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PLANT LIFE IN
ALPINE SWITZERLAND

ARBER

423

Edward Alexander
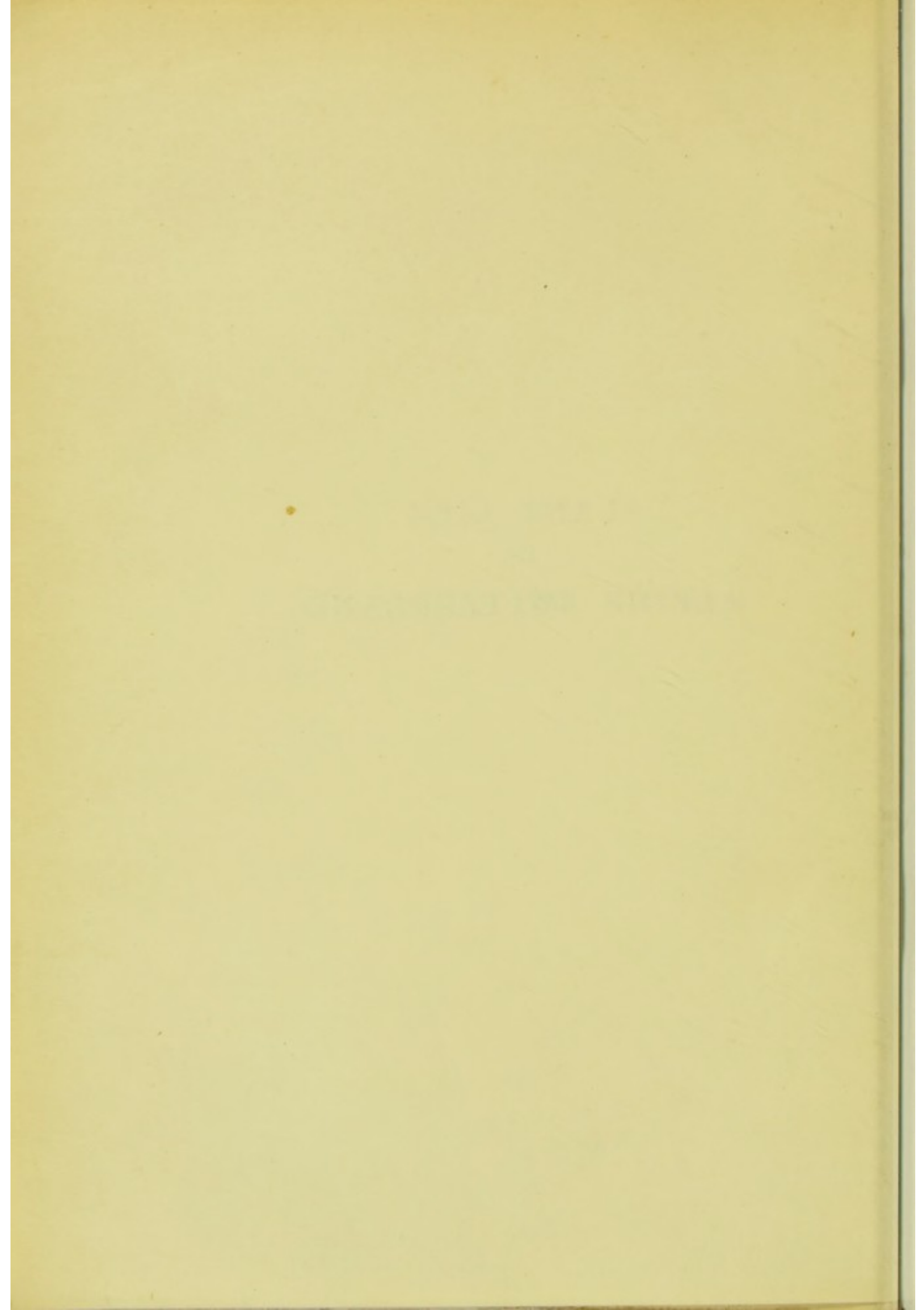
PLANT LIFE

IN

ALPINE SWITZERLAND

A Typical Damp Pasture Association.   The Globe Flower (*Trollius europæus*, Linn.), the Aconite-leaved Buttercup (*Ranunculus aconitifolius*, Linn.), and the White Veratrum (*Veratrum album*, Linn.).

