, Manures and Feeding Stuffs, Forest Trees and their Diseases, Wild Animals and Birds, etc., Insects and other Pests injurious to Farm and Garden Crops, Fruit Trees and Bushes, Fungi injurious to Farm and Garden Crops, Fungi injurious to Fruit and Fruit Trees. Moreover the authorities allow access to their library and also grant loans of books to country residents. The same remarks apply to Scotland and Ireland, where efficient Boards also exist. The Royal Botanic Gardens, Kew, publish a *Bulletin* full of useful information.

Stimulated by this useful Government work—till recently hampered by funds—there are, in addition to the agricultural colleges, in every district periodical shows and horticultural gatherings by means of which fresh impetus is given to the study of economic as well as purely botanic questions. Botanic gardens may be referred to in this connexion as equally serviceable toward the same end.

Some wholesome remarks as to the neglect of agriculture in the past have been made by Professor Bower concerning this matter; in referring to the chief object in view in studying pure botany, he says: "And if this [the nature and manifestations of life] be the ultimate view as regards the branches of pure botany, so it may also be in much of the work which would pass under the name of applied botany. Scientific agriculture is physiology on a manufacturing scale, and, with less direct powers of control over the experiments, is scientific forestry." In all these cases knowledge of pure botany is essential. In referring to the state of botany some years back Professor Bower says: "As a consequence of the great increase in the introduction of cheap food materials from abroad, coming on the back of a series of bad seasons at home, the agriculture of the country fell into such difficulties as to draw general attention to the need for more precise and economical methods."

The exhibition of economic specimens in the British Museum (Natural History) and the publication of economic reports have also an influence on the question of encouraging botany and serve to show that if agriculturists in the past have

not risen to the need or value of museums, the same cannot be said to-day.

There are many subjects that are likely to appeal to those interested in pure botany as well as in agriculture from a practical point of view. Such a topic as "how to grow straight timber," *i.e.* by a judicious method of thinning out saplings in a plantation, is worthy of discussion. Again the rustic industry of hurdle-making carried on by the countryman in a primitive manner irrespective of any but rough-and-ready methods can be dealt with from an economic and a botanical point of view. "How to grow Water Cress as an accessory to successful farming," is another topic of economic interest, since cress-growing is carried on to-day in a crude manner; but it is capable of scientific treatment in the same way as garden plants and fruit trees. The neglect into which many of our native vegetables have fallen from ignorance of the sterling qualities of many of them, which are unknown to-day, is another subject. Of these we give several instances in Chap. IV.

6. Various Ways in which Botany is, and can be, Encouraged in Great Britain. Though it is deprecated as a general principle, as being likely to lead to the extermination of species, yet there is little doubt that the interchange or exchange of botanical specimens, whether between members of a school, an association, or private individuals, has a stimulating and encouraging result. The mutual goodwill engendered by exchange is in itself of the nature of stimulus.

In this connexion we may note that the British Empire Naturalists' Association has as one of its objects the maintenance of wild flower farms, "where beautiful and rare wild plants will be cultivated for distribution to the members of the Association." Since the second object of this body is also to secure protection for wild life, wild plants, etc., it may be assumed that these farms will do more good than harm, and the organization of such a scheme on thoroughly popular lines is sure to make itself felt by the encouragement of natural history in general. We therefore welcome its good work in a sphere peculiarly adaptive to fresh ideas.

Moreover we may note the question of obtaining wild flower seeds and planting them in districts where such plants have been exterminated, in order that they may be reintroduced in suitable places. This is probably no more artificial than the dispersal of seeds by the wind or through the agency of

railway trains, canal boats, ships, or by man himself in walking from one place to another, taking seeds adhering to his boots, or by birds with seeds attached to their feet or beaks. But we confess we hardly like this purposeful upsetting of the balance of nature artificially ; of course if a thing is extinct in one place it rather modifies one's objections. There are, besides, some artificial ways in which the seeds or fruits of plants are dispersed which aid man in his work though the agents are unconscious. Rooks have a habit (like magpies) of hiding acorns, when there are plenty, in cavities in the ground, such as cracks. When the winter comes they return to these spots and pick them out ; but many of necessity are overlooked in this way, and so grow up. In a similar way the Hazel nut is distributed by Field Mice and Squirrels taking them afield to their winter stores.

People are frequently in the habit of transplanting wild flowers from their natural habitats to their own gardens, or to places set aside for wild gardens, and it is well to know that the best time to do this is in the evening when the plant's activity is least. Moreover a fair amount of earth should be taken up with the plants. Conversely there are those who have a habit of beautifying wild or waste places by planting there pretty or interesting garden flowers. The same advice as to planting may also be given. To the restocking of open spaces in or near large towns, where a natural flora would itself be largely alien or casual, there is not the same objection as there is to the habit of sowing wild flower seed broadcast in the country itself, for that at once upsets all natural distribution and human calculations thereon.

In quite a different way botany can be encouraged again by the formation of a system for the exchange of microscope slides. By this means can be had slides of such objects as pollen grains, stomata on parts of a leaf, leaf-hairs, and so on, all of which can be preserved with care in a slide, whereas, though they can be seen with a lens in the fresh state, they soon shrivel up if not sectioned and mounted. This is likely to encourage botany in physiological and morphological directions.

The formation of a Nature Photographic Society is one of the means whereby collecting can be discouraged and study stimulated by the taking of a photograph instead, and is to be warmly encouraged.

The subject and practice of town planting is another

way in which city dwellers can be brought into touch with the beauties of the countryside, and it is satisfactory to know that our city authorities are rising to the necessity of this beautifying effect upon towns generally.

A very useful practice in Norfolk is the establishment of a " Bird and Tree Society " for children, where the children select a bird and a tree, which they are told to observe, upon which they take notes, and about which they read for six months. At the end of that time they write an essay on each subject and are allowed the use of their note-book, which is supervised. A certain number from each school are selected, and the best from these again selected, and prizes given.

In the same way in some museums there are drawing competitions for elementary school children for the same object.

7. The Preservation of Plants. In these days of Nature Study and scientific activity it is inevitable that plants suffer; on account of this it is necessary that there should be some means of preventing it.

Instead of trees dispersed naturally up and down the country in these days of feverish energy and hyper-organized business, we see, in their place, rows of telegraph wires not only along the railway lines, but along our roads and often across country. Moreover, in addition to the lopping of such famous avenues as the Burnham Beeches, there is considerable trimming and shaving of the hedges and plastering of the banks, which is detrimental to wayside flowers, apart from the ugly appearance. Protests by Lord Carlisle and others have been made in which they have compared the necessary trimming of trees for telegraph wires, etc., and the needless mutilation of trees in rural districts and removal of all the gorse, wild roses, honeysuckle, etc. The fact that the cutting down of hedges is detrimental to the farmer, because it allows dust caused by motors to be blown over the pasturage, instead of being accumulated or stopped by the hedges, ought to serve as a practical reason for the abolition of these evils.

In France things are done in a better manner; in regard to the preservation of landscape, the following passage shows how careful they are not to destroy beauty for the sake of utility;

" In cases in which new roads or railways are to be constructed, or quarries to be worked, or watercourses to be diverted for generating electricity, every effort is to be made

to reconcile æsthetic considerations with the requirements of public traffic and the demands of commercial and industrial enterprises."

The felling of trees in popular resorts, or on a wide scale on private property for mere gain, is to be deprecated, and it is to be hoped that members of the public in such districts will be ready to protest when it occurs. There are many old mansions on the outskirts of towns where fine avenues of trees used to grow, which under the pressure of mortgage or other cause have been marked out for the woodman's axe. When this occurs the town councils, which do much to plant new avenues in towns, should endeavour to save these old beauty spots, considering such a measure a stroke of good business. These matters are only one reason for the reafforestation of districts where trees have been felled, apart from the profligacy of the last method, without replanting. It would, if carried out on scientific lines, also have the effect of restoring a more natural flora to the country, artificially altered by enclosing, grazing, etc.

There are those who think that it is justifiable to disperse wild flowers broadcast about the country where they have become scarce, on the plea that a list of wild flowers in any one district has no interest unless they grow in an area which completely represents one kind of soil. But this is entirely a mistaken way of looking at things, ignoring the motive of ecology and the existence of plant associations. If experiments in the artificial introduction of wild flowers are made let them be carried out on waste ground, or, if elsewhere, let the fact be advertised by a notice on the spot or a publication in some journal, as is done in the case of shells. That distribution is largely artificial generally is no excuse for adding to the troubles of the plant geographer. It is another question to suggest that blackened railway banks once gay with flowers should be restocked, for the embankments or cuttings are always artificial.

We quite agree with the protest against the practice of mowing down wayside wild flowers wholesale in the summer, and think that this should be restricted rather to the noxious, widely spreading docks, thistles, nettles, etc. The absence of the primrose in many places to-day is largely due to the greed of the hawker pandering to the public taste for these and other flowers, either cut, or rooted up ; and in some public places it

may be even wise to replant roots so removed, if precaution is taken against a recurrence of such vandalism. Fresh seeds can be sown in cold frames and planted out in due course.

Indeed we are far behind our neighbours on the Continent. In nearly every other European country, as well as in our own Colonies, there are measures for preservation or reservation.

The whole subject has been summarized admirably by Prof. H. Conwentz in "The Care of Natural Monuments" (Camb. Univ. Press), where he describes the objects of preservation, the dangers to which the monuments, such as views, water, rocks, fens, woods, plants, and animals, are exposed, and the measures (which have been widely employed abroad, Prussia having a State Department for the purpose) to be adopted here to prevent such dangers.

In this country preservation was long ago attempted by the British Association in 1886, but the scheme fell through. More recently Professor Boulger has pursued the subject, and has a Bill to lay before Parliament, which Lord Avebury approved in principle. The Selborne Society has also taken the question up more ardently and has recently published, by the help of the county councils, leaflets (which are reproduced on pp. 104 and 105) addressed to elementary school teachers throughout the country. It would be well if we could in this country do what is done in Vienna, namely, forbid the sale of certain rare wild flowers in the street. In England no such measures are adopted, except so far locally where county councils * have been courageous enough to obtain power to issue by-laws for the protection of wild flowers or ferns; and by imposing a penalty of £5 upon those who "uproot or destroy any ferns growing in any road, roadside waste, wayside bank or hedge, common, or other public place in such manner as to damage such public place." This is the intention of the Surrey County Council, and its example has been followed by the County Councils of Essex and Devonshire and other counties.

If we turn to the Continent for comparison we find that the naturalists of so small a country as Switzerland have banded themselves together to reserve the alpine flora and fauna.

To some extent school-children in the following of Nature

* Recently an appeal was made to every County Council to adopt this plan, which will be preliminary to the imminent framing of a Wild Flowers' Protection Act.

Study, if not cautioned by teachers, may help to diminish plants, but if the leaflets distributed are followed up there need be no fear upon this score.

THE SELBORNE SOCIETY.

Plant Protection Section.

*SPECIAL LEAFLET, NUMBER 2.**

AN APPEAL TO NATURE STUDY TEACHERS.

The Selborne Society, having regard to the great importance of preserving wild flowers and ferns and recognizing the widespread influence of nature study teaching as well as the good resulting therefrom, desires to call the attention of teachers to this matter, with a view to enlisting their aid in an appeal to children (and through them to their parents) to respect the following rules :

(i) Flowers should be collected for a definite purpose, and a limit should be placed on the number to be obtained.

(ii) Rare species propagated by seed should be allowed to ripen their seeds. Bulbous plants and ferns should not be uprooted.

(iii) It should be borne in mind that common species serve equally well with rare ones for teaching principles.

(iv) Specimens should be placed as soon as possible in water ; and when far from home those which easily fade should not be collected.

(Signed) A. B. RENDLE, *Chairman.*
A. R. HORWOOD, *Recorder.*

Copies of this Leaflet may be obtained for distribution from the Secretary of the Selborne Society, Wilfred Mark Webb, 42 Bloomsbury Square, London, W.C.

The SELBORNE MAGAZINE, which is the organ of the Selborne Society, contains articles which appeal to children on the subject of the preservation of animals and plants, as well as on other objects of interest.

* Leaflet No. 1 outlines the reasons for plant protection, the causes of extinction, and the means to be adopted to prevent it.

THE SELBORNE SOCIETY.

Plant Protection Section.

SPECIAL LEAFLET, NUMBER 3.

TO THE PUBLIC.

It is now well known that there is a marked increase in the rarity of many wild flowers such as the Primrose, Bluebell, and many Orchids, as well as of most Ferns, not only around towns, but also in the heart of the country. The vandalism which arises from the wholesale uprooting of plants for commercial purposes is due to the mercenary spirit of dealers who employ hawkers to strip the countryside of its treasures. The Selborne Society therefore calls upon the general public:

(i) To abstain from needlessly uprooting or damaging wild plants.
(ii) To discourage this spirit of selfishness in others.
(iii) To inform the County Council authorities and the Selborne Society of any wholesale practices of the kind indicated.

(Signed) A. B. RENDLE, *Chairman.*
A. R. HORWOOD, *Recorder.*

Copies of this Leaflet may be obtained for distribution from the Secretary of the Selborne Society, Wilfred Mark Webb, 42 Bloomsbury Square, London, W.C.

N.B. It is hoped that, before long, local orders making it illegal to hawk wild flowers in the streets, or to collect them in quantities, will be enforced by all County Councils. In the meantime the Selborne Society asks the public to support its efforts by discouraging all actions which tend to impoverish the flora and fauna of the country.

CHAPTER IV

GENERAL OUTLINES OF THE SUBJECTS TO BE TREATED, AS PART OF THE LIFE-HISTORY OF A PLANT. AN ATTEMPT TO REMODEL THE PROCESS OF TREATING THE DESCRIPTION OF PLANT-FORMS.

1. The establishment of a new method of studying the life-history of a plant. 2. On the necessity of an acquirement of interest before the taste for study is spoilt by too much analytic detail. 3. The value of the synthetic method. 4. The ancestors of our modern plants. 5. Plant distribution. 6. The types of British vegetation. 7. The habitats of plants. 8. The habits of plants. 9. The floral mechanism. 10. The seasons and struggle for existence. 11. The period of flowering. 12. Pollination. 13. Fruit and seed dispersal. 14. The soil requirements of plants. 15. Plants and fungi and insect pests. 16. The names of wild plants. 17. Plants and their folk lore. 18. Plant economics.

Introductory Remarks

1. The Establishment of a New Method of Studying the Life-History of a Plant. A reproach has long lain at the door of systematic botany that it was too formal. But since the birth of ecology it has been possible for the pure systematist to rid himself of this taunt by entering into an alliance with this sister subject. For as the one deals with forms and characters of the plants irrespective of environment, or the functions and stimuli evoked by the environment, the other, on the contrary, neglects the form and characters and inquires rather into the nature of the habitat, the life of the plant in the field, and the manner in which that life is influenced by juxtaposition with other plants (a principle unheard of—unthinkable we should almost conclude—in the early days of strictly systematic botany).

Now this union is firmly established, and ecologists can be counted like blackberries on all hands. But at the present time there has been no attempt to weld together the purely ecological factors (to use the word in a restricted sense) in a plant's life, and those essentially biological features on which life-continuance must be primarily based, that is to say, the functions of reproduction and dispersal of seed, etc. They are so vital, and in a measure so intimately wrapped up with the environment, that in a logical delimitation of a plant's entire activities they must inevitably play a prominent part. The present day is an era of life-history studies. We cater for this or for that creature comfort in the individual, and endeavour, in a similar manner to the method here foreshadowed, to delimit and classify and improve every function or activity of the individual also—whether he or she likes it or not. Then, too, we follow, logically, with the question of growth and nutriment as dependent on the character of the soil; this leads to the questions as to what pathological or destructive agencies are at work to undo the effect of growth and nutriment.

Having then inquired into the main factors entering into the plant's life-history irrespective of man's interference or association, we proceed to the names he has given them—for life is not all botany—coming lastly to the practical questions of to-day concerning their uses to us.

2. On the Necessity of an Acquirement of Interest before the Taste for Study is Spoilt by too much Analytic Detail. One of the chief drawbacks to scientific study from the popular point of view is the large amount of analytical work which is required before the broad principles of a subject can be fully understood. In other words it is necessary to cover a great deal of ground in traversing an area or district before one can attain to some height or some width or breadth of view, and obtain a panorama of the whole tract or region. So in this matter, unless exceptionally well piloted or aided by an intuitive sense of direction, it is probable that a long time must be spent in feeling the way or reconnoitring before a short cut is found to the higher, broader basis of things, the principles underlying the facts.

In botany, perhaps more so than in zoology, the beginner is bewildered by the mass of detail, the variations and permutations of differences that occur. An animal is more symmetrical

than a plant, and there is only slight variation in different species, whilst different specimens in the case of plants vary considerably, exhibiting a remarkable range of asymmetry depending largely on habitat and surroundings, included in the general term habit.

But, and here is the crux, if before the necessity of acquiring these very necessary details of fact the interest can be aroused in a general way in a subject, then by a judicious leading up to the matter that interest may be maintained until such time as the determination to pursue the subject to the end has been made.

Now the grouping of plants under such popular heads as those adopted in the last chapter can arrest the attention by their synthetic nature. The natural orders and their characters, difficult at first to assimilate, are hidden by the coloured imagery, as it were, imparted by the suggestive title Bog or Heath Plants, etc. For by these names the whole associations of such habitats are mentally conjured up, and they serve as mnemonics. Gradually the interest thus aroused will lead on to a desire to learn as much about each component part of the association as is known at first generally—but pictorially and incompletely—of the whole association.

3. The Value of the Synthetic Method. There can be no doubt that the best way to start the study of an extensive subject is to have its matter or contents arranged and tabulated upon a broad and well-conceived plan, which can be readily represented to the mind both in its entirety and in its larger details. This may be illustrated by the methods of mapping an unknown territory. The explorer does not commence by making a detailed survey of a small tract, extending its area as the work goes along. He first surveys a large area, puts in the main features that strike and impress him on first acquaintance with the country, and leaves to others that come after, the task of filling in the minute features, or, better, he does it later himself.

It is the same with botany. Given a summary of the whole subject, or that particular side of it we wish to study, we can pick up the threads of the subject-matter better by obtaining this initial *tout ensemble* than by any number of consecutive observations on details whose correlation we cannot as yet understand.

This broad treatment of things, this synthesis of facts, is indeed the royal road to progress in the acquisition of principles.* And since it is important to learn principles early, the mode of attacking the problems of analysis here advocated will, it is hoped, prove of assistance. It is important that analysis should play as considerable a part as synthesis, but let it be regarded as a pleasant duty, which is more liable to instil patience and perseverance than to act as a hard taskmaster. *Festina lente* applies here as in all matters of moment ; it is only the wag or the quack who can afford to be in a hurry.

For a long time the limits of descriptive floras have been almost entirely restricted to a definition in purely formal scientific terms of the main characteristics by which one plant can be distinguished from another.

Any other features beyond the systematic characters have been reserved for books dealing with the physiology and morphology of the plant, which have mainly dealt with a few types, often cultivated species such as the pea, bean, maize, etc. In a few isolated cases details of the life-history of the plant are to be found in county floras, but this is the exception. Only a few scientific treatises have set out to describe for a number of species the details of some one factor of the life-history of each species, such as pollination.

A work such as Kerner and Oliver's "Natural History of Plants," though a mine of information upon the full life-history of plants in general, including their cell structure, tissue, and mechanism, which we here exclude, includes the details of very few phases of the actual life of the plant, the description of its most essential life-phases ; for its object is rather to describe principles than to give details of life-histories. The popular works upon botany, moreover, do not proceed so far, but merely describe in more popular terms the specific characters or a few unconnected features of the life of the species.

In Chap. I (section 13) I have outlined the method here advocated of studying the life-history of the plant. It is not assumed that these features constitute the whole life-history of a plant.

* Hence the success which has attended the teaching of Nature Study (to use a paradox). For field-work presents life *en masse*, whilst in the school or laboratory only individuals or their parts are available for study. It is in the field that comparison, classification, ideas of variation, etc., first become possible.

Other observations, such as those of germination, ought to be included, but for the present purpose those features are selected which, as it appears to us, will most interest the young student or the beginner. The other features can be worked in in their place as opportunity presents itself.

The following Table shows the divisions into which the study of the plant may be divided, or the points that under this system should be studied:

(1) Fossil types.
(2) General distribution.
(3) Occurrence in British Isles.
(4) Habitat.
(5) Habit (vegetative characteristics).
(6) Systematic characters (floral mechanism).
(7) Mode of pollination of flower, and insect visitors.
(8) Mode of dispersal by fruits or seeds.
(9) Soil requirements.
(10) Fungal and insect pests.
(11) Explanation of scientific names.
(12) Common English names.
(13) Folk-lore.
(14) The uses of plants.

The following sections illustrate the main points of interest afforded by a study of plants upon the above principles.*

4. The Ancestors of our Modern Plants. Years ago it would have seemed of little or no interest to inquire how far back the plants of the existing period are represented in beds of earlier age than the present-day peat formations, in which their remains are being preserved for the generations to come to study, as the ancestors of the new flora into which our flora will gradually evolve, if it does not remain stationary. But the study of the mutations of plants, or the almost inappreciable variations that occur to-day and are links in the chain of species manufacture, serves to show that plants, at least many mobile or variable species, are now becoming altered as a result of the effects of environment or inherent tendencies towards variation.

* I have pursued this system in the description of a number of British plants in a book now being prepared ("British Wild Flowers in their Natural Haunts"), to which the reader is referred.

If then there are fluctuations in the status of each species to-day it becomes of interest to study the character of earlier types, and to try to discover the lines along which variation or heredity has proceeded in the past. During the last thirty years a great deal of information has been accumulated as to the occurrence of plants in the last geological phase and that preceding it, or in glacial and pre-glacial times. There are very few British types or forms that are confined to these islands ; in all there are about 130 species and 100 varieties, and of these 30 are **Brambles** or **Rubi**, and 70 are **Hawkweeds** or **Hieracia**, which are mainly Arctic alpine. The bulk of the British plants are members of the Continental Flora, and only a few are American.

The effect of climate has been to divide plants into lowland types and upland or Arctic plants, with a few sub-Arctic or intermediate plants.

Owing to altitude or the orography of the country, there are other divisions of plants, depending on their relation to sea-level and increased moisture or cold. As a general rule in England and Wales the hilly tracts are to the west, forming a broad wedge whose apex is fixed in central England, to the east of which we have a huge plain, with low-lying tracts along the east coasts. This gives us a division into maritime plants, or coastal species, and aquatic plants growing in lowland tracts, with rivers, ponds, lakes, etc. Marsh and bog plants are transitional between these last and many of them are Arctic. Heath plants occur at higher levels, meadow plants occur on clay soils, etc., being derived from a woodland type of formation, while others are addicted to chalk or limestone. Some plants are of western type, occurring in Cornwall, Devon, and W. Ireland, and are considered to be Pyrenean, the Irish types being also different from the English. They include **Heaths, Strawberry Tree**, etc., **Euphorbias**.

Three American plants are found in Ireland, and one found there is not found in Europe elsewhere.

Many British plants moreover are found all over the world, such as **Water Blinks, Cleavers, Meadow Rush, Chickweed, Persicaria**, etc.

Climate, migration, and dispersal best explain these facts.

Before the present temperate climate was inaugurated England underwent a great change, and was glaciated, cold periods alternating with milder intervals.

Southern types were driven out to the south, and northern types also came south. The northern types on the return of more temperate conditions retreated to the Alpine tracts, and the southern types returned north. The British Isles during the glaciation were united with the Continent, and migration and dispersal then came into play ; after their final severance the flora must have become largely settled. In the pre-glacial beds a large number of present-day plants occur, especially lowland southern types, whilst in glacial beds northern forms occur.

5. Plant Distribution. As has been noticed in the last section, certain plants are restricted to particular regions, such as the few native or endemic plants which are confined to the British Isles. In the same way other countries or regions contain members of a flora which are peculiar to them, and, in a general way, these limits of distribution are due to climate, barriers such as oceans, island formation, mountains, etc.

Other factors determine distribution, namely, temperature, moisture, light, soil, competition, animal and human agency. Plants whose seeds are dispersed by ants, for instance, Gorse and Broom, unless otherwise dispersed, must to a great extent be dependent on the existence of ant colonies in the district. These again may depend upon the making of tracks or roads along which ants largely travel.

On account of the difference in temperature due to the relative position of the earth's axis to the sun, the earth is divided into thermal zones, hot, temperate, and cold regions. The limits of these zones are also those of large groups of plants that require different degrees of heat. The Torrid or Hot Zone includes plants of a succulent character, that mature quickly, and many of the Saprophytes and Epiphytes flourish on such plants. Plants that are dry-soil lovers or Xerophytes flourish best in a sub-tropical climate such as that of the Warm Temperate Zone. Many of these plants are bushes or shrubs, and grasses and cereals form a predominant feature. About two-thirds of the known species of plants, or over 200,000 species, are found in the Warm Temperate Zone. The Cold Temperate Zone succeeds the last, and vegetation in this continues for some six months of the year. It supports many deciduous trees, whose leaves fall at the close of the growing season, in autumn. And a few are

evergreen and xerophytic, adapted to a lack of moisture in the winter.

Many herbaceous perennials continue their existence for many seasons, by prolongation of the subterranean roots and stems, and the stems of the year die down entirely or not as the case may be.

In the Arctic regions there are about 800 characteristic types with shrubby dwarf vegetation. Other zones are the northern glacial zone, the northern zone of cold winters, and the northern zone of hot summers. Each has its characteristic flora.

6. The Types of British Vegetation. For the convenience of estimating the local distribution of plants throughout the British Isles they have been divided into counties more or less corresponding in some cases with the political divisions, or combinations of them. Primarily these counties or vice-counties, as they are termed, are grouped into provinces, and these again into sub-provinces. There are twelve provinces in England and Wales and 71 vice-counties. In Scotland there are three provinces and four sub-provinces, with 41 vice-counties. In Ireland there are four provinces and 36 vice-counties, or, according to R. L. Praeger, 40.

They serve to record, by the numbers by which each vice-county is known, the distribution of each plant in the British Isles, in a convenient and abbreviated form. A complete record of the occurrence thus serves to constitute a census of the species, or its range. The same divisions have been adopted by the Conchological Society for the recording of the distribution of British land and freshwater shells, and they are thus of standard value. The connexion between plants, as food material, and mollusca makes this all the more uniform.

In addition to the divisions of the country according to vice-counties and provinces it is also divisible into zones according to altitude, based upon the height to which cultivation is carried. The Arctic region is divided into three zones depending on the upper limit of **Ling** and **Cross-leaved Heath**, the mid-Arctic zone lying between. The infra-Arctic zone is a region above cultivation, below the limit of *Erica tetralix*. The agrarian zone, which includes altitudes up to which cultivation can be carried on, is divided into the supra-agrarian zone, parts of N. and N.W. Scotland with Alpine plants, the mid agrarian zone, or lowlands between the Clyde

and Tay on the north and the Humber and Dee on the south, and hilly tracts in Wales. The infra-agrarian zone is the region south of the Dee and Humber, except the mountains of Wales.

Again, according to their presumed origin or range the types of British vegetation have been divided into eight groups: British (S. Mid. and N. Britain), English (confined to England, chiefly southern), Scottish (converse of the English), Intermediate (in N. parts of England and S. provinces of Scotland), Highland (Highlands Scotland, Alpine Arctic or Montane), Germanic (E. or S.E. counties), Atlantic (W. England), and a local or doubtful type.

7. The Habitats of Plants. The previous section dealt with plant topography. Plant geography deals with the floristic characters of a flora or the data upon which topography is based, or the delineation of large regions, the distribution of each species, etc.; whilst plant ecology deals with the association of plants as components of certain formations dependent upon soil, climate, etc.

Plant communities depend largely upon the factors determining the growth-forms.

Primarily the habitat may be terrestrial or aquatic, so plants are xerophytes or hydrophytes, and a large number are intermediate. The formations that depend upon such factors may be summarized thus:

(1) HYDROPHYTES . Aquatic formations.
(2) HELOPHYTES . Marsh formations.
(3) OXYLOPHYTES . Sour acid soil formations, heath and bog formations.
(4) HALOPHYTES . Maritime formations.
(5) LITHOPHYTES . Rupestral formations, growing on rocks.
(6) PSAMMOPHYTES . Sand and gravel formations.
(7) CHERSOPHYTES . Waste ground formations.
(8) MESOPHYTES. . Intermediate between hydrophytes and xerophytes, meadow and pasture land plants.

8. The Habit of Plants. By habit we may understand that of the vegetative part.

The physiognomy or general character of a formation is distinguished by the habit of the plants. or the growth-forms.

Trees, shrubs, herbs are growth-forms forming forests, bush, heath, meadow, pasture growth. They may be dense or close, and height may vary so that there may be various strata, such as the tree, shrub, and ground flora in a wood. The number of plants in a community of course largely affects their habit.

The Beech forest may have no bush or ground flora at all. The number and character of the species living in a community affect the habit and determine the relative frequency of any particular species apart from soil, etc. The habit of plants may be anomalous, as in the case of saprophytes and parasites such as **Dodder** ; or it may be aquatic, when the plant has parallel-veined leaves, slender, long stems, or in general the characters of shade plants. Other land plants are annual or biennial, and short-lived with uniform habit of rosette type ; perennials may be renascent, with a resting period, scale leaves, storing up reserve food, and whilst some form tubers some are travelling plants or geophytes.

Here also are to be included rosette plants with erect shoots, close-set leaves, creeping or prostrate plants with long internodes, and land plants with long, erect, long-lived shoots, " cushion plants " such as saxifrages, undershrubs, " switch plants," etc.

9. The Floral Mechanism. In studying the life-history of the plant the initial task of identifying it will be accomplished mainly by a knowledge of its floral structure. Linnæus was the first to recognize this. Besides being constant in the individual or species, whereas the vegetative portion is extremely variable amongst plants of the same sowing, it is more or less typical not only of genera, but also of families and orders ; hence a knowledge of the flower is indispensable.

Flowers are modified leaves, the stamens are reduced leaves, and the petals, as need arose, were developed from them also. The first flowers were pollinated by the wind, but insects were abundant fairly early in geological time, so that the petal is of rather ancient origin. In some flowers the petals do not form a tube, and probably these were the earlier flowers. By a modification of the receptacle a calyx tube was formed in which honey was secreted at a variable distance from the entrance to the flower.

Sometimes the flower may possess petals united to form a tube ; when they are so united the stamens are also frequently

connected with each other. It may in some cases have no corolla, when it is said to be apetalous. All these and many other facts are essential to a proper understanding of the flower.

10. The Seasons and Struggle for Existence. The alternation of summer and winter and the complete disappearance of annuals, the dying down of growing parts of biennials and perennials, the persistence of evergreens, the deciduous nature of the foliage of many trees and shrubs, all bear witness to the intensity of the struggle for existence that plants undergo. The alternate seasons of wet and dry conditions also influence plants in this respect. To withstand winter, in all but evergreen plants, the leaves fall; the buds of deciduous trees are protected by scales.

Some plants mature and seed in one season, whilst others take two seasons, and then die. Perennials may linger a variable number of years and seed more than once, or many times. Annuals last but a few weeks, and are frequently ephemeral. The shoots are elongated, and there are no contrivances for storing up reserve food. Biennials store up food the first year, and flower and mature their seed the second.

Perennials have a variety of methods by which growth is prolonged. The shoots may be lignified and the leaves deciduous. The shoots are elongated with long internodes, and some are erect, some prostrate; the renewal buds may be high up, or at the base; and there are numerous other factors, such as the bud characters, size of the plant, adaptations for transpiration, and other characters bound up with the life-struggle.

11. The Period of Flowering. The opening of the flowers is connected with the cycle of the seasons, and with the means by which plants resist the rigour of winter and prepare for the renewal of activity in spring.

Bulbous plants flower early before the woodlands are darkened by the shade of the overhanging boughs laden with leaves. Trees which are largely pollinated by the agency of the wind also flower early, in most cases before the leaves appear. Insect-pollinated plants also adjust their blooming to the appearance of the insects that specially frequent them.

Phenology, as this branch of botany is called, is intimately connected with the relation of the earth's axis to the sun, and the relative warmth that is registered month by month. In other words each flower has its thermal constant.

The period during which flowers are in bloom * varies immensely, some lasting but a few days, whilst others last almost all the year, or flowers can be met with during most months, such as **Dandelion, Daisy, Groundsel, Shepherd's Purse,** and the **Red** and **White Dead Nettles.** January includes few flowering plants, such as **Winter Aconite, Spurge Laurel, Snowdrop.** In February a few more, such as **Hellebore, Mistletoe, Hazel,** etc., bloom. March is the month when trees flower, and about forty flowers are in bloom. In April we may count a hundred, but May, June, July, and August are the months of flowers. From September to December the number decreases again.

12. Pollination. In order that flowers may be fertilized and the seed may mature, it is necessary that pollination take place, whereby pollen from the anthers is transferred to the stigma, and so by aid of the pollen-tube to the ovule, enclosed in the ovary, where as an embryo it is furnished as a rule with endosperm or other reserve material for its future office of plant perpetuation.

Pollination can be effected in one of four ways, by the plant itself, by the agency of insects, by the wind, and sometimes by water. The agency of birds is invoked in a few cases which are outside the scope of this work.

In the case of plants in which the anthers are situated in juxtaposition to the stigma, if they mature at the same time the plant is self-pollinated, unless contrivances are furnished to prevent this. As the pollen of the same plant is not nearly so fertile in most cases as that of a different plant, it is of advantage to secure the transfer of pollen by outside agency from a distant or different individual. This may be accomplished in some cases, and cross-pollination encouraged by the separation of the sexes, or in those in which they are found together by the maturing of anthers before stigmas, or vice versa. Needless to say, in plants where there are only male or female flowers some outside agency is required. The study of these contrivances is one of the most interesting phases of plant life.

13. Fruit and Seed Dispersal. A still further phase in the life-history of the plant connected with the maintenance of its struggle for existence is the means which it employs for the effective dispersal of fruit or seed. A large proportion of fruits

* *See* any good general flora for dates.

and seeds are extremely small, and it is easy to see that these, like spores, may be readily dispersed by the agency of the wind. But some of the fruits or seed-vessels are not, as in the pepper-box-like capsule of the Poppy, adapted to such means of dispersal. Some of them are in fact only distributed by reason of their special contrivance for ejecting the seed to a distance, as, for instance, by the splitting open of the capsule of **Heartsease** and by its contraction when ripe, so that the seeds do not passively fall around the root-stock, but are scattered far and wide. The valves of the capsule again may under the influence of alternate heat and moisture, by a principle termed hygroscopism, hurl the seed or fruit to a distance as in the case of the **Meadow Cranesbill.** Or the carpels may be turgid and upon a slight touch be expelled as "sling fruits" as in **Touch-me-not.** An elastic movement of the pod when dry serves to expel the seeds of **Furze,** which are also carried about by ants and thus dispersed. Other fruits with hooked prickles and bristles catch in the fur or wool of animals and are thus dispersed, as **Burdock.** Edible fruits are carried long distances by birds. Winged fruits such as those of the Ash spin in the air and are carried far from the parent tree. Many fruits or seeds have tufts of downy pappus and are carried away like a parachute by the wind, and lastly many seeds are carried along by water, some being adapted to resist long immersion.

14. The Soil Requirements of Plants. One of the most potent causes of the distribution of plants is the difference in the character of the soil in different areas. There are about six main types of soil, which are dependent upon the character of the sub-soil or rock-soil from which they are derived, or the geological formations which together make up the earth's crust.

The main terrestrial plant formations are moreover based upon the character of the soil. There are the clays and loams, the coarse sandstones and grits; the older siliceous rocks or schists, slates, etc.; and also the limestones and chalk. Humus is another soil, in this case organic, which may be dry or wet, acid or not. Peat is a further stage of an organic soil, which also characterizes certain districts that retain, by virtue of position or the conformation of the underlying rock, a great deal of water. In the case of bare rocks with no soil, there is again the question whether it forms a flat shelf-like structure, or is fissured with crevices. Here the composition is largely a

determining factor, whilst in every case the porosity and density of the soil or its relative air and water content is an important factor.

15. Plants and Fungi and Insect Pests. Apart from the relation of plants to insects and the use the latter are to the former as pollen-bearers, there are the interrelations which the two afford as a means of subsistence.

A few plants are insectivorous, digesting by means of acid secretions the insects which are attracted to them and are captured by the sticky glands they bear, *e.g.* **Sundew, Butterwort, Bladderwort,** and the **Teazel.**

More important is the relation between plants and insects wherein the former serve as food for the latter. The ravages done by caterpillars to trees and bushes in a garden is a single instance, but a sufficient one, of the part plants play in the life-history of insects. The plants which are selected by insects for food are well known to the entomologist, but the botanist has not paid much attention to this question. The usefulness of plants as food for higher animals, as well as snails, etc., is another feature which is intimately connected with plant life-history or bionomics.

Then again fungi are very largely parasitic upon higher plants. Many microscopic forms attack the leaves or stems of herbaceous plants. But by far the most important connexion between fungology and plants higher in the scale is the extent to which trees valuable as timber or as fruit trees, etc., are exposed to the attacks of fungi, and this is an economic question which is of the highest interest to gardeners, horticulturists, and foresters.

16. The Names of Wild Plants. Every English plant is known by a scientific name, consisting of two Latin words, a system invented by Linnæus, which enables people of all nations, since these combinations are universally accepted, to know exactly what plant is meant, whether or not they are able to understand the language of the country in which it is found. It is of interest to understand the meaning and to know something of the history of these scientific names, since they are often a guide to some character of the plant by which alone it can be distinguished from a closely related plant.

There are also the vernacular, in our case English, names, which on the contrary are seldom if ever known outside a particular country. Moreover there are very often a number of local

names by which a plant is known, used perhaps in one or more districts, but unknown in others. The country folk very often have a set of names of their own for the common plants ; since the same name is used for different plants in different districts it is well to know the exact meaning of each name, and a study of all the local names of a plant is of very great interest. The origin and history of these names are often very interesting ; they are closely connected with the folk-lore of plants, which is dealt with in the next section. These two sections may be considered the archæology of the subject.

17. Plants and their Folk-lore. In the first stages of human civilization, before history was in the making, man was animistic, and worshipped the elements, sun, moon, stars, or animals such as the hawk and ibis, etc. In other cases, exemplified by Druidism, he held such plants as the **Oak** and **Mistletoe** sacred.

The lightning which was held in awe was connected with many plants such as **Hazel, Rowan,** etc. Witches were held in dread and **Elders** planted to drive them from the dwelling. Plants played their part also in demonology, and orchards were held to be the special resort of evil spirits.

Fairyland is in itself intimately wrapped up with plant-life ; the **Foxglove** afforded the fairies part of their fanciful attire. Many plants, such as clover, thistle, etc., were connected with the pursuit of love as love-charms. Since Virgil's day the **Elm** has passed as the abode of dreams ; flowers also were connected with death. **Lilies** if dreamt of were propitious. Many of the sayings of the husbandman are illustrated by reference to plants and their flowering and other features, a form of folk-lore lingering to-day, as in the case of the **Oak** and **Ash** and their leaf development.

Proverbs are largely based upon plant lore, *e.g.* sowing wild oats. Festal occasions would have been less picturesque had they no connexion with flowers.

Flowers play their part in the symbolism of language. In all phases of life indeed plants and their folk-lore are intimately interwoven.

18. Plant Economics. Apart from their use as timber in the case of trees, and as fruit and jam in the case of fruit trees, or as fodder, cereals, or ornament for the garden, little is known by the majority of people as to the value of British plants. But it may be correctly stated that almost every plant

has some economic use, and in many cases this has been already discovered, though in numerous instances it is not generally known.

Gums are furnished by the **Pine**. Many plants such as **Poppy, Flax,** etc., yield oils, and menthol is derived from the **Mints.** Dyes are furnished by a number, such as **Weld, Woad, Madder, Alkanet, Mercury,** etc. The **Sloe** and **Oak** furnish marking ink, tannin is yielded by the **Elm**, etc. **Mallow**, nettles, etc., yield bast, and flax is derived from the **Flax.**

Drugs are furnished by many plants, and a large number are really efficacious, though rather overlooked or despised to-day because of the absurd reasoning of the Doctrine of Signatures as applied to them in the Middle Ages.

Perfumes are obtained from several plants, *e.g.* **Violet, Woodruff, Melilot.** Fodder is furnished for cattle and horses by a number of plants, *e.g.* **Clover**, and bird-seed by others, whilst fruits are yielded by numerous wild plants, the ancestors of our garden fruit trees. A number of wild plants serve as vegetables or pot-herbs, the latter now fallen, unwisely, into comparative disuse.

Timber is afforded by our forest trees, and is the basis of one of our great industries.

CHAPTER V

AN OUTLINE OF THE PLANT FORMATIONS THAT CAN BE STUDIED UPON A BROAD AND CONVENIENT BASIS.

1. General remarks. 2. Meadow and pasture plants, including clay and sand lovers. 3. Cornfield and arable land plants. 4. Woodland plants. 5. Roadside and hedgerow plants. 6. Mountain and hillside plants, including limestone and chalk plants, siliceous soil-loving plants. 7. Maritime plants. 8. Bog and marsh plants. 9. Heath and moorland plants. 10. Aquatic plants. 11. Waste ground, casual, or alien plants. 12. Rupestral plants, and those addicted to sandy and gravelly soil.

1. General Remarks. In order to study plants from the ecological standpoint it is necessary at the outset to understand some of the terms which have been applied to vegetation or its components.

Generally speaking two factors determine the character of vegetation at the outset, *i.e.* the nature of the surroundings, whether land or water, giving at once two divisions—terrestrial or land plants and aquatic or water plants.

In the case of vegetation, climate and soil are very potent causes of the character of plant physiognomy in the first group.

Primarily we have then certain types of plant formation which are determined by the character of the habitat. These are largely dependent upon the character of the soil. And there are, broadly speaking, five types of soil which give rise to types of formation, viz. :

1 Plant formations of clays and loams.
2 ,, ,, coarser sandstones and sands.
3 ,, ,, poor, sandy, and gravelly soil, heath formation.

Plant formations of older siliceous soils.
,, ,, calcareous soils (limestone, chalk, and of marls and calcareous sandstones).

There are also formations which are based upon the character or relative amount of water in the case of aquatic plants, for some plants are found in salt water, some in fresh water, and in the latter case much depends on the relation of the plant to its surroundings, *i.e.* if living entirely in water, or whether in a submerged terrestrial habitat. Again the character of the water determines other aquatic vegetation. This also is connected largely with the relative altitude.

Aquatic vegetation thus consists of the freshwater aquatic formation and marsh formation.

The soils which are rich in peat closely connected with the water content may also in general terms be described as

Moor formation, lowland and upland.

Fen formation, allied to the marsh formation ; and with these are included heaths with little peat.

Depending upon altitude, again, a factor of climate, is the Arctic alpine vegetation. This includes the Arctic alpine grassland formation, and the upper Arctic alpine formation, including a formation of mountain-top detritus and snowpatch vegetation, and the Arctic alpine chomophyte formation.

The vegetation of the sea-coast includes the salt-marsh formation, the sand-dune formation, and shingle beach.

A plant association is a community of plants within a formation which is governed by the dominant species in each, and of these there may be several in each formation, *e.g.* woodland scrub, grassland, whilst in each association there may be a plant society or body of species forming a minor feature in the association. The association is less dependent on habitat than the formation, the society being characterized by some slight variation in the habitat.

According to the physiognomy of the vegetation that they contribute to form, plant formations may be described in more general terms under eight heads.

We may thus distinguish *woodland* in itself as one. Of true native woodland very little now exists, the bulk of our forest lands being planted and of modern origin. Originally, however, a great part of England was woodland.

There is *grassland*, which may be natural, but is usually semi-natural and derived from woodland.

Heathland is to be considered natural on poor sandy soils in S.E. England, and further north on well-drained hill sides, and some may possibly be primitive.

Moorland on deep peat with low mineral content is to be found in regions with relatively high rainfall, on hill-slopes and plateaux.

Fenland is represented in the Fens, and occurs on deep peat with a high mineral content, on the edges of lakes and estuaries. The **Alder** is a dominant tree. The lower parts of estuaries may be marshland.

Salt marshes are formed on tidal mud of protected bays and estuaries and the vegetation adds to the land yearly.

Sand-dunes are made up of blown sand, usually forming later grassland or heath.

In *shingle beaches* pebbles form banks at high tide, with a vegetation allied to that of sand-dunes.

2. Meadow and Pasture Plants. (Plates X, XI.) Originally most of the country was woodland, but for centuries, especially since the Norman period, the ancient forests have been cut down and the cleared ground devoted to arable, a fact reflected in the ridge and furrow of the Midlands.

Meadow plants are intermediate in character between woodland plants which require much moisture and shade and dry soil-loving plants which require little moisture and are light-seekers. In the same way that woodland plants are dependent on different soil conditions, oak, beech, and ash woods differing in this respect, so do the meadow and pasture plants which succeeded them require different types of soil according to the species which make up this type of flora.

Some meadows are dry, some wet, some are lowland, some are upland, and they merge into marsh or moor or heath in proximity to the latter. A large part of the meadow vegetation is composed of grasses with which many plants are ill able to compete ; rushes and sedges are also dominant. Most of the plants are perennials. Some have creeping rhizomes enabling them to spread far and wide.

There are about 120 pratal species ; about twenty of these are addicted to a lime-soil, others to clay, or loam, sand, or siliceous rocks.

Since the enclosure of land, the date of which varies in

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VEGETATION OF A PASTURE

Photo, L. R. J. Horn

different parts of the country, most meadow and pasture land has become more artificial still by the planting of hedges and the making of ditches, draining, and the planting of trees. Each of these habitats thus has an artificial association of plants, the hedgerow plants being more closely related to woodland types than the open ground species. Those of the ditches and ponds again are of aquatic type, equally in such cases artificially distributed.

The following plants * are typical of meadows and pastures:

Upright Meadow Crowfoot	Wild Carrot
Pilewort (hedgerows and banks)	Devil's Bit Scabious
	Daisy
Lady's Smock (wet meadows)	Yarrow
Dame's Violet	Oxeye Daisy
Ragged Robin (wet meadows)	Knapweed
Meadow Crane's Bill	Long-rooted Cat's Ear
Red Clover	Dandelion
White Clover	Goat's Beard
Hop Trefoil (banks)	Cowslip
Bird's-Foot Trefoil	YellowRattle (wet meadows)
Meadowsweet (wet meadows)	Self Heal
Common Yellow Cinquefoil	Purple Orchis (or in woods)
Lady's Mantle	Spotted Orchis (wet meadows)
Great Burnet	Crocus (naturalized).

Meadow plants differ from pasture plants, owing to the different treatment of each (Plate XI). Annually, as a rule, a meadow is mown for hay. A pasture is regularly grazed, and the character of the pasture may be modified, apart from the difference due to soil, by the type of stock, horses, cattle, sheep, etc., that graze upon it (Plate X).

In a meadow the grasses are the chief feature, and in examining a tract they should be noted first in the order of their abundance.

The following is a list of plants observed on April 28 on alluvium in a lowland pasture (c = common; f = frequent; d = dominant):

Alopecurus pratensis	dominant grass	*Poa annua*	dominant grass
Poa pratensis	,, ,,	*Rumex viridis*	c.
		Sisymbrium Alliaria	c.

* These are described in the author's book referred to on p. 110. This applies to the English names of plants in each formation.

Veronica hederæfolia (from waste ground)	f.	*Lathyrus pratensis*	c.
Lychnis dioica	c.	*Cnicus lanceolatus*	c.
Galium Aparine	c.	*Cnicus arvensis*	c.
Stellaria media	c.	*Prunella vulgaris*	c.
Heracleum Sphondylium	c.	*Achillea millefolium*	c.
Potentilla reptans	c.	*Rumex acetosa*	c.
Anthriscus sylvestris	c.	*Trifolium repens*	c.
Lapsana communis	c.	*Cardamine pratensis*	c.
		Nepeta Glechoma	c.

At a later period other species would be found in such a field, therefore lists for comparison require to be made at different times of the year. This type of meadow is technically called neutral grassland.

On the same date on similar soil, loamy, the plants observed in a pasture were as follows :

Dactylis glomerata	d.	*Lamium purpureum* from waste ground	
Poa pratensis	d.		
Poa annua	d.	*Potentilla anserina* from waste ground	
Ranunculus bulbosus	c.		
Bellis perennis	c.	*Cratægus Oxyacantha* hedgerow types	
Taraxacum officinale	c.		
		Rosa canina ,, ,,	

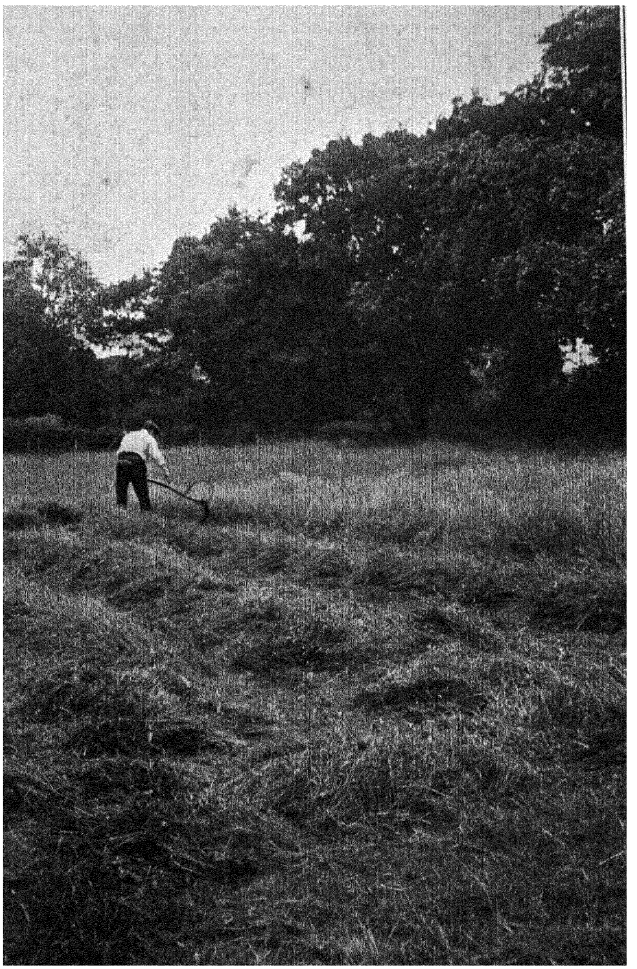
On Lower Lias in another pasture the following plants occurred on the same date (f.c = fairly common ; a = abundant ; l.a = locally abundant ; o = occasional) :

Cynosurus cristatus	d.	*Hypochœris radicata*	l.a.
Primula veris	l.a.	*Taraxacum erythrospermum*	o.
Ranunculus acris	a.	*Galium verum*	f.
Centaurea nigra	l.a.	*Lotus corniculatus*	l.a.

On glacial drift in another field of the pasture type the following plants were noted on May 16 :

Anthoxanthum odoratum dominant grass		*Silaus pratensis*	l.a.
		Galium verum	l.a.
Lolium perenne ,, ,,		*Primula veris*	l.a.
Deschampsia cæspitosa ,, ,, in wet places		*Hypochœris radicata*	l.a.
		Leontodon hispidus	l.a.
Chrysanthemum leucanthemum	a.	*Ophioglossum vulgatum*	l.a.
		Plantago media	l.a.
		Conopodium denudatum	o.

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VEGETATION OF A MEADOW (HAY-TIME)

Photo, L. R. J. Horn

Luzula campestris	l.a.	*Pyrus malus*, var. *acerba*	planted
Lotus corniculatus	a.	*Acer campestre*	,,
Ulmus campestris	planted	*Fraxinus excelsior*	,,
Ulmus campestris, var. *glabra*	planted	*Cratægus Oxyacantha*	,,
Ulmus montana	,,	*Equisetum arvense*	l.a.
Quercus Robur	,,	*Prunella vulgaris*	a.
		Rumex acetosa	l.a.

Adjacent to this on Lower Lias, in a meadow, plants noted on the same date were :

Anthoxanthum odoratum	dominant grass	*Leontodon hispidus*	l.a.
Cynosurus cristatus ,,	,,	*Hypochæris radicata*	l.a.
Rhinanthus Crista-galli	a.	*Primula veris*	a.
Ophioglossum vulgatum	l.a.	*Pimpinella magna*	o.
		Achillea millefolium	l.a.

On June 1 in a field of the pasture type, where the soil was sandy, with some limy bands, on Rhætic beds, the following plants were observed :

Dactylis glomerata	dominant grass	*Cnicus arvensis*	l.a.
Lolium perenne ,,	,,	*Rubus cæsius*	hedge
Cynosurus cristatus ,,	,,	*Urtica dioica*	,,
Poa annua ,,	,,	*Tamus communis*	,,
Festuca ovina ,,	,,	*Geranium dissectum*	o.
Poa pratensis, var. *angustifolia*	dominant grass	*Rosa canina*, var. *dumalis*	hedgerow
Kœleria cristata ,,	,,	*Chærophyllum temulum*	,,
Plantago media	l.a.	*Achillea millefolium*	l.a.
Primula veris	a.	*Trifolium pratense*	a.
Bellis perennis	a.	*Hieracium Pilosella*	l.a.
Taraxacum officinale	a.	*Lotus corniculatus*	a.
Lathyrus pratensis	l.a.	*Hypochæris radicata*	a.
Pimpinella magna	o.	*Leontodon autumnalis*	f.
Plantago major	a.	*Trifolium dubium*	l.a.
Galium verum	f.	*Luzula campestris*	l.a.
Geum urbanum	f.	*Polygonum aviculare*	in cart ruts

An interesting association of plants was observed in a meadow on a clayey and loamy soil on Lower Lias, on June 9, including (r = rare) :

Alopecurus pratensis dominant grass
Anthoxanthum odoratum ,, ,,
Deschampsia cæspitosa (in wet places) dominant grass
Briza media ,, ,,
Lolium perenne ,, ,,
Festuca pratensis ,, ,,
Cynosurus cristatus ,, ,,
Avena pubescens ,, ,,
Holcus lanatus ,, ,,
Glyceria pedicellata (pond margin) ,, ,,
Festuca elatior ,, ,,
Arrhenatherum avenaceum ,, ,,
Rhinanthus Crista-galli l.a.
Tragopogon pratense (type)* r.
Lotus corniculatus a.
Prunella vulgaris (white flowers) l.a.
Trifolium pratense, var. *sylvestre* a.
Conopodium denudatum l.a.
Cerastium triviale f.
Rumex acetosa l.a.
Ranunculus acris a.
Poterium officinale l.a.
Ophioglossum vulgatum l.a.
Botrychium Lunaria o.
Ajuga reptans (white flowers) l.a.
Spiræa Filipendula l.a.
Juncus glaucus l.a.
Carex glauca l.a.
Carex panicea f.
Cardamine pratensis f.
In wet places :
Spiræa Ulmaria l.a.
Plantago lanceolata f.
Cnicus palustris f.
Heracleum Sphondylium l.a.
Galium verum f.
Scabiosa succisa l.a.
Lychnis Flos-cuculi l.a.
Veronica Beccabunga l.a.
Juncus lamprocarpis f.
Equisetum arvense l.a.
Veronica Chamædrys l.a.
Polygala vulgaris f.
Chrysanthemum leucanthemum a.
Centaurea nigra l.a.
Hypochæris radicata a.
Hieracium Pilosella l.a.
Trifolium repens l.a.
Lathyrus pratensis f.
Poterium Sanguisorba l.a.
Plantago media f.
Primula veris l.a.
Bellis perennis a.
Potentilla sylvestris l.a.
Achillea millefolium l.a.
Silaus pratensis l.a.
Leontodon hispidus l.a.
Juncus bufonius f.

* The variety *minus* is more generally distributed.

In an adjoining meadow on very wet ground the association was as follows :

Orchis maculata	l.a.	*Solanum Dulcamara*	o.
Vicia angustifolia	o.	*Carex glauca*	l.a.
Ranunculus Flammula	l.a.	*Carex vulgaris*	l.a.
Lotus major	l.a.	*Carex ovalis*	o.
Galium uliginosum	o.	*Luzula campestris*	a.
Stellaria uliginosa	o.	*Caltha palustris*	l.a.
Corylus Avellana (hedgerow)	o.	*Stellaria graminea*	o.
Juncus lamprocarpus	f.	*Hypericum tetrapterum*	l.a.
Mentha hirsuta	l.a.	*Aspidium filix-mas*	o.
Glyceria pedicellata (stream margin)	a.	*Inula dysenterica*	l.a.
Juncus conglomeratus	f.	*Alchemilla filicaulis*	o.
Juncus effusus	f.	*Cardamine pratensis*	l.a.
Juncus bufonius	l.a.	*Equisetum palustre*	l.a.
Carex panicea	f.	*Stachys Betonica*	o.
Cnicus palustris	l.a.	*Equisetum arvense*	l.a.

Such wet meadows are rush associations and merge in places into marshes. The following pasture association was observed early in June, on alluvium, and is intermediate between wet meadow and marsh vegetation :

Deschampsia cæspitosa	dominant grass	*Senecio aquaticus*	l.a.
Festuca ovina	,, ,,	*Potentilla anserina*	o.
Briza media	,, ,,	*Lysimachia Nummularia*	l.a.
Alopecurus geniculatus (border of backwater)	dominant grass	*Galium verum*	f.
		Œnanthe fistulosa	l.a.
		Eleocharis palustris	l.a.
Rhinanthus Crista-galli	a.	*Valeriana dioica*	l.a.
Lathyrus pratensis	l.a.	*Juncus lamprocarpus*	l.a.
Cnicus palustris	l.a.	*Medicago lupulina*	f.
Rumex acetosa	f.	*Lotus major*	l.a.

On dry soil at higher elevations, on a sandy soil, on Northampton sand, the flora of a meadow observed early in October is of very different character, as follows :

Lolium perenne	dominant grass	*Dactylis glomerata*	dominant grass
Cynosurus cristatus	,, ,,	**Agrostis vulgaris*	,, ,,

Those marked with an asterisk (*) are especially characteristic.

Deschampsia cæspitosa	dominant grass	*Fraxinus excelsior*	hedgerow
Trisetum flavescens	,, ,,	*Sambucus nigra*	,,
**Festuca ovina*	,, ,,	*Crataegus monogyna*	,,
Poa annua	,, ,,	*Ulmus montana*	,,
Holcus lanatus	,, ,,	*Lotus corniculatus*	a.
**Avena pratensis*	,, ,,	*Leontodon autumnalis*	l.a.
Rumex acetosa	f.	**Carduus nutans*	l.a.
Achillea millefolium	f.	*Veronica Chamædrys*	f.
Plantago lanceolata	f.	**Arenaria serpyllifolia*	f.
Galium verum	f.	*Geranium molle*	o.
Cnicus arvensis	l.a.	*Trifolium dubium*	l.a.
Ranunculus bulbosus	f.	*Bellis perennis*	a.
Cerastium triviale	f.	*Leontodon hirtus*	o.
Urtica dioica	l.a.	**Veronica arvensis*	o.
**Taraxacum erythrospermum*	f.	*Ranunculus acris*	l.a.

Those marked with an asterisk (*) are especially characteristic.

A type of wet meadow on chalky boulder clay, where there has been some drainage, and originally part of a marsh or bog, yielded in May the following list (l.sd = locally subdominant):

Anthoxanthum odoratum	dominant grass	*Anthriscus sylvestris*	l.a.
Poa pratensis	,, ,,	*Carex glauca*	a.
Poa annua	,, ,,	*Luzula campestris*	a.
Cnicus pratensis	l.sd.	*Equisetum arvense*	l.a.
Alchemilla vulgaris	f.	*Juncus conglomeratus*	l.a.
Centaurea nigra	l.a.	*Potentilla erecta*	l.a.
Poterium officinale	l.a.	On drier ground:	
Vicia hirsuta (on adjoining banks)	f.	*Viola riviniana*	f.
Galium Mollugo (on adjoining banks)	f.	*Veronica Chamædrys*	f.
Vicia angustifolia (on adjoining banks)	f.	*Crepis virens*	f.
Cardamine hirsuta	f.	*Lathyrus pratensis*	f.
Primula veris	l.a.	*Ranunculus bulbosus*	f.
Ajuga reptans	f.	*Scabiosa succisa*	l.a.
Rumex acetosa	l.a.	*Cerastium triviale*	f.
		Lotus corniculatus	l.a.
		Rhinanthus Crista-galli	l.a.
		Galium verum	f.

In a low-lying meadow adjoining this last, on alluvial soil, the following plants were found :

Anthoxanthum odoratum	d.	*Luzula campestris*	l.a.
Orchis Morio	l.a.	*Ranunculus acris*	a.
Ophioglossum vulgatum	l.a.	*Lotus corniculatus*	f.
Stachys betonica	f.	*Rhinanthus Crista-galli*	l.a.
Silaus pratensis	f.	*Taraxacum officinale*	f.
Poterium officinale	a.	*Spiræa Ulmaria*	l.a.
Rumex acetosa	f.	*Plantago lanceolata*	f.
Lathyrus pratensis	f.	*Centaurea nigra*	l.a.
Primula veris	l.a.	*Cardamine pratensis*	l.a.

A type of limestone pasture on calcareous soil, on Lower Lias, is of different character, yielding in July the following list of characteristic species :

**Festuca ovina*	dominant	*Polygala vulgaris*	l.a.
**Briza media*	grass	**Polygala depressa*	l.a.
Phleum pratense (on sandy soil)	,,	On wet ground, more clayey :	
Phleum pratense, var. *bulbosum*	,,	**Linum catharticum*	a.
**Avena pratensis*	,,	*Scrophularia aquatica*	f.
Cynosurus cristatus	,,	*Juncus lamprocarpus*	f.
**Sieglingia decumbens*	,,	*Carex ovalis*	r.
Carex glauca	l.a.	*Lychnis Flos-cuculi*	l.a.
**Galium verum*	f.	*Mentha aquatica*	l.a.
Poterium officinale	l.a.	*Tussilago Farfara*	l.a.
Lotus corniculatus	l.a.	*Chrysanthemum leucanthemum*	l.a.
**Poterium Sanguisorba*	l.a.	*Œnanthe Lachenalii*	r.
Pyrus Malus	hedgerow	*Tragopogon pratense*, var. *minus*	o.
**Cnicus acaulis*	a.	*Apium nodiflorum*	f.
Ononis spinosa	f.	*Juncus bufonius*	l.a.
**Thymus chamædrys*	l.a.		

The plants in the above list marked with an asterisk (*) are characteristic species. The foregoing are a few types of meadow and pasture associations mainly belonging to the typical grassland of clayey or loamy soils, except where stated, or rush associations. A comparison between them shows that different meadows and pastures yield a very different *facies* on different soils, and according as the soil is wet or dry.

Innumerable observations of fields and meadows systematically surveyed may yield valuable results.

3. Cornfield Plants. The vegetation of a cornfield is perhaps, after that of waste ground, the most artificial of all associations or communities of plants, for it is entirely dependent upon man's operations, and the dispersal of the characteristic cornfield flora is due to his agency entirely. But none the less it has a distinctive character, and can only be studied in such artificial habitats as corn, clover, rye, or similar fields, and where roots or potatoes, peas, beans, etc., are grown.

There is a difference in pasture and arable land which is of high importance. In the first the herbage is repeatedly being grazed down to a certain level, and only herbs distasteful to cattle, horses, or sheep are left.

The pasturage is also largely influenced by the cattle, etc., that graze upon it ; it is even influenced by the type of excreta. Meadow land is not influenced to the same extent, and till hay harvest all the meadow plants can flourish together, unless they come on later.

In a cornfield, as in a meadow, all the so-called weeds, unless well hoed up, flourish till harvest-time. The flora of a cornfield differs from that of meadows and pastures in being largely made up of annuals, which disappear in the winter. They are again not true natives of the soil, but are sporadic, alien, colonist, or denizen in status.

Though of such ephemeral duration, cornfield plants are none the less controlled in their distribution largely by the character of the soil. A cornfield is usually well drained and dry, hence most of the plants are xerophilous, and resemble in this respect plants of the dry pastures. The cornfield flora is largely related to that of waste land or waste places, but, being more uniform in character and more distinctive, is kept separate.

Along with the followers of cultivation is a number of meadow and pasture plants, largely grasses, which extend from neighbouring fields, dispersed by the wind, or which are relics of former grassland before it was ploughed.

Typical plants to be found in cornfields are :

Mousetail	Common Red Poppy
Corn Buttercup	Red Rampant Fumitory
Larkspur (E. Counties)	Charlock

Gold of Pleasure	Corn Marigold
Candy Tuft (E. Counties)	Blue Bottle
Heart's Ease	Corn Sow Thistle
White Campion	Venus' Looking-Glass
Corn Cockle	Scarlet Pimpernel
Spurrey	Field Bugloss
Common Flax	Corn Gromwell
Alsike Clover	Small Snapdragon
Shepherd's Needle	Ivy-leaved Speedwell
Fool's Parsley	Common Hemp Nettle
Blue Sherardia	Wild Oat
Lamb's Lettuce	Darnel.

The flora of cornfields and allied arable fields depends largely on the character of the associated crops, whose source of origin likewise is diverse, apart from the difference due to soil variation.*

In a ryefield on Middle Lias marlstone, of a sandy character, the following plants were noticed in May :

Lolium perenne	d.	In cornfield :	
Geranium molle	f.	*Carduus nutans*	f.
Sherardia arvensis	l.a.	*Scandix pecten-veneris*	o.
Trifolium hybridum	l.a.	*Chrysanthemum segetum*	l.a.
Trifolium pratense	l.a.	*Myosotis versicolor*	o.
Alchemilla arvensis	r.	*Brassica Napus*	r.
Senecio vulgaris	f.		
Lychnis alba	f.		

Another cornfield on marlstone at the end of May yielded a far more extensive list, being in this case on higher ground :

Stellaria media	f.	*Lamium incisum*	r.
Cnicus arvensis	l.a.	*Veronica agrestis*	l.a.
Veronica arvensis	f.	*Brassica arvensis*	f.
Fumaria officinalis	l.a.	*Polygonum Convolvulus*	f.
Galium Aparine	a.	*Potentilla Anserina*	f.
Veronica hederæfolia	a.	*Lamium purpureum*	l.a.
Convolvulus arvensis	f.	*Carduus crispus*	a.
Specularia hybrida	r.	*Polygonum aviculare*	a.
Lychnis alba	l.a.	*Anagallis arvensis*	l.a.
Viola arvensis	a.		

* *See* papers by Miss Winifred Brenchley.

The flora of a turnip field on glacial drift, of a sandy character, yielded in July a rather different result, as follows :

Ranunculus arvensis	l.a.	*Agrostis alba* (in wet ground)	f.
Alopecurus agrestis	f.	*Rumex crispus*	l.a.
Bartsia Odontites	l.a.	*Caucalis anthriscus*	l.a.
Veronica arvensis	o.	*Æthusa Cynapium*	a.
Anagallis arvensis	f.	*Potentilla Anserina*	f.
Vicia hirsuta	r.	*Arrhenatherum avenaceum*	f.
Pastinaca sativa	l.a.	*Atriplex deltoidea*	o.
Equisetum arvense	f.		
Anthemis cotula	l.a.		

On shaly, more marly beds of the Middle Lias a cornfield in August yielded the following plants :

Viola arvensis	a.	*Mentha arvensis*	r.
Alchemilla arvensis	f.	*Euphorbia exigua*	a.
Anagallis arvensis	l.a.	*Silene noctiflora*	f.
Sherardia arvensis	l.a.	*Lychnis alba* (*flore roseo*)	l.a.
Spergula arvensis	a.		

The short list is remarkable for the large proportion of plants whose Latin specific names are *arvensis* (belonging to arable land).

The arvatical flora of a clover field is illustrated by the following list of plants, growing on gravelly beds, or river gravels, noticed in May :

Trifolium pratense	d.	*Prunella vulgaris*	f.
Sherardia arvensis	l.a.	*Geranium molle*	f.
Sisymbrium thalianum rare in such a habitat		*Rumex obtusifolius* (ditch)	l.a.
		Vicia cracca (hedgerow)	l.a.
Equisetum arvense	f.	*Veronica arvensis*	f.
Alchemilla arvensis	a.	*Matricaria inodora*	l.a.
Cerastium triviale	f.	*Erodium cicutarium*	o.
Potentilla Anserina	f.	*Medicago lupulina*	f.
Epilobium hirsutum (ditch)	l.a.	*Veronica Buxbaumii*	l.a.
Tussilago Farfara	l.a.	*Scandix pecten-veneris*	o.
Viola arvensis	a.	*Barbarea vulgaris* (ditch)	f.

On calcareous soil in a cornfield in August the following characteristic association of plants was observed :

**Cichorium Intybus*	r.	*Phleum pratense*	l.a.
Aethusa Cynapium	f.	*Agropyron repens*	l.a.
Polygonum aviculare	a.	**Galeopsis Ladanum*	f.
Euphorbia exigua	a.	*Viola arvensis*	a.
Anagallis arvensis	f.	**Carduus nutans*	f.
Veronica polita	o.	**Silene latifolia*	f.
**Linaria vulgaris*	f.	**Specularia hybrida*	r.
Scabiosa arvensis	l.a.	*Medicago lupulina*	f.
Potentilla reptans	f.	**Centaurea Scabiosa*	a.
Plantago major, var. *intermedia*	f.	*Galium verum*	o.
Potentilla Anserina	f.	*Lapsana communis*	f.
Tussilago Farfara	f.	*Galium Aparine*	f.
Polygonum Convolvulus	l.a.	**Ononis repens*	f.
Euphorbia Helioscopia	f.	*Stellaria media*	f.
Arenaria serpyllifolia	l.a.	*Cnicus arvensis*	l.a.
Geranium dissectum	f.	*Daucus Carota*	l.a.
Trifolium hybridum	f.	*Campanula rotundifolia* (roadsides)	f.
Cerastium triviale	f.	*Ononis spinosa*	f.
Sherardia arvensis	l.a.	*Geranium molle*	f.
Arctium Lappa	o.		

The plants marked in the above list with an asterisk (*) are characteristic chalk or limestone species.

The flora of a turnip field on sandy soil, on glacial drift, yielded so late as November the following list :

Galeopsis Tetrahit	o.	*Chenopodium album*, var. *candicans*	f.
Stellaria media	a.	*Chenopodium album*, var. *viride*	f.
Brassica Sinapis	a.	*Polygonum Convolvulus*	l.a.
Carduus arvensis	f.	*Viola arvensis*	l.a.
Matricaria inodora	f.	*Spergula arvensis*	l.a.
Senecio vulgaris	f.		

4. Woodland Plants. (Plate XII.) As remarked already, considerable difference exists in the nature of woodlands owing to the character of the soil. Thus **Oak** is found largely on clays and loams, **Beech** on chalk, **Ash** on limestone, and so forth.

It is considered that there is very little true aboriginal woodland left to-day.

In Cæsar's day the Caledonian Forest spread over a great

part of Britain ; Ireland was similarly clothed with a vast virgin forest. But several causes have contributed to change the character of this country ; not the least has been the pre-eminence of Britain as an island nation and a naval Power ; the substitution of steel for the old wooden ships has brought it about that this factor plays little or no part now as regards forests and woods. But in the past the demand for fuel and timber for building also helped to diminish the area of woodland ; so that in the Midlands, to take one area alone, there are but remnants of a former vast forest, in the detached forests of Arden, Charnwood, and Sherwood.

Woodland vegetation influences the character of plants in respect of light, warmth, and moisture. Woods are specially open to attack by fungi and animal pests, unlike more open types of vegetation.

A type of vegetation associated with woodland is what may be called bushland, which may be a degenerate type of woodland, or an extension of it. This type of vegetation is to-day very often artificial, being encouraged as cover for game or foxes, especially in the shires, and meadow or pasture land will revert to this type, if left uncultivated. **Sloe, Hawthorn, Briars, Dogwood, Brambles,** etc., all help to form bushland, and with it grow typical herbaceous pasture plants.

Many woodland plants of the tree type are deciduous in the North Temperate Zone. A few are evergreen. Under the tree stratum is one of shrubs or undershrubs, and finally a ground flora. Many of the latter are bulbous plants. Here also occur several climbers and trailers. The typical woodland flora consists of :

Wood Anemone	Mountain Ash
Goldielocks	Rosebay
Green Hellebore (chalk)	Enchanter's Nightshade
Columbine	Sanicle
Sweet Violet	Angelica
Red Campion	Ivy
Linden	Wayfaring Tree (chalk)
Wood Sorrel	Honeysuckle
Holly	Woodruff
Wild Cherry (chalk)	Primrose
Strawberry	Wood Loosestrife
White Beam (chalk)	Small Periwinkle

Wood Forget-me-not	Wood Spurge
Foxglove	Wych Elm
Marjoram (chalk)	Dog's Mercury
Wood Betony	Oak
Yellow Archangel	Beech (chalk)
Wood Sage	Tway Blade, etc.

The various types of woodland are characterized by the dominant tree types. The damp oakwood of the lowlands, in which the pedunculate variety is the common type, is found on clays and loams.

On keuper marl the following association may be observed :

Quercus Robur, var. *pedunculata*	dominant tree	*Arenaria trinervis*	f.
Fraxinus excelsior	,, ,,	*Luzula campestris* (in open parts)	
Acer campestre	shrub	*Heracleum Sphondylium*	f.
Corylus avellana	,,	*Viola riviniana*	f.
Ligustrum vulgare	,,	*Urtica dioica*	l.a.
Pyrus acerba	,,	*Stachys sylvatica*	f.
Cornus sanguinea	,,	*Geranium robertianum*	f.
Cratægus monogyna	,,	*Myosotis arvensis*	f.
Sambucus nigra	,,	*Carex remota*	o.
Hedera Helix	climber		

In another damp oakwood with Oak, Ash, *Acer campestre*, Sycamore, the following plants occurred :

Ranunculus Ficaria	l.a.	*Arum maculatum*	l.a.
Sanicula europæa	f.	*Lonicera Periclymenum*	f.

A similar wood on keuper marls furnished the following list :

Quercus Robur	dominant tree	*Sanicula europæa*	f.
Fraxinus excelsior	,, ,,	*Primula vulgaris*	f.
Acer Pseudoplatanus	,, ,,	*Viola hirta*	l.a.
Rubus idæus	shrub	*Viola riviniana*	l.a.
Rubus pulcherrimus	,,	*Ranunculus Ficaria*	l.a.
Rubus dasyphyllus	,,	*Epilobium angustifolium*	l.a.
Ribes Grossularia	,,	*Arctium Lappa*	f.
Pyrus Aucuparia	r.	*Arum maculatum*	f.
Brachypodium sylvaticum	a.	*Veronica serpyllifolia*	f.

Nepeta glechoma	l.a.	*Cytisus scoparius*	one plant
Ranunculus acris (usually in meadows)		*Geum urbanum*	l.a.
		Viola arvensis	a straggler
Geranium Robertianum	f.	*Aspidium filix mas*	l.a.
Juncus conglomeratus	d.	*Aspidium filix femina*	l.a.
Sagina procumbens	o.	*Lastræa dilatata*	l.a.

This wood exhibits certain characters which give it a resemblance to the sandy oakwood in the occurrence of *Pyrus Aucuparia*, *Epilobium angustifolium*, etc.

Of another type, but a damp oakwood on keuper marl, in all essential characters, is the following association :

Quercus Robur, var. *pedunculata*	dominant tree	*Ajuga reptans*	l.a.
Fraxinus excelsior	,, ,,	*Lycopus europæus* (in damp parts)	v.r.
Betula verrucosa	,, ,,	*Caltha palustris*	o.
Alnus glutinosa	,, ,,	*Stellaria Holostea*	l.a.
Prunus spinosa	shrub	*Orchis mascula*	f.
Salix caprea	,,	*Scilla nutans*	a.
Rubus dasyphyllus	,,	*Carex sylvatica*	l.a.
Rubus idæus	,,	*Conopodium denudatum*	l.a.
Ulex europæus	,,	*Potentilla erecta*	f.
Lonicera Periclymenum	climber	*Holcus lanatus*	f.

A mixed wood, chiefly made up of damp oakwood with some conifers, on keuper marl, is illustrated by the following list :

Quercus Robur	dominant tree	*Ajuga reptans*	l.a.
Fagus sylvatica	,, ,,	*Geum urbanum*	a.
Fraxinus excelsior	,, ,,	*Primula vulgaris*	l.a.
Ulmus campestris	,, ,,	*Veronica Chamædrys*	l.a.
Acer campestre	shrub	*Circæa lutetiana*	f.
Prunus spinosa	,,	*Urtica dioica*	l.a.
Sambucus nigra	,,	*Arenaria trinervis*	f.
Salix caprea	,,	*Viola riviniana*	f.
Rubus echinatus	,,	*Rumex viridis*	f.
Rubus dasyphyllus	,,	*Brachypodium sylvaticum*	l.a.
Fragaria vesca	l.a.	*Lastræa dilatata*	l.a.
Scilla nutans	a.	*Aspidium filix mas*	l.a.

The following is a good example of an oak, hazel, bluebell wood, or dry oakwood :

Quercus Robur	dominant	tree	*Fragaria vesca*		f.
Alnus glutinosa	,,	,,	*Ranunculus Ficaria*		l.a.
Fraxinus excelsior	,,	,,	*Oxalis Acetosella*		l.a.
Betula verrucosa	,,	,,	*Luzula sylvatica*		l.a.
Ulmus montana	,,	,,	*Deschampsia cæspitosa*		l.a.
Populus Tremula	,,	,,	*Stellaria Holostea*		f.
Ilex Aquifolium	,,	,,	*Holcus mollis*		l.a.
Pyrus malus		shrub	*Arctium minus*		f.
Cratægus oxyacantha		,,	*Lathyrus macrorhizus*		o.
Prunus spinosa		,,	*Ajuga reptans*		l.a.
Rosa arvensis		,,	*Hypericum hirsutum*		f.
Rubus foliosus		,,	*Spiræa Ulmaria*		l.a.
Lonicera Periclymenum		climber	*Milium effusum*		l.a.
Scilla nutans		a.	*Circæa lutetiana*		l.a.
Sanicula europæa		a.	*Cnicus palustris*		f.
Asperula odorata		l.a.	*Luzula erecta* (in open rides)		l.a.
Lamium Galeobdolon		v.a.	*Valeriana sambucifolia* (in open rides)		l.a.
Primula vulgaris		l.a.	*Stachys betonica* (in open rides)		f.
Arum maculatum		f.	*Angelica sylvestris*		r.
Viola riviniana		f.	*Prunella vulgaris*		f.
Anemone nemorosa		l.a.			
Scrophularia nodosa		l.a.			
Carex sylvatica		l.a.			

On sandy soils another type of oakwood, namely, a dry oakwood, is developed. Such woods are as a rule upland, but less so than the oakwoods formed on siliceous soils, where the type of oak is mainly the sessile oak. In a sandy oakwood there may be examples of the pedunculate or sessile oak.

On sandy beds of the keuper the following association was observed in June :

Quercus Robur, var. *pedunculata*	dominant	tree	*Prunus Avium*		shrub
Populus Tremula	,,	,,	*Viburnum Opulus* (on damp ground)		,,
Alnus rotundifolia (on damp ground)	,,	,,	*Pteris aquilina*		l.sd.
Rubus dasyphyllus		shrub	*Scilla nutans*		l.sd.
Rubus idæus		,,	*Melica uniflora*		l.a.
Rosa arvensis		,,	*Milium effusum*		f.
Lonicera Periclymenum		,,	*Veronica montana*		o.
Salix Caprea		,,	*Mercurialis perennis*		l.a.
			Holcus mallis		l.a.

Scrophularia nodosa	f.	*Hypericum pulchrum*	f.
Lychnis dioica	l.a.	*Hieracium boreale*	l.a.
Lysimachia nemorum	l.a.	*Juncus effusus*	f.
Viola riviniana	f.	*Arctium Lappa*	o.
Oxalis Acetosella	l.a.	*Scrophularia aquatica*	o.
Galium saxatile	f.	*Potentilla anserina*	l.a.
Teucrium Scorodonia	l.a.	*Hypericum hirsutum*	l.a.
Angelica sylvestris	f.	*Primula vulgaris*	f.
Ajuga reptans	f.	*Campanula latifolia*	o.
Potentilla sylvestris	f.	*Geum urbanum*	l.a.
Deschampsia flexuosa	l.a.	*Orchis maculata* (on wet	
Melampyrum pratense	o.	ground, clayey)	o.
Stellaria Holostea	l.a.	*Potentilla procumbens*	r.
Digitalis purpurea	f.	*Cnicus palustris*	l.a.
Stachys Betonica	l.a.	*Mentha arvensis*	o.
Lathyrus macrorhizus	o.	*Circæa lutetiana*	l.a.
Potentilla reptans	l.a.	*Lychnis Flos-cuculi*	f.
Aspidium filix mas	l.a.	*Nepeta Glechoma*	l.a.
Lastræa dilatata	f.	*Veronica serpyllifolia*	f.

On similar soil, but somewhat more loamy, the following association was noticed in May, a dry oakwood in part, with local associations of *Luzula maxima*, *Pteris aquilina*, *Teucrium Scorodonia*, and on adjacent siliceous rocks merging into a sessile oakwood type at higher levels with Birch :

Quercus Robur, var. *pedunculata*	dominant tree	*Luzula sylvatica*	l.sd
		Ajuga reptans	o.
Betula verrucosa	,, ,,	*Anemone nemorosa*	l.a.
Fraxinus excelsior	,, ,,	*Oxalis Acetosella*	l.a.
Acer Pseudoplatanus	,, ,,	*Pteris aquilina*	l.sd.
Corylus avellana	shrub	*Scilla nutans*	l.sd.
Salix caprea	,,	*Lychnis dioica*	f.
Pyrus malus	,,	*Arenaria trinervis*	f.
Prunus spinosa	,,	*Lastræa spinulosa*	l.a.
Prunus insititia	,,	*Aspidium filix mas*	l.a.
Sambucus nigra	,,	*Viola riviniana*	f.
Rubus idæus	,,	*Teucrium Scorodonia*	l.a.
Rubus spp.	,,	*Digitalis purpurea*	f.
Cratægus Oxyacantha	,,	*Urtica dioica*	l.a.
Lonicera Periclymenum	climber	*Rumex crispus*	o.
		Mercurialis perennis	r.

Holcus lanatus	f.	*Circœa lutetiana*	f.
Juncus articulatus (ditch)	f.	*Aspidium filix femina*	l.a.
Potentilla sterilis	f.	*Carex sylvatica*	l.a.
Primula vulgaris	l.a.	*Lastrœa dilatata*	l.a.
Ranunculus Ficaria (on clayey ground)	l.a.	*Stellaria Holostea*	f.
		Valeriana sambucifolia	d.

In other parts of the same wood the following also occurred :

Lathyrus macrorhizus	o.	*Alisma Plantago aquatica* (pond)	o.
Ilex Aquifolium	f.	*Ranunculus sceleratus* (pond)	o.
Ulex europœus	r.	*Juncus conglomeratus* (pond)	f.
Tilia parvifolia	l.a.	*Callitriche verna* (pond)	f.
Taraxacum officinale unusual in a wood			
Lysimachia nemorum	l.a.		
Scrophularia nodosa	f.		

On siliceous soils this merges into a birch association with *Quercus Robur* and :

Senecio Jacobœa	l.a.	*Digitalis purpurea*	in crevices
Myosotis versicolor	l.a.	*Rumex Acetosella*	on slate
Polypodium vulgare	in crevices	*Cotyledon umbilicus*	,,
		Ranunculus repens	f.
		Teesdalia nudicaulis	r.

Oak-Birch heath is a further stage of sandy oakwood which is more open in character and merges into heath pure and simple. The sort of association which characterizes this plant community is illustrated by the following flora :

Betula verrucosa	dominant tree	*Alchemilla filicaulis* (on open pasture)	o.
Quercus Robur	,, ,,	*Sieglingia decumbens* (on open pasture)	o.
Pteris aquilina	l.sd.	*Lysimachia nemorum*	f.
Scirpus setaceus	l.a.	*Galium saxatile*	l.a.
Juncus supinus	f.	*Scilla nutans*	l.sd.
Carex ovalis	o.	*Hypericum humifusum*	l.a.
Carex hirta	f.	*Epilobium angustifolium*	l.a.
Carex prœcox (on open pasture)	f.	*Veronica officinalis*	a.
Pedicularis sylvatica (on open pasture)	l.a.	*Myosotis cœspitosa*	l.a.
		Erythrœa Centaurium	f.
		Scutellaria galericulata	l.a.

Peplis Portula	f.	*Viola palustris* (wet ground)	l.a.
Fragaria vesca	l.a.	*Carex sylvatica*	f.
Veronica serpyllifolia	l.a.	*Polytrichum commune*	o.
Rubus leucostachys	o.	*Blechnum Spicant*	o.
Ajuga reptans	f.	*Lastræa Oreopteris*	l.a.
Myosotis versicolor	f.	*Epipactis latifolia* (wet ground)	l.a.
Agrostis canina	l.a.	*Luzula vernalis*	o.
Deschampsia flexuosa	l.a.		

In some respects this association may be compared to the sandy oakwood, into which it passes laterally, and to the wet heath, *see post.*

The siliceous soils are characterized by the sessile oak. On the Pennines Dr. Moss has found the following association, a selection only of the species noted being quoted here :

Quercus sessiliflora	dominant tree	*Circæa lutetiana*	l.a.
		Sanicula europæa	l.a.
Betula tomentosa	,, ,,	*Valeriana sambucifolia*	l.a.
Pyrus Aucuparia	,, ,,	*Petasites ovatus*	l.a.
Fraxinus excelsior	,, ,,	*Cnicus palustris*	l.a.
Alnus glutinosa	shrub	*Lysimachia nemorum*	l.a.
Prunus Padus	,,	*Myosotis scorpioides*	l.a.
Rosa arvensis	,,	*Scrophularia nodosa*	a.
Rubus spp.	,,	*Veronica montana*	l.a.
Cratægus monogyna	,,	*Lamium Galeobdolon*	a.
Acer campestre	,,	*Ajuga reptans*	a.
Sambucus nigra	,,	*Mercurialis perennis*	a.
Viburnum Opulus	,,	*Iris Pseudacorus*	l.a.
Anemone nemorosa	f.	*Scilla-non-Scripta*	a.
Ranunculus Ficaria	l.a.	*Allium ursinum*	l.a.
Caltha palustris	f.	*Juncus effusus*	l.a.
Cardamine flexuosa	f.	*Luzula pilosa*	a.
Viola riviniana	f.	*L. maxima*	a.
Lychnis dioica	f.	*Arum maculatum*	l.a.
Stellaria Holostea	l.a.	*Milium effusum*	l.a.
Oxalis Acetosella	a.	*Bromus sterilis*	l.a.
Vicia sepium	a.	*Athyrium filix fœmina*	a.
Geum rivale	l.a.	*Lastræa aristata*	a.
Spiræa ulmaria	l.sd.	*L. montana*	l.a.
Fragaria vesca	f.	*Equisetum sylvaticum*	l.a.
Epilobium montanum	f.		

In drier and in more open situations with much acid humus there are different associations. On siliceous soils, which are close, some humus may collect, hence their occurrence in the foregoing list, e.g. *Arum*.

On limestone soils, such as the older carboniferous or mountain limestone, and on oolite, there is a woodland association dominated by the Ash. This is seen in the Pennines, the Bristol area, the Cotswolds, and elsewhere.

The trees commonly met with are the **Ash, Wych Elm, Hawthorn, Juniper, Yew, Willow, Aspen, Beech, Hazel, Alder, Birch.** The shrub layer includes species of **Lime, Spindle-wood, Buckthorn, Cornel, Wayfaring Tree, Privet, Spurge Laurel.**

The ground flora on a dry soil includes such plants as **Dog's Mercury, Moschatel,** which form small or large associations or societies, with also **Ground Ivy, Hairy St. John's Wort, Nettle, Woodsage, Lily-of-the-Valley, Melic Grass, Three-nerved Sandwort, Whitlow Grass, Rue-leaved Saxifrage, Biting Stonecrop, Wild Thyme,** etc.

Very similar is the association to be found on the chalk, which is typical of the South of England, East Anglia, Lincolnshire, Yorkshire, etc.

Here the chief tree is the **Beech,** and it may give rise to such a thick shade that there is no shrub layer and practically no ground flora, the ground being covered with leaves.

But where the beechwood is more open other trees or shrubs occur, such as the **White Beam, Ash, Bird Cherry, Yew,** and the ground flora includes associations of **Dog's Mercury, Sanicle, Hairy Violet, Wood Violet, Wild Strawberry, Enchanter's Nightshade,** and many Orchids, such as the **Fly, Bee, Spider Orchis,** and the various species of **Helleborine,** with **Bird's-Nest Orchis, Broomrape, Bird's-Nest,** etc.

On marls and calcareous sandstones there is an ash, oak, hazel association. It is developed on the boulder clay, and on the lias and oolites. The following is an example of such an association on Middle Lias marls and sandstones:

Fraxinus excelsior	dominant tree		*Salix viminalis*	dominant tree	
			Prunus Avium	shrub	
Quercus Robur	,,	,,	*Fragaria vesca*	l.a.	
Ulmus montana	,,	,,	*Viola odorata*	f.	
Salix alba	,,	,,	*Nepeta Glechoma*	l.a.	

Mercurialis perennis	l.a.	*Scolopendrium vulgare*	l.a.
Veronica montana	o.	*Sisymbrium Alliaria*	f.
Trifolium dubium (from pasture)	f.	*Campanula latifolia*	l.a.
Agrimonia Eupatoria (from pasture)	f.	*Impatiens parviflora*	introduced
Carex sylvatica	l.a.	*Ribes Grossularia*	o.
Aspidium filix mas	l.a.	*Viola hirta*	l.a.
		Euonymus europæus	o.

A somewhat different *facies* is presented by the following association on glacial drift, examined in July :

Fraxinus excelsior	dominant tree	*Veronica Chamædrys*	f.
Quercus Robur	,, ,,	*Arctium Lappa*	f.
Acer Pseudoplatanus	,, ,,	*Arenaria trinervis*	f.
Ilex Aquifolium (planted)	,, ,,	*Stellaria media*	f.
Carpinus Betulus	,, ,,	*Taraxacum officinale* (in rides)	f.
Taxus baccata (planted)	,, ,,	*Poa annua* (in rides)	f.
Pyrus Aucuparia (planted)	,,	*Tamus communis* (trailer)	f.
Sambucus nigra	shrub	*Ranunculus repens*	f.
Ribes rubrum	,,	*Stachys sylvatica*	l.a.
Ribes Grossularia	,,	*Brachypodium sylvaticum*	l.a.
Rubus dasyphyllus	,,	*Cnicus lanceolatus*	f.
Cornus sanguinea	,,	*Dactylis glomerata*	f.
Acer campestre	,,	*Holcus lanatus*	f.
Euonymus europæus	,,	*Carduus crispus*	f.
Viburnum Lantana	,,	*Anthriscus sylvestris*	l.a.
Viburnum Opulus	,,	*Sisymbrium Alliaria*	f.
Hedera Helix	climber	*Lamium album*	f.
Lonicera Periclymenum	,,	*Heracleum Sphondylium*	f.
Arum maculatum	l.a.	*Myosotis arvensis*	f.
Nepeta Glechoma	f.	*Prunella vulgaris*	l.a.
Galium Aparine	o.	*Bellis perennis*	o.
Mercurialis perennis	r.	*Primula vulgaris*	l.a.
Aspidium filix mas	o.	*Cardamine hirsuta*	o.
Viola riviniana	l.a.	*Plantago major*	o.
Rumex viridis	f.	*Circæa lutetiana*	l.a.
Geranium Robertianum	l.a.	*Bryonia dioica*	o.
Geum urbanum	f.	*Sagina procumbens*	o.

A more typical association on chalky boulder clay is afforded by the following observations made in July :

Fraxinus excelsior	dominant tree	*Deschampsia cæspitosa*	l.sd.
		Mercurialis perennis	l.a.
Quercus Robur	,, ,,	*Asperula odorata*	f.
Corylus Avellana	shrub	*Holcus mollis*	o.
Rosa arvensis	,,	*Scilla nutans*	l.a.
Prunus spinosa	,,	*Carex sylvatica*	f.
Rubus lindleyanus	,,	*Juncus effusus*	l.a.
Rubus pulcherrimus	,,	*Cnicus palustris*	f.
Rubus idæus	,,	*Lastræa spinulosa*	f.
Lonicera Periclymenum	climber	*Galium palustre*	f.
		Primula veris	f.
Aspidium filixmas	l.a.	*Circæa lutetiana*	f.

5. Roadside and Hedgerow Plants. (Plate XIII.) As remarked in reference to the vegetation of fields, hedgerows are entirely artificial. A couple of centuries ago most roads, likewise artificial, were usually not enclosed by hedges, but to-day they are the exception, save in a few outlying remote parts of the country.

A roadside with its hedgerow is in a measure similar to a field with its boundary hedges; but in the former case we have the influence of the macadam unrepresented in the latter, and the marginal strips of grass are also treated by man in a manner different from fields and pastures; they receive no artificial manure, except such as is accidentally removed from the macadam and cast upon the grass. The vegetation is thus more akin to that of a meadow than a pasture, but it may assume the same character as the latter when cattle or horses are allowed to stray and feed upon it.

The macadam itself affords at the margin a favourite habitat for such Cinquefoils as **Silverweed** and **Common Cinquefoil**; the **Strawberry-headed Clover** is also fond of the same habitat. The grass borders furnish a variable flora depending on the character of the soil. When it is a wet clayey soil, sedges and rushes commonly grow by the wayside. Broken or open ground cleared by the roadscraper for ditches or runlets of water is a regular habitat for the **Great Plantain,** which is so common around gateways, and with it occurs **Knot-grass,** common also on waste ground.

Along the grass sward a bushland of sloe, bramble, sallows, or roses may also be formed when it is allowed to grow up, as may often happen, but this is usually cut down periodically.

The ditch between this last section and the hedgerow affords a suitable habitat for aquatic or semi-aquatic vegetation, **Water Buttercup, Wild Celery, Water Cress,** etc. The hedge with a bank below affords a habitat for those plants that frequent the same station in fields and meadows.

The road may be made between deep cuttings and on the steep banks dry soil lovers will be found. Here and there a pond or stream may be met with, so that this type of flora is exceedingly comprehensive.

The following plants are typical :

Traveller's Joy	Cornel
Barberry	Elder
Hedge Mustard	Moschatel
Winter Cress	Cleavers
Garlic Mustard	Teasel
Great Stitchwort	Hoary Ragwort
Perforate St. John's Wort	Nipplewort
Herb Robert	Ash
Spindle Tree	Barren Strawberry
Violet Tufted Vetch	Dog Rose
Common Yellow Vetchling	Ground Ivy
Sloe	Bugle
Bramble	Nettle
Silverweed	Black Bryony
Crab Apple	Great Hedge Bindweed
Hawthorn	Red Bartsia
Bryony	Wild Basil
Hemlock	Spurge Laurel
Cow Parsnip	Elm
Hedge Parsley	Cuckoo Pint.

The flora of a roadside is really artificial, but the examination of one may afford a good training in the practice and method of making notes on ecological lines.

The hedgebanks of a road on chalky boulder clay yielded in April the following list :

Ranunculus auricomus	f.	*Geum urbanum*	l.a.
Nepeta Glechoma	f.	*Myosotis arvensis*	f.

These are shade-loving plants, but are less so than those that grow under, or in, the hedge itself, except the trees and shrubs, such as :

Prunus spinosa	*Hedera Helix*
Corylus Avellana	*Quercus Robur*
Fraxinus excelsior	*Sambucus nigra*
Acer campestre	*Pyrus malus*
Viburnum Opulus	*Rosa canina*

This corresponds to the tree zone in a wood. On the ditch banks the following occur :

Lamium album	l.a.	*Galium Cruciata*	f.
Ranunculus Ficaria	l.a.	*Pimpinella magna*	o.

In the ditch itself the following may be noticed :

Heracleum Sphondylium	f.	*Stachys sylvatica*	l.a.
Urtica dioica	l.a.	*Ranunculus repens*	l.a.
Anthriscus sylvestris	f.	*Epilobium hirsutum*	l.a.
Galium aparine	f.		

These are plants that require a good deal of moisture.

Along the roadside on the sward occur the following :

Achillea millefolium *Potentilla anserina*, etc.

Akin to the flora of a roadside is that of a hedgerow, in so far as both are largely artificial. By natural processes of dispersal, however, the hedge forms a barrier to seeds and fruits blown by wind or carried by birds, and so is intermediate in character :

On tea-green marl, or keuper, the following plants were noticed in October :

Caucalis Anthriscus	l.a.	*Geum urbanum*	l.a.
Barbarea vulgaris	o.	*Carduus crispus*	l.a.
Arrhenatherum avenaceum	f.	*Pyrus acerba*	f.
Geranium Robertianum	l.a.	*Taraxacum officinale*	f.
Tamus communis	f.	*Anthriscus sylvestris*	l.a.
Acer campestre	f.	*Sambucus nigra*	f.
Poa pratensis, var. *angustifolia*	o.		

6. Mountain and Hillside Plants. (Plate XIV.) Plants may be divided according to altitude into upland and lowland. To a great extent they are different, though some common plants range from sea-level to the highest levels. Though soil conditions and the relative water content, with the

accompanying proportion of the peat-layers formed, if conditions are suitable for it, are really more natural bases upon which to found the types of plant formations, yet mountains and hills from a broad point of view afford a fairly natural habitat of plants.

High and low moor formations are characteristic of wet hills. Barren highlands afford a heath formation; bare rocks support rupestral vegetation, and rocks with crevices support the crevice seekers such as **Navel Wort**. In upland regions the rocks are more easily seen at the surface, so that their influence on vegetation is more evident; in the lowlands they are obscured by alluvium and drift.

Owing to the natural drainage of hills most of the plants, where the soil is not water-logged as on moors and bogs, are dry soil lovers. The change in character of the **Common Dandelion** as it ranges from the lowlands to higher ground is well shown in the forms characteristic of each habitat.

When the rocks are hard little soil is formed, while in some cases disintegration of granite results in kaolin, and this is typical of some hills and mountains in Scotland and Cornwall. The chalk which usually weathers down more readily forms a typical rubble.

Other formations such as coal measures and red marl are more easily worn down into plains, with few undulations; so hard a rock as the marlstone, however, seldom weathers down, but typically supports a highland flora of dry soil plants. When there are alternations of soft shales and hard dykes the contour is made up of undulatory hills and valleys.

Hard siliceous rocks support **Ploughman's Spikenard** and **Clary.** Bare sand rock yields **Musk Mallow, Wild Thyme, Sheep's Fescue,** etc. Sand soil supports **Cotton Thistle, Sheep's Sorrel. Kidney Vetch** and **Rest Harrow** are found on bare stony ground, with also **Hare's Foot Trefoil. Field Scabious** and **Dropwort** grow on clayey ground. On the chalk grow **Dyer's Weed, Rock Rose, Hairy Violet, Silky Mountain Vetch, Sainfoin, Box, Musk Orchis.**

On wet hills the following may be found, viz.: **Yellow Balsam, Gentians, Felwort,** and the **Fragrant Orchis.**

On limestone grow **Oak-leaved Mountain Avens, Salad Burnet,** and many others.

In each case the relative porosity or density of the rock has a great influence on the flora it supports.

The flora of a hill is distinguished as a rule by the prevalence of dry soil types, or in the case of lofty mountains in regions of high rainfall by the prevalence of moorland, and wet conditions in the hollows, where Sphagnum grows.

It is to some extent an artificial grouping, but is based upon the fact that altitude influences distribution. Soil, except where humid conditions overrule the influence of the underlying soil by the accumulation of peat, also influences the vegetation of different hills. Typically, limestone floras are hill floras, as the limestone usually forms massifs of high elevation. The same largely applies to the chalk and oolite floras, and as has been said, to the wet hills which are mainly formed by the western palæozoic rocks. The lowlands of clay in the Midlands, sand or silt or lowland peat in the east of England, have distinct types of flora.

The character of a hill flora may be illustrated by the following list of plants growing at an elevation of about 700 ft. on Middle Lias marlstone :

Poterium Sanguisorba	l.a.	*Geranium molle*	l.a.
Hieracium Pilosella	l.a.	*Avena pratensis*	f.
Taraxacum erythrospermum	l.a.	*Kœleria cristata*	a.
Saxifraga granulata (dwarf)	f.	*Cerastium semidecandrum*	r.
Cerastium glomeratum	f.	*Caucalis nodosa*	o.
Carduus nutans	a.	*Cerastium arvense*	o.
Galium verum	f.	*Carduus nutanti-crispus*	l.a.
Erophila verna	f.	*Thymus Serpyllum*	l.a.
Campanula glomerata	r.	*Campanula rotundifolia*	f.
Chelidonium majus	l.a.	*Alchemilla arvensis*	l.a.
Pimpinella Saxifraga	f.	*Sisymbrium officinale*	f.
Sagina procumbens	o.	*Geranium pusillum*	l.a.
Veronica Chamædrys	l.a.	*Mercurialis perennis*	l.a.
Saxifraga tridactylites	o.	*Arum maculatum*	l.a.
Rumex acetosa	f.	*Malva moschata*	o.
		Sanicula europœa	f.

This is really a type of limestone pasture. On limestone on a similar type of hill the following plants were observed :

Carduus nutans	f.	*Verbascum Thapsus*	o.
Linum catharticum	a.	*Kœleria cristata*	f.
Galium verum	l.a.	*Bryonia dioica*	f.
Thymus Serpyllum	l.a.	*Hieracium Pilosella*	f.

Erodium cicutarium	o.	*Clinopodium vulgare*	o.
Filago germanica	o.	*Pimpinella Saxifraga*	f.
Sedum acre	o.	*Porella platyphylla*	f.
Petroselinum sativum	f.	*Malva moschata*	o.
Lychnis alba	o.	*Scrophularia nodosa*	o.
Saxifraga tridactylites	l.c.	*Hypericum perforatum*	f.
Asplenium ruta muraria	o.	*Campanula rotundifolia*	f.

7. Maritime Plants. (Plate XV.) The vegetation of the sea coast is very well marked and consists of plants which require a large proportion of saline soil or chloride of sodium. Growing at sea-level few of them are affected by altitude, though **Sea Plantain** and **Thrift,** found on Scotch mountains are exceptions ; occasionally **Saltwort** is found to stray into a cornfield.

The plants are xerophytes or adapted to dry conditions, most being succulent with thick fleshy stems. Soil conditions are influential in causing a certain association of these seaside plants according as the soil is rock, sand, clay, etc. ; a preponderance of moisture causes some to be marsh plants, which grow in salt marshes.

Samphire, Sea Lavender, and **Thrift,** are usually rock lovers, though Sea Lavender also grows on sand or shingle.

Sea Kale, Saltwort, and others grow on sand soil. Many plants have bluish glaucous stems such as the lovely stately **Yellow Horned Poppy.**

As in the case of many other formations it is possible to recognize definite bands or zones of different types of association such as that of **Samphire,** another with **Oraches,** and **Sea Blite,** a third with **Sea Kale, Sea Rocket, Saltwort, Sea Purslane, Sea Bindweed,** whilst a fourth consists of **Lyme-grass, Sea Couch Grass, Marram, Buckshorn Plantain,** etc.

A scrub is formed inland by **Sea Buckthorn, Tamarisk, Furze,** with a mat of **Sand Sedge.**

Zostera grows on clay under water with **Samphire** above low water.

Sea Manna Grass, Sea Plantain, Sea Milkwort, Sea Lavender, Scurvy Grass form meadow land further inland, and on higher ground **Thrift, Centaury, Sea Plaintain,** etc., grow.

Salt marshes are commonly fringed with **Sea Rush, Sea Club Rush.**

The typical maritime plants found on sand-dune, salt marsh, or shingle beach, are :

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VEGETATION OF THE SEA COAST

Robin Hood's Bay, Yorkshire, with boulder clay in the foreground ; with thrift, etc

Photo, L. R. J. Horn

Yellow Horned Poppy	Seaside Bindweed
Common Scurvy Grass	Sea Plantain
Woad	Saltwort
Sea Kale	Sea Buckthorn
Sea Rocket	Common Sea Rush
Sea Campion	Grass Wrack
Sea Purslane	Sea Club Rush
Tamarisk	Sand Sedge
Sea Holly	Marram Grass
Samphire	Hedgehog Grass
Thrift	Seaside Manna Grass
Sea Lavender	Rushy Wheat Grass
Sea Milkwort	Squirrel Tail Grass
Centaury	Lyme Grass

Along the coast there is frequently an extensive tract of fen silt, with ditches intersecting the inland salt marshes flanked by banks on the seaward side, with mud-banks, saltings, lagoons, and creeks.

To seaward of this comes frequently a series of sand-dunes, and often between these and the sea, or in place of the dunes, a shingle bank or beach. The last type is well developed on the east coast, where there is a north and south drift of the shingle along the easterly facing shores, or on the north coast of Norfolk a west and east drift responsible for the interesting shingle spit of Blakeney and the district between Blakeney Point and Weybourne, where cliffs take its place.

On the shingle banks a very characteristic plant is the **Yellow Horned Poppy,** which forms small or large associations just where the highest part of the shingle beach merges into the sand-dune formation. Here the surface is more level, and does not slope at an angle, as do the banks, of which there are three or four tiers, which come next to the high-water level. As these tiers are frequently changing places, as the tide washes them down, especially during storms, few plants grow upon them.

The shingle is loose and made up of pebbles, from an inch to four or five inches in diameter. In N. Norfolk it reposes on a blue clay or fen silt or warp, and the shingle is accumulated to a variable depth of eight to ten or more feet. Except for the shingle, small stones and shell fragments with occasional patches, more sandy in character, there is no soil in the

ordinary sense in the shingle beach formation, at least on the surface. The plants that grow in it are long-rooted or have long rhizomes which may reach down to a more sandy substratum, but in any case their existence is a precarious one, for apart from the poor soil, they are continually exposed to wind and storms. Hence they need the special characteristics alluded to in order to gain a footing, and to retain it once obtained.

Another common plant on the shingle beach is the **Sea Campion.** This plant spreads over the surface in a trailing manner, and has a long main root, and a thick rootstock, which gives rise to numerous, tufted, branches, which commence below the surface of the shingle, and are, like the roots, white in colour, very hard and stringy or fibrous, though pliant. It is a difficult matter to pull up one of these plants by the root when once it has become established. If broken off it is usually above the rootstock, and the plant will recover itself and grow even after all the visible parts are pulled up or broken away. The Sea Campion occurs in small societies or sometimes in isolated patches.

Amongst other plants also common to the shingle beach is the **Sea Purslane,** with a habit like the Sea Campion, but more fleshy and succulent.

Sagina maritima	o.	*Atriplex laciniata*	l.a.
Spergula salina, var. *media*	l.a.	*Suæda fruticosa*	l.a.
Sedum acre	o.	*Rumex sanguineus*	l.a.
Glaux maritima	l.a.	*Agropyron pungens*	l.a.
Plantago maritima (landward side)	l.a.		

Other plants that have been noticed include:

Sagina procumbens	*Calystegia Soldanella*
Tussilago Farfara	*Atriplex patula*
Sonchus arvensis	*Rumex crispus*, var. *triangulatus*
S. oleraceus	
Mertensia maritima	*Poa annua*
Myosotis collina	*Agropyron junceum*
Statice maritima	*Ammophila arenaria*
Limonium binervosum	*Elymus arenarius*

Some of these are stragglers from inland vegetation.

The sand-dunes are formed in some areas by the gradual

accumulation of sand in banks brought by the wind, and stabilized or retained by the protective action of such sand-binders as *Elymus arenarius*, *Ammophila arenaria*, and other plants with long reaching rhizomes.

The sand is piled up in some cases to a height of 30–50 ft., often less, up to 15 ft., and between the culms of the grasses it is loose and soft as in a desert, being formed by the same agency in each case. The flora is a very limited one, and includes but one or two main species which dominate the association, such as the sand-binding grasses, or shrubs such as *Hippophæ*, or *Salix repens*, with some other species which are of occasional or sporadic occurrence.

It includes the following :

Erodium cicutarium
Senecio Jacobæa
Calystegia Soldanella
Salsola Kali
Ammophila arenaria

and on banks on fen silt corresponding to this zone, but not of the same origin occur :

Dipsacus sylvestris
Bellis perennis
Artemisia maritima
Carduus nutans
Carduus crispus
Plantago Coronopus
Plantago Coronopus, var. *ceratophyllum*
Suæda fruticosa
Suæda maritima
Poa annua
Agropyron pungens
Hordeum murinum
Hordeum maritimum

Between the dunes and the sea there is often an association of strand plants, and these include :

Cakile maritima
Crambe maritima
Arenaria peploides
Atriplex patula
Atriplex hastata
Atriplex Babingtonii
Salsola Kali
Polygonum Raii

The dune may be either mobile or continually being added to by fresh sand and so travels inland. On the leeward side another series may form which becomes a fixed dune with a covering of vegetation differing from that on the travelling dunes. When the most seaward part of the dune is no longer added to it, it also becomes fixed.

In the travelling dune the chief plants are :

Erygium maritimum	*Ammophila arenaria*
Carex arenaria	*Festuca rubra*, var. *arenaria*

The fixed dune has a more extensive association of plants many of them of inland type :

Cerastium semidecandrum	*Hieracium Pilosella*
Erodium cicutarium	*Anagallis arvensis*
Galium verum	*Calystegia Soldanella*
Senecio Jacobœa	*Phleum arenarium*
Cnicus lanceolatus	*Corynephorus canescens*
Cnicus arvensis	*Polypodium vulgare*

The sand-dunes may form the seaward barrier to the salt-marsh formation which comes next to this formation or the shingle beach.

The salt marsh is generally a low-lying area, inundated at high tide or during storms by the sea, and supporting halophytic vegetation, unlike the last or sand-dune formation which is eremophytic, or of desert type.

The following is a list of characteristic plants, in which are included some inland types which are frequently found in association with the true salt marsh types :

Ranunculus sceleratus	ditches	**Limonium vulgare*	
Caltha palustris	,,	**Limonium binervosum*	
Glaucium flavum	o.	**Limonium rariflorum*	
**Cochlearia officinalis*		**Statice maritima*	
**Frankenia lævis*	o.	**Samolus valerandi*	
Silene maritima		**Plantago maritima*	
Erodium cicutarium		**Plantago Coronopus*	
Lotus uliginosus		**Atriplex portulacoides*	
Spiræa Ulmaria	ditches	**Salicornia europœa* (and other species)	
Sedum acre			
Hydrocotyle vulgaris		**Suœda fruticosa*	
**Apium graveolens*		**Suœda maritima*	
Sium erectum		*Salix viminalis*	
**Œnanthe Lachenalii*		**Juncus Gerardi*	
Galium palustre		*Juncus effusus*	
**Aster Tripolium*		**Juncus maritimus*	
Pulicaria dysenterica		*Juncus articulatus*	
**Artemisia maritima*		**Triglochin maritimum*	
Cnicus palustris		**Ruppia rostellata*	

Zostera marina (marine)
**Scirpus maritimus*
Carex vulpina
Carex echinata
Phalaris arundinacea
**Ammophila arenaria*
Phragmites communis
Poa pratensis
Poa annua

Those marked with an asterisk (*) in the foregoing list are the true saltmarsh types, the others belonging to a grassland association, aquatic vegetation or fen association, which have invaded the salt marsh formation.

8. Bog and Marsh Plants. (Plate XVI.) Bogs and marshes are alike in one respect, in that they support plants that are usually fond of moisture ; the former grow upon a more or less deep layer of peat, and are often found at high levels, being upland plants, though many are lowland ; the marsh formation is, however, as a rule, of lowland type. They differ from aquatic plants, at once, in not being totally submerged. Marsh plants are usually half submerged, whilst bog plants may be practically terrestrial though their soil is saturated.

The marsh plants are mainly perennial, some are tufted. A large number of bog plants are xerophilous.

Amongst marsh and fen plants there may be such associations as the Reed Association, the bush swamp association, or Fen Carr. As in the case of other formations, zones may be recognized, formed by associations of reeds, bulrushes, spike rush, sedges, reedmace, horsetails.

True bog plants require acid humus. **Alder** characterizes the wooded type of marsh formation, and here grow **Purple Loosestrife, Meadowsweet, Buckthorn, Sedges, Willow, Guelder Rose,** etc. Willow associations are another tree type of marsh community in which grow **Crack Willow, White Willow, Great Yellow Loose-strife, Great Hairy Willow Herb, Valerian, Meadow Sweet,** etc., and on higher ground **Bittersweet, Great Bindweed, Hop.** Another tree type is afforded by Birch and Pine associations, with a typical ground flora, found on dry peat, or heaths.

Wet meadow vegetation may be transformed into marsh land. And in the same way drainage may convert a true aquatic formation into marshland. Similarly wet meadows in the lowlands or highlands may be converted into low moor and high moor formations, in which true bog plants are represented such as **Sundew, Cranberry, Rosemary, Bog Pimpernel, Butterwort, Bog Myrtle, Bog Asphodel, Cotton Grass.** etc.

Marsh and bog formations are characterized by such plants as :

Great Spearwort	Common Butterwort
Marsh Marigold	Common Bladderwort
Grass of Parnassus	Bog Bean
Sundew	Golden Dock
Water Dropwort	Bog Myrtle
Valerian	White Willow
Cranberry	Marsh Helleborine
Wild Rosemary	Bog Asphodel
Bog Pimpernel	Common Joint Rush
Water Violet	Galingale
Bog Speedwell	Common Spike Rush
Marsh Lousewort	Cotton Grass, etc.

A marsh formation is frequently found at low levels in association with aquatic vegetation with a woodland association of alder and willow. On higher ground it may be developed in morasses that accumulate at the outcrop of porous rocks where springs arise, or these may give rise to a rush association or even a bog.

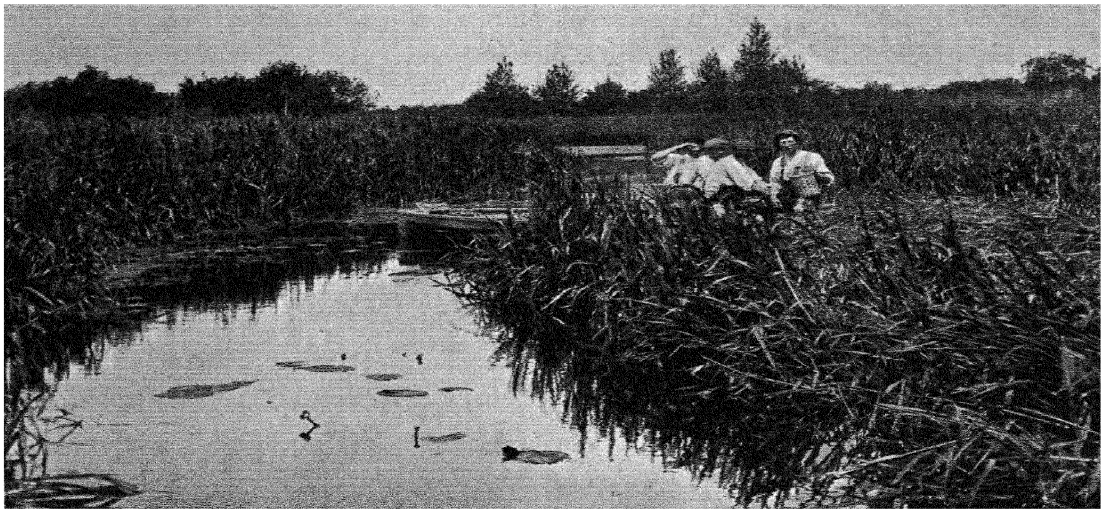
On Middle Lias one of these upland marshes yielded the following plants :

Equisetum maximum	l.a.	*Spiræa Ulmaria*	a.
Equisetum limosum	l.a.	*Caltha palustris*	l.a.
Juncus conglomeratus	l.a.	*Lotus uliginosus*	f.
Epipactis palustris	o.	*Carex panicea*	l.a.
Equisetum palustre	l.a.	*Galium uliginosum*	o.
Angelica sylvestris	f.	*Ranunculus Flammula*	f.
Stellaria uliginosa	l.a.	*Listera ovata*	o.
Carex paniculata	o.	*Pedicularis sylvatica*	f.
Valeriana dioica	l.a.	*Orchis maculata*	f.

A similar marshy tract at a high elevation on a hillside is more akin to moorland or bog vegetation, and is succeeded below by a *Nardus* heath.

Eriophorum angustifolium	l.a.	*Juncus conglomeratus*	l.a.
Orchis incarnata	o.	*Lychnis Flos-cuculi*	l.a.
Carex stellulata	l.a.	*Hypericum tetrapterum*	f.
Carex goodenovii	f.	*Cnicus palustris*	f.
Juncus articulatus	f.	*Galium palustre*	l.a.

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VEGETATION OF MARSHES AND BOGS

Fen carr with bush carr in the background, with alder, etc Closed reed swamp and aquatic vegetation in the foreground
Reed cutters in a dyke, Norfolk

Photo, L. R. J. Horn

A typical marsh is formed where low-lying ground borders aquatic vegetation, as in the wide valleys of older rivers. The following list shows the character of such a flora :

Cardamine pratensis	l.a.	*Juncus lamprocarpus*	l.a.
Juncus effusus	l.a.	*Glyceria aquatica*	l.a.
Juncus conglomeratus	l.a.	*Mentha aquatica*	f.
Caltha palustris	f.	*Deschampsia cæspitosa*	l.a.
Carex glauca	f.	*Ranunculus bulbosus*	f.
Carex goodenovii	l.a.	*Senecio aquaticus*	l.a.
Carex paludosa	a.	*Veronica Beccabunga*	f.
Ranunculus acris	l.a.	*Galium palustre*	l.a.
Taraxacum officinale	l.a.	*Geranium dissectum*	o.
Lotus corniculatus	f.	*Cerastium triviale*	l.a.

In the above list there are some meadow plants, which are established on drier ground which may be regarded as neutral grassland or a rush association. The following list shows the type of woodland in a marsh or fen formation :

Alnus glutinosa	dominant tree	*Eleocharis palustris*	a.
		Caltha palustris	f.
Salix fragilis	,, ,,	*Cardamine pratensis*	f.
Fraxinus excelsior	,, ,,	*Carex paludosa*	l.a.
Quercus Robur	,, ,,	*Spiræa Ulmaria*	f.
Viburnum Opulus	shrub	*Angelica sylvestris*	f.
Pyrus malus, var. *acerba*	,,	*Salix cinerea*	f.
Prunus spinosa	,,	*Populus Tremula*	o.
Phragmites communis (bordering river)	d.	*Apium nodiflorum*	f.
		Galium uliginosum	o.
Orchis incarnata	o.	*Equisetum limosum*	l.a.
Orchis mascula	l.a.	*Stellaria uliginosa*	f.
Hydrocotyle vulgaris	l.a.	*Juncus lamprocarpus*	f.
Œnanthe fistulosa	l.a.	*Primula veris*	o.
Poterium officinale	l.a.	*Centaurea nigra*	f.
Scabiosa succisa	f.	*Equisetum palustre*	f.
Valeriana dioica	f.	*Rumex acetosa*	f.
Saxifraga granulata	l.a.	*Lysimachia Nummularia*	l.a.
Senecio aquaticus	f.	*Ranunculus Flammula*	f.
Cnicus palustris	f.		

A fen association is formed by the following plants which grow in proximity to aquatic vegetation, and in which a more

boggy or moorland flora is also to be distinguished. This was observed in June :

Alnus rotundifolia	dominant tree	*Cnicus palustris*	f.
Salix fragilis	,, ,,	*Spiræa Ulmaria*	l.a.
Carex riparia	a.	*Galium cruciata*	f.
Lychnis Flos-cuculi	f.	*Euphrasia nemorosa*	l.a.
Equisetum limosum, var. *fluviatile*	l.a.	*Phragmites communis*	l.a.
Epilobium palustre	f.	*Vicia Cracca*	f.
Valeriana dioica	f.	*Scutellaria galericulata*	f.
Caltha palustris	l.a.	*Menyanthes trifoliata*	l.a.
Eriophorum angustifolium	l.a.	*Parnassia palustris*	l.a.
Carex acuta	a.	*Galium uliginosum*	f.
Iris Pseudacorus	o.	*Lotus major*	f.
Orchis maculata	f.	*Pedicularis palustris*	l.a.
Galium palustre	l.a.	*Epipactis palustris*	l.a.
Lysimachia Nummularia	a.	*Carex panicea*	f.
Œnanthe fistulosa	l.a.	*Carex teretiuscula*	l.a.
Lathyrus pratensis	f.	*Carex vulgaris*	l.a.
Epilobium parviflorum	f.	*Orchis incarnata*	f.
Listera ovata	l.a.	*Stellaria glauca*	l.a.
Rhinanthus Crista-galli	f.	*Hydrocotyle vulgaris*	l.a.
Angelica sylvestris	f.	*Lathyrus pratensis*	f.
Polygonum amphibium, var. *terrestre*	o.	*Carex pulicaris*	l.a.
		Ranunculus Flammula	f.
		Senecio aquaticus	f.

A similar association is presented by the flora of a wet meadow of the fen type, bordering a stream with an alder-willow association of trees :

Alnus glutinosa	l.a.	*Listera ovata*	l.a.
Prunella vulgaris	l.a.	*Spiræa Ulmaria*	f.
Caltha palustris	l.a.	*Chrysanthemum leucanthemum*	l.a.
Triglochin palustre	o.	*Juncus conglomeratus*	l.a.
Ranunculus Flammula	l.a.	*Inula dysenterica*	f.
Habenaria conopsea	a.	*Pedicularis palustris*	l.a.
Epipactis palustris	l.a.	*Menyanthes trifoliata*	a.
Epilobium parviflorum	f.	*Angelica sylvestris*	f.
Linum catharticum	a.	*Mentha aquatica*	l.a.
Œnanthe fistulosa	f.	*Scrophularia aquatica*	f.
Myosotis cespitosa	f.	*Lychnis Flos-cuculi*	l.a.
Senecio aquaticus	f.		

Galium palustre	f.	*Epilobium hirsutum*	l.a.
Veronica Beccabunga	l.a.	*Rumex conglomeratus*	f.
Veronica scutellata	l.a.	*Nasturtium palustre*	o.
Centaurea nigra	o.	*Mimulus Langsdorfii*	o.
Eriophorum angustifolium	l.a.	*Myosotis palustris*	l.a.
Eriophorum latifolium	l.a.	*Cnicus lanceolatus*	l.a.
Lathyrus pratensis	f.	*Veronica serpyllifolia*	l.a.
Cnicus palustris	f.	*Lotus major*	f.
Anagallis tenella	l.a.	*Sieglingia decumbens*	f.
Festuca pratensis	f.	*Carex pallescens*	l.a.
Carex fulva	l.a.	*Juncus acutiflorus*	l.a.
Carex rostrata	l.a.		

Moorland vegetation (see next section) is characterized by the dominance of Sphagnum, Cotton Grass, *Scirpus cæspitosus*, Bilberry, Heather.

9. Heath and Moorland Plants. (Plate XVII.) Heathland is, as a rule, barren and not rich in those constituents which are not necessary for the growth of woods or rich meadow or pasture land. It is poor in calcium salts, like the bogs which are found in upland regions, whereas marshes are usually lowland, and sometimes relatively rich in calcium salts.

The heath vegetation is made up of dry soil plants ; in all there are about eighty ericetal species. Being exposed to wind, few trees characterize this type of formation ; it is, however, often derived from a former woodland formation, and may consist of a sort of bushland of furze and broom with birch, which are commonly found on gravelly soils.

The leaves are often very slender or filiform, as in the **Heaths** and **Ling.**

Moorland plants are really akin to the bog plants which were included in the last section, and are differentiated from heath plants by their requirement of wetter conditions. A low moor formation requires a soil rich in humus acid and peat, with some proportion of lime salts, and is more akin to marsh vegetation.

Sedges contribute to form sedge moor, and other plants are **Cotton Grass, Bulrush, Hair Grass, Bent Grass, Rushes, Angelica, Marsh Willow Herb, Birch, Alder, Heaths,** etc.

Associations are formed by sedges, cotton grass, rushes, etc.

Grass heath is formed by **Mat Grass, Sedges, Bents, Ling,** etc. The soil is dry and not deep.

The high moor formation includes bog mosses, and true bogs occur here, where the soil is moist ; it may be derived from a low moor, so that heath, low moor, and high moor are largely related. It is poor in calcium salts, like bogs, bog mosses not being addicted to lime. The **Sphagnum** helps to form a thick covering of peat, of an acid nature. Here grow sedges, **Cotton Grass, Silver Bent Grass, Whortleberry, Cranberry, Cross-leaved Heath, Ling, Cloudberry, Red Rattle, Creeping Willow, Birch,** etc.

Peat is formed also by **Bulrushes, Cotton Grass, Heath, Ling,** etc.

Considerable differences exist between the low and high moor, apart from the presence or absence of calcium salts.

The plants of heaths and moorland are :

Milkwort	Ling
Grassy Stitchwort	Common Dodder
Pretty St. John's Wort	Eyebright
Furze	Red Rattle
Broom	Common Sylvan Cow Wheat
Tormentil	Pennyroyal
Heath Bedstraw	Creeping Willow
Cat's Foot	Wood Rush
Wall Hawkweed	Meadow Rush
Sheep's Bit Scabious	Early Sedge
Harebell	Green Ribbed Sedge
Whortleberry	Small Bent Grass
Cross-leaved Heath	Heath Hair Grass
Crimson Heath	Matweed

Heaths are really developed on a sandy soil and related to oak birch heath and the dry sandy oakwood.

A Nardus heath may be more or less entirely made up of *Nardus stricta,* with *Deschampsia cæspitosa, Sieglingia decumbens, Pedicularis sylvatica, Aira præcox,* etc.

Grass heath is illustrated by the following list of plants :

Aira præcox	dominant grass	*Festuca ovina,* var. *tenuifolia*	dominant grass
Aira caryophyllea	,, ,,	*Festuca sciuroides*	,, ,,
Koeleria cristata	,, ,,	*Rubus pulcherrimus*	f.
Festuca ovina	,, ,,	*Hieracium Pilosella*	l.a.

Ornithopus perpusillus	f.	*Galium verum*	f.
Rumex Acetosella	l.a.	*Trifolium striatum*	f.
Alchemilla arvensis	l.a.	*Erodium cicutarium*	f.
Thymus Serpyllum	l.a.	*Arenaria serpyllifolia*	f.
Lotus corniculatus	f.	*Veronica arvensis*	o.
Senecio sylvaticus	l.a.	*Cerastium semidecandrum*	r.
Potentilla argentea	r.	*Trifolium scabrum*	r.
Scleranthus annuus	o.	*Trifolium repens*	f.
Trifolium dubium	f.	*Sedum acre*	a.

Another type of grass heath is formed in close proximity to older rocks of siliceous type, such as :

Teesdalia nudicaulis	r.	*Aira præcox*	f.
Potentilla argentea	r.	*Aira præcox*, var. *erecta*	r.
Draba verna	l.a.	*Lotus corniculatus*	f.
Plantago lanceolata	l.a.	*Achillea Millefolium*	l.a.
Veronica serpyllifolia	f.	*Scleranthus annuus*	o.
Alchemilla arvensis	l.a.	*Geranium molle*	l.a.
Myosotis versicolor	l.a.	*Filago minima*	r
Hieracium Pilosella	l.a.		

A further less marked type of grass heath yielded the following representative plants :

Pedicularis sylvatica	o.	*Alchemilla filicaulis*	f.
Polygala vulgaris	o.	*Festuca ovina*	l.a.
Listera ovata	f.	*Agrimonia Eupatoria*	f.
Orchis maculata	f.	*Poterium officinale*	f.
Potentilla sterilis	f.	*Carduus crispus*	o.
Nardus stricta	r.	*Cnicus palustris*	f.
Carex hirta	f.	*Centaurea nigra*	f.
Avena pubescens	f.	*Anthoxanthum odoratum*	l.a.
Ophioglossum vulgatum	f.	*Cnicus lanceolatus*	l.a.
Stachys Betonica	l.a.	*Senecio erucæfolius*	o.
Scabiosa succisa	l.a.	*Galium verum*	f.
Primula veris	o.	*Veronica Chamædrys*	f.
Ajuga reptans	l.a.	*Spiræa Ulmaria*	f.
Luzula campestris	f.	*Conopodium denudatum*	l.a.
Luzula vernalis	o.	*Carex glauca*	l.a.

A limestone heath on oolite yielded in August the following list :

Senecio Jacobœa	a.	*Lotus corniculatus*	l.a.
Euphrasia nemorosa	l.a.	*Bartsia Odontites*	f.

Cnicus lanceolatus	f.	*Trifolium pratense*	l.a.
Silene Cucubalus, var.		*Trifolium repens*	l.a.
puberula	l.a.	*Cnicus arvensis*	f.
Pimpinella Saxifraga	f.	*Plantago lanceolata*	f.
Centaurea Scabiosa (white		*Ononis repens*	l.a.
flowers)	l.a.	*Scabiosa arvensis*	l.a.
Chrysanthemum Leucanthemum	f.		

10. Aquatic Plants. (Plate XVIII.) Plants are at once divided into land plants and water plants according as their habitat is terrestrial or aquatic. The latter have their roots, if attached, embedded in the soil below water, and the soil here plays a part as with true land plants. It is natural that such entirely different conditions necessitate a totally different habit, and the mode of nutrition, etc., is also dissimilar.

Some aquatic plants float on the surface, or have floating leaves, some are submerged, or attached, some are attached to soil, some to rocks. The plant is secured by its root, and nutriment is largely absorbed by all parts, the stem and leaves. A large number reproduce by offshoots, etc., and seldom flower, as **Frogbit**, but form winter buds.

Certain associations can be recognized such as the *Lymnæa* association, so called from the prevalence of the pond snail; these are submerged or have floating leaves. A large proportion is made up of **Pondweeds, Water Pepper, Bur Reed, Water Lilies, Water Buttercup, Water Celery.**

There are about 100 aquatic plants. Some are littoral, some riparian, forming a link with marsh plants. Most aquatic plants are herbaceous and perennial, and usually have creeping stems, and a crowded growth. **Naias** is annual. The habit may be that of rosette plants as in **Lobelia,** *Nymphæa* type as in Water Lilies, which are long-stalked, with floating leaves, or of long-stemmed type as in pondweeds.

Associations arranged in zones may be recognized, such as Algæ, Stoneworts, Water Lily, Water Buttercup, Lymnæa, Rosette, Lobelia, etc.

The Hydrocharis and Lymnæa associations merge into each other. The amphibious **Knotgrass** may take to a terrestrial habitat, like some of the Water Cress group.

The aquatic plants include the following:

Meadow Rue	Water Figwort
Water Fennel	Musk
Yellow Water Lily	Brooklime
White Water Lily	Water Mint
Water Cress	Gipsy Wort
Great Yellow Cress	Blue Skull Cap
Great Water Chickweed	Amphibious Knotweed
Purple Loosestrife	Alder
Great Hairy Willow Herb	Crack Willow
Water Bedstraw	Frogbit
Common Flea Bane	Yellow Flag
Butterbur	Snake's Head Fritillary
Coltsfoot	Reed Mace
Water Ragwort	Bur Reed
Marsh Thistle	Sweet Flag
Great Yellow Loosestrife	Duckweed
Moneywort	Water Plantain, etc.
Scorpion Grass	

Aquatic vegetation is of freshwater or marine type. The former includes the following associations :

Association of foul water.
Association of waters relatively rich in mineral salts.

(*a*) Water nearly stagnant (ponds).
(*b*) Slowly flowing water (lochs).

Association of water poor in mineral salts.
Association of quickly flowing water (cascades).

(1) Water non-calcareous.
(2) Water calcareous.

In each case there is a zonation of the vegetation with (1) a marginal reed swamp (closed or open) ; (2) floating-leaf association ; (3) submerged leaf association.

In the case of a small stream of the slow-flowing type the following plants are to be found where alluvium has been formed, influencing the marginal or riparial vegetation here included :

Arum maculatum	f.
Spiræa Ulmaria	f.
Juncus glaucus	l.a.
Cardamine hirsuta	

	Ranunculus Ficaria	f.
Submerged types	*Callitriche verna*	l.a.
	Zannichellia palustris	f.
Reed swamp .	*Glyceria plicata*	l.a.

In other cases there may be the following associations :

Stream bank .	*Convolvulus Sepium*
	Epilobium hirsutum
	Conium maculatum
Reed-swamp .	*Sparganium ramosum*
Submerged type	*Potamogeton crispus*

The aquatic vegetation of the backwater of a river is illustrated by the following association observed in June :

Riparial . .	*Myosotis palustris*	Passing into the marsh formation
	Salix triandra	
	Galium palustre	
	Poa trivialis	
	Mentha aquatica	
	Spiræa Ulmaria	
	Salix fragilis	
	Epilobium parviflorum	
	Triglochin palustre	
Reed-swamp .	*Carex riparia*	
	Phragmites communis	
	Carex acutiformis	
	Apium nodiflorum	
	Iris Pseudacorus	
	Veronica Beccabunga (or half-submerged)	
	Equisetum limosum	
	Sparganium ramosum	
	Carex acuta	
	Sium angustifolium	
	Alisma Plantago Aquatica	
Floating-leaf .	*Lemna minor*	
	Lemna trisulca	
Submerged .	*Callitriche verna*	
	Nasturtium amphibium	half-submerged
	Veronica Anagallis	
	Nasturtium officinale	
	Elodea canadensis	

The flora of a ditch is intermediate between aquatic vegeta-

tion and marsh vegetation, consisting largely of riparial plants. The following is a typical association :

	Ranunculus sceleratus	f.
	Stellaria aquatica	l.a.
	S. media (banks)	l.a.
	S. graminea (banks)	o.
	Catabrosa aquatica	o.
	Poa trivialis	l.a.
Half-submerged .	*Epilobium hirsutum*	a.
	Epilobium parviflorum	l.a.
	Myosotis palustris	f.
Half-submerged	*Veronica Beccabunga*	a.
	Nasturtium officinale	l.a.
	Cardamine flexuosa	l.a.
	Barbarea vulgaris	f.

In an adjoining brook the following plants form a characteristic type of association :

Riparial . .	*Alnus glutinosa*
	Salix viminalis
	Salix Caprea
	Salix fragilis
	Salix Smithiana
	Scrophularia aquatica
	Rumex conglomeratus
	Juncus conglomeratus
	Juncus glaucus
	Conium maculatum
	Solanum Dulcamara
	Hypericum hirsutum
Reed-swamp .	*Iris Pseudacorus*
	Carex acutiformis
Floating-leaf .	*Sparganium natans*
	Nuphar lutea
Half-submerged .	*Nasturtium amphibium*
	Alopecurus geniculatus
	Apium nodiflorum

The flora of a canal is illustrated by the following association :

Riparial . .	*Cardamine amara*
	Juncus effusus

	Juncus conglomeratus
	Spiræa Ulmaria
	Lathyrus pratensis
Reed-swamp	*Lycopus europœus*
	Angelica sylvestris
	Carex paniculata
	Hypericum quadrangulum
	Phalaris arundinacea
	Galium palustre
Floating type	*Lemna trisulca*
Submerged type.	*Elodea canadensis*
	Ranunculus circinatus.

In a canal of a different type the association observed in May was much richer in the number of forms :

Riparial	*Cardamine amara*	Marsh vegetation
	Cardamine pratensis	
	Caltha palustris	
	Equisetum arvense	
	Myosotis palustris	
	Lychnis Flos-cuculi	
	Juncus lamprocarpus	
	Epilobium parviflorum	
	Galium palustre	
Reed-swamp	*Eleocharis palustris*	
	Sparganium ramosum	
	Angelica sylvestris	
	Carex acutiformis	
	Rumex Hydrolapathum	
	Equisetum limosum	
	Butomus umbellatus	
	Alisma Plantago Aquatica	
	Œnanthe fistulosa	
	Apium nodiflorum	
Floating type	*Ranunculus pseudofluitans*	
	Potamogeton natans	
	Potamogeton lucens	
	Nuphar lutea	
	Polygonum amphibium	
Submerged type.	*Ranunculus circinatus*	
	Ranunculus fluitans	
	Elodea canadensis	

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VEGETATION OF ROCKS

Mouth of Gaping Ghyll pot-hole, at the side of Ingleborough, Yorks Limestone rocks, with stonecrops, cloudberry, heather spleenwort, Ceterach, and other ferns

Photo, L. R. J. Horn

Papaver Rhœas
Artemisia vulgaris
Poterium officinale
Vicia hirsuta
Daucus Carota
Myosotis arvensis
Veconica agrestis
Achillea Millefolium
Lychnis alba
Caucalis Anthriscus
Linaria vulgaris
Melilotus altissima
Veronica Buxbaumii
Plantago lanceolata
Malva sylvestris

In a quarry on calcareous soil or oolite the flora includes such plants as :

Agrimonia Eupatoria
Scabiosa arvensis
Silene latifolia
Viola hirta
Papaver Rhœas
Convolvulus arvensis
Peucedanum sativum
Cnicus lanceolatus
Crepis virens
Chœrophyllum temulum
Medicago lupulina
Lathyrus pratensis

12. Rupestral Plants. (Plate XX.) The plants that are found on bare rocks and walls are those that flourish in little or no soil. Such habitats exist not only in upland regions where no soil accumulates, or where only a stony debris is formed above the rock itself, but also in lowland regions, where natural exposures exist. Shelving and vertical cliffs are common in fact to all altitudes. These are distinct again from rock habitats in which crevices occur where certain plants alone find suitable conditions for existence. In some cases rock habitats are dry, in others, especially sloping faces, they continually stream with moisture or water, which flows naturally and regularly from the outcrop of the beds.

Mural plants are of course purely artificial, and the original habitat must have been a rock or bare wall.

Of these rupestral or saxicolous plants there are about 180, and of these 120 are alpine, 60 are lowland species, about a dozen are found on wet rocks and about 25 prefer limestone rocks.

The exposure of the rock has a great influence on the character of the vegetation as also has the slope of the face. As already emphasized, the composition of the rock is of paramount importance ; the porosity also is an important feature.

Where humus has accumulated **Stonecrops** grow on shelving ledges, **Orpine** may grow in clefts or under a hedgerow in other

cases. Many of these plants have the rosette habit and are tufted. Most are perennials ; some are xerophytes fond of a dry soil, a few are halophytes, maritime, and salt-lovers.

We have included here a few that are specially addicted to sandy or gravelly fields, or stony places ; some grow on chalk.

The following are typical rupestral, mural, sandy or gravelly soil plants :

Yellow Fumitory	House Leek
Wallflower	Golden Rod
Vernal Grass	Mouse Ear Hawkweed
Cheddar Pink	Wall Lettuce
Field Mouse Ear	Rampion
Sandwort Spurrey	Yellow Centaury
Bird's Foot	Ivy-leaved Toadflax
Horse Shoe Vetch	Field Speedwell
Rue-leaved Saxifrage	Pellitory
White Meadow Saxifrage	Silky Wind Grass
Navel Wort	Silvery Hair Grass
Orpine	Flat Stalked Poa
Biting Stone Crop	Sand Fescue

Walls and rocks are both characterized by the fact that the soil is shallow or absent. Such plants as *Linaria Cymbalaria*, *Asplenium Ruta-muraria*, *Polypodium vulgare*, Ivy, grow in the crevices of bricks. Others such as *Lactuca muralis*, *Sisymbrium Thalianum*, various types of **Hawkweed, Wall Rocket,** *Geranium lucidum*, various types of **Willow Herb,** *Poa compressa*, *Veronica arvensis*, grow on the top of a wall, with such plants as **Wallflower, Stonecrop, Cat's Valerian,** which are often grown in gardens.

On a marlstone wall the following have been noted :

Plantago major	*Poa compressa*
Potentilla Anserina	*Asplenium adiantum nigrum*
Rumex obtusifolius	*Polypodium vulgare*
Rumex acetosa	*Scolopendrium vulgare* (often in wells)
Nepeta Glechoma	*Anthriscus vulgaris*
Sedum reflexum	*Chelidonium majus*
Sedum dasyphyllum	
Saxifraga tridactylites	

On or at the base of a similar wall the following were noticed :

Geranium molle
Crepis virens
Stellaria media
Chenopodium Bonus Henricus
Pimpinella Saxifraga
Centaurea nigra
Potentilla reptans
Medicago lupulina
Sonchus asper
Taraxacum officinale
Arenaria serpyllifolia
Leontodon hispidus
Hieracium Pilosella
Polygonum aviculare
Caucalis nodosa
Carum segetum
Achillea Millefolium

On a limestone wall the following were noted :

Festuca rigida
Festuca rubra
Saxifraga tridactylites
Humulus Lupulus
Veronica arvensis
Arenaria trinervis

APPENDIX

The Gripper (p. 41)

THIS is a very useful walking-stick pruning apparatus, and a tool that is admirable for botanical work, enabling one to reach plants in the water, to bring them safely to land, and to obtain fruit, catkins, etc., from tall trees. By pressing a lever at the handle end the blades close together, cut through the bough and retain the portion cut, so that it can be brought down uninjured. By pressing the knob at the end of the stick the blades and the specimen are released at the same time.

It is a defect of most pruning tools that one cuts off the bough, but lets it fall, and for botanical purposes this is a disadvantage.

A few instructions issued by the firm * that supplies this useful tool may be appended.

To cut flowers. Hold the tool so that the ring is toward the blossom, otherwise the severed blossom will drop. Cut large stems near the hinge and small ones about halfway down. It is the side blades that cut, not the end portion.

The tool may also be used to weed, when it should be held vertically: press the point well into the ground by the side of the weed, and close the other jaw gently on to it, then pull. By turning the knob at the end the blades can be set close together. When the blades are opened wide the tool may serve as a spud.

The length of the gripper is usually 4 ft. (or 3 ft. long with black finish, 5s.) with green cane, selected parts and plated (7s. 6d.). Longer tools can be had at 1s. a foot extra. The blades of the tool are kept sharp for two years by the makers, free.

Modelling Flowers in Wax (p. 66)

THE following account of the process originally introduced by the well-known modellers, Messrs. Minton and Mogridge,

* Gripper Manufacturing Company, Portland Road, Leicester.

has been kindly supplied me by Mr. W. E. Mayes of Leicester Museum, who has had a long practical experience of this method, and has in turn elaborated a quicker and more effective method himself (*see post*).

The first thing to do is to obtain a suitable specimen, *e.g.* a branch of apple with leaves and bloom. A leaf is cut off at the base. A quantity of fine casting powder is required to make a mould of the leaf. The plaster should be mixed in a small bowl, till it has a creamy consistency. A thin coat of this is carefully spread with a camel-hair brush over the surface of the leaf, which is then laid on one side to dry for about fifteen minutes. All the leaves are dealt with in the same way. A note as to their exact position upon the twig should be made.

Next, the first leaf now dry is taken, and a plaster coat three-quarters of an inch thick is built up of thicker plaster, a stiff knife being used for this process, which applies to all the leaves.

When they are set, but not dry, trim up the moulds, and remove the leaves, which will come away easily. The impression of the leaf thus made is perfect, but upside down.

Boil the moulds for ten minutes in strong borax and water, then place them in an oven at a gentle heat, until they are quite dry and hard.

As the final finished model is in wax a supply of this is necessary.

For colouring waxes melt together in a small basin in a water bath the following:

Paraffin wax 2 parts
Beeswax 1 part
Canada balsam ¼ part.

The liquid wax thus obtained by heating may be coloured by stirring in with a brush or spatula sufficient oil colour to give the desired tint.

For waxed fabrics take some white fabric, jap silk by preference, and cover the surface of each with coloured wax, *e.g.* green wax for the leaves. This may be done by straining the fabric over a basin or a box, and brushing the hot wax carefully and evenly over the surface, taking care not to go over the same place a second time, until the first coat has set. Two coats are generally required.

To take an impression of the leaf immerse the plaster mould in boiling water for about ten minutes. Cut a piece of the prepared fabric slightly larger than the size of the impression already in the mould. Press this fabric well into the mould while still warm, but not too hot.

Take a thin wire, and lay it along the middle of the leaf, then place on this a thin piece of fabric, in order to more or less sandwich the wire, and press it well together until both fabrics have united.

When the mould is cold carefully lift out the cast fabric. Trim it around the margin with a pair of small scissors, and touch it up generally. The result should be an exact reproduction of the original leaf.

In order to reproduce the stems or leafstalks thin strips of fabric are rolled around wires up to the required thickness. Large shoots with several leaves may be made up in this way.

In order to model the apple-blossom white fabric is prepared in the same way as the green (for the leaves), using flake white. The fabric is made as thin as possible in this case.

Take a petal and press it upon the fabric, and cut round to obtain the shape. This is done for each one, when a series of fabric petals which need modelling, is obtained. Lay one of them in the palm of the hand, and with the round end of a modelling tool or large glass-headed hat-pin, model it into the required shape, and trim the edges.

Having completed the modelling of the petals, the sepals may be done in the same way.

The stamens are perhaps best made by cutting up thin fibres of waxed fabric, touching the ends with hot coloured wax to suggest anthers.

All the parts of the flower having been completed, they require to be put together. This may be done in different ways, by wiring, etc., according to the character of the flower.

As regards the tools required the following are necessary :

One pair of medium-sized straight scissors.
One pair of short curved surgical scissors.
Two pairs forceps, large and small.
One pair wire-cutters.

An assortment of various thicknesses of wire (silk-covered milliners' wire).

A box of oil colours.

This method has been improved upon by Mr. Mayes, by a method of his own invention, whereby the lengthy process of casting is dispensed with, whilst at the same time an accurate representation of the object is obtained. Examples of the work executed by Mr. Mayes are to be seen at Leicester Museum. At the author's suggestion he undertook a series of models to illustrate the pollination of flowers, and the life-size models and enlargements of floral structure are indeed very true to nature in every respect.

This method will no doubt supersede all others in course of time. For personal reasons the method is not described, as naturally the secret lies with the discoverer.

Preservation in Plants of their Natural Colours (p. 68)

In the ordinary way specimens preserved in spirit have to be bleached, so that they lose their natural colour. The colours of vegetables used as food have been retained by aid of copper salts. By using copper acetate dissolved to saturation in strong acetic acid, Professor J. W. H. Trail has succeeded in obtaining a compound of chlorophyll with copper and retaining the green colour; four parts water are added to one part of the solution. The specimens are steeped in it for a month or more, then washed in clean water for a few minutes and placed in preservative fluid. An improved method is to boil the specimen in copper acetate to prevent any effects of decomposition or discoloration. This method is much quicker. Twenty minutes suffice.

By this process, not only is the green colour of the stem and leaves preserved, but also to some extent that of the flowers, as in roses. Some plants, after boiling and washing, may be dried, and will retain the green colour when exposed to light.

The following is the method advocated by Professor Trail:

"The method of treatment found to give the best specimens is as follows: Saturate the volume (say one gallon) of commercial strong acetic acid with copper acetate, shaking the bottle occasionally until no more will dissolve, some acetate being left at the bottom of the bottle. Pour off the clear solution, and add an equal volume of distilled or very soft water. Of this fluid enough is poured into an open enamelled or earthenware dish to allow the specimens for treatment to

be submerged in it while it is being boiled over a suitable gas-burner. The specimens may be put at once into the boiling fluid, and should be kept sunk in it for periods as stated above, varying with their texture from two minutes to about twenty minutes. The fumes of boiling acetic acid are apt to be irritant to the eyes, nose, and throat, and also injure certain metals ; hence it is well, if possible, to boil the specimens in a fume chamber, or in a place where the vapour can readily escape. The specimens should be lifted out with wooden forceps, and if they appear to have been long enough they should be washed for a few minutes in water, and if necessary brushed or rubbed to remove deposits on their surfaces. They may then in most cases be prepared at once for permanent preservation, either in any of the usual preservative fluids, or dried."

A method of preserving the colours of plants employed by English is to immerse the plant in petroleum and press it in the usual way. Afterwards the plant is first dried by embedding it in plaster of Paris heated to a temperature of 100° F. Petroleum is then applied with a camel-hair brush. This takes eight to twelve hours for small plants, larger plants taking twice as long. All that is needed is a wooden tray or shallow box, various boxes of different sizes for embedding, a trowel, camel-hair pencils, a wide-mouthed glass cylinder or bottle to hold hydrochloric acid to fume the red flowers ; a bottle of varnish, diluted to half the strength with equal parts of turpentine and benzoline.

After embedding in plaster the plant is left for an hour. To dust it tap and dust. Then apply the varnish.

Another method is to use equal quantities of plaster and lime, and to reverse the previous order. The plants are embedded first and then heated.

The plants can be mounted as for the herbarium or in shallow drawers. Form is preserved best, the colour next.

Travelling Exhibit (p. 87)

THE method adopted by Mr. W. Mark Webb (Editor of *Knowledge*) by whose courtesy we are able to reproduce the illustrations, is to use glass-topped boxes of a convenient size. The specimens are thus separated from each other, not crowded, each complete in itself, and the label can be put

level with the top of the box. The boxes can be interchangeable and the specimens can be taken out for examination if need be. The series can be placed in a frame of sufficient length to carry say half a dozen. They can thus be hung upon the wall and changed from time to time. Such a series with half a dozen boxes and the back frame, etc., will cost less than half a sovereign. The principle lends itself to the exhibition of such objects as photographs of trees in summer and winter, leaves to show anatomy, fruits, oak galls, etc., with the insects, birds' nests found in a particular area, and a map. Other subjects for treatment suggested by Mr. Webb are :

A case illustrating resemblance or mimicry among English insects and snails.

The making of collections of seeds and of nuts and shells opened by rodents and birds, showing the relationships between plants and animals.

Illustrations of the healing of wounds and grafting.

Methods of showing animals which have to be preserved in spirit, *e.g.* wood lice.

Comparison of implements illustrating stages of civilization in this country.

An index collection of molluscs.

A local collection of land and fresh water shells.

This idea may be extended to any subject desired, and for school purposes or the circulation of these series from one school to another, nothing could be more excellent.

A simple but admirable form of travelling-case consists of four flaps or sides hinged together, closing up like a folding map, and fastened with hooks.

BIBLIOGRAPHY

In the collecting of information for this little handbook, recourse has been had to published works on the subject, but they are not numerous. A list below gives the titles of those which may be of use to the reader as they have been to the author.

Natural History Journals, Nature, Knowledge, New Phytologist, The Museums' Journal, Vol. 1. onwards, *Museum Reports*, various dates; *Kew Bulletin*, etc.

J. L. English:
A Manual for the Preservation of the Larger Fungi and Wild Flowers.

H. L. Tagg:
Notes on Museum-Methods in use at the Royal Botanic Garden, Edinburgh.

M. Browne:
Artistic Modelling and Taxidermy.

Various Authors:
Admiralty Handbook.

Dr. A. B. Rendle:
British Museum, Notes on Collecting.

Dr. H. F. Parsons:
Hints on Natural History Collecting.

J. W. White, F.L.S.:
The Preservation and Mounting of Flowering Plants.

S. Guiton:
Hints on Collecting and Preserving Plants. An excellent little manual to which the author is indebted for many useful hints.

J. M. B. Taylor:
Handbook of Plant Collecting.

J. E. Taylor:
Notes on Collecting and Preserving Natural History Objects.

Prof. Balfour:
The Botanist's Companion.

Rev. W. W. Spicer:
The Collector's Handbook of Algæ, Diatoms, Desmids, Fungi, Lichens, Mosses, etc.

General Works

Sir F. Darwin :
Elements of Botany.

Dr. F. Cavers :
Plant Biology.

J. C. Willis :
Flowering Plants and Ferns.
How to Study Wild Flowers.

L. Ganong :
The Living Plant.

E. Step and A. E. Knight :
The Flowering Plant.

J. A. Davis :
The Flowering Plant.

R. L. Praeger :
Open-Air Studies in Botany.

C. A. Timiriazeff :
The Life of the Plant.

A. Kerner and Prof. F. W. Oliver :
The Natural History of Plants.

D. H. Campbell :
Plant Life and Evolution.

Prof. J. B. Farmer :
Plant Life.

Rev. G. Henslow :
Floral Structure.

T. Fox :
How to Find and Name Wild Flowers.

A. R. Horwood :
British Wild Flowers in their Natural Haunts. In the Press.
Plant Life in the British Isles. 3 vols.

Systematic Botany

Prof. C. C. Babington :
Manual of Botany. 9th ed.

Sir J. D. Hooker :
The Students' Flora.

F. N. Williams :
Prodomus Florœ Britannicæ.

G. C. Druce :
Botanist's Pocket Book.

Dr. C. E. Moss :
Cambridge Flora.

J. Sowerby :
English Botany.

W. M. Watts :
School Flora.

Bentham and Hooker :
Handbook of the British Flora.

Dr. A. B. Rendle :
The Classification of Flowering Plants. Vol I.

Dr. H. G. Carter :
The Genera of British Plants.

W. J. Gordon :
Our Country's Flowers.

ECOLOGICAL WORKS

A. G. Tansley :
Types of British Vegetation.

J. F. Bevan and H. J. Jeffreys :
British Plants, their Scology and Ecology.

A. F. W. Schimper :
Plant Geography.

Prof. G. S. Boulger :
Plant Geography.

E. Warming :
Œcology of Plants.

E. J. Russell :
Soil Conditions and Plant Growth.

A. D. Hall :
The Soil.

W. Somerville :
Agriculture.

H. B. Woodward :
The Geology of Soils and Substrata.

F. H. King :
The Soil.

GENERAL BIOLOGY, ETC.

Dr. D. H. Scott :
Evolution of Plants.

H. Muller :
Fertilisation of Flowers.

P. Knuth :
Flower Pollination.

C. Darwin :
Cross and Self Pollination.
Fertilisation of Orchids.
Climbing Plants.
Forms of Flowers.
Insectivorous Plants.
Origin of Species.
Vegetable Mould and Earthworms.
Movements of Plants.

Lord Avebury :
Flowers, Fruits, and Leaves.
On Seedlings.
On Buds and Stipules.

L. H. Bailey, and H. De Vries :
Plant Breeding.

R. C. Punnett :
Mendelism.

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