PLANT LIFE IN ALPINE SWITZERLAND

BEING AN ACCOUNT IN SIMPLE LANGUAGE OF THE NATURAL HISTORY OF ALPINE PLANTS

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ILLUSTRATED BY 48 PLATES OF PHOTOGRAPHS
FROM NATURE, AND 30 FIGURES IN THE TEXT

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BY

E. A. NEWELL ARBER

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PREFACE

A FEW words may be necessary to explain the scope and intention of the present volume.

It has often been remarked, and with some measure of truth, that botanists, in common with other scientists, have in the past done little to bring the results of their researches within the reach of the layman, in a language in which they can be commonly understood and appreciated. The present volume attempts, no doubt imperfectly, the difficult task of trying to draw attention to some points of botanical interest among the better-known members of the Alpine flora of Switzerland.

As the result of repeated visits to the Alps, now extending over a period of more than twenty years, I have been struck on many occasions by the inadequate information, at present available, for those who are interested in the habits of Alpine plants, but have not had the good fortune to have been able to devote much time previously to a serious study of Botany. Again and again I have

watched the natural sequence of events. The tourist, arriving among the High Alps perhaps for the first time, is at once struck by the extreme beauty and richness of the flora. I have noticed that, in nine cases out of ten, he will devote more attention to the Alpine flowers than he is at all likely to bestow on our British wild plants. He is anxious, and rightly so, to ascertain the name of this or that plant, which he may happen to have come across, usually quite unexpectedly, in his wanderings and excursions. Yet, to determine the genus and species is often an extremely difficult task for the layman, and in certain cases even for a trained botanist. If, rather by good luck than otherwise, perhaps by resort to a book containing crudely coloured illustrations of some of the commoner Swiss plants, the name of a flower is obtained, as a rule all further interest in the plant ceases. It is either thrown away or perhaps "pressed," and, as often as not, forgotten.

Yet, to the trained botanist, the name of a plant is frequently the least interesting matter in connection with it. He too, like the layman, may have to take some pains to find out the genus and species, but, once these have been ascertained, a whole host of fascinating, even absorbing, interests may be presented by almost any Alpine plant. Originally a knowledge of each of these was won from the domain of ignorance by the researches of some botanical student of Alpine vegetation. The results of his scientific explorations are buried in a host of

scattered, sometimes obscure, and inaccessible scientific periodicals, or in the transactions of learned societies, and may have been published in almost any one of the European languages. This "literature," as it is called, is naturally beyond the ken of the layman, whereas the trained botanist is familiar with, and is constantly brought into contact with, these memoirs, and is an expert in the use of such means as exist, whereby one can reach all that is known, or has been written, on a particular subject. Thus the botanist is at a great advantage, an advantage which has always appeared to me to be somewhat unfair.

It should here be stated clearly that this work is not intended to give any aid towards ascertaining the names of Alpine plants. Even the photographs which illustrate it are not published for that purpose. To determine a species or genus, the reader must make use of some one or other of the systematic floras of Switzerland, the more useful of which are indicated in Appendix III. In this volume I propose, rather, to attempt to explain, in simple language, some of the features presented by Alpine plants which appear to me to be of special interest. So far as possible, technical terms will be avoided. It will be assumed, however, that the reader is familiar with the ordinary features of a plant, especially of the flower. A summary of this subject will be found in Appendix II.; whereas the first Appendix contains a list of the commoner

technical terms applied to the Higher Plants, including those used or mentioned in this volume.

In the preparation of this volume I have, in addition to new and original observations, drawn freely on many sources of information, which are too numerous to permit of specific mention. I would, however, record my indebtedness to the works of Kerner, Christ, and Schroeter, mentioned in Appendix III.; to various scientific memoirs by Professor Bonnier and other members of the French School of Experimental Alpine Cultivation; and to those of the Swiss School of Ecology, of which Professor Schroeter of Zurich is the head.

I am also indebted to many friends for information, advice, and criticism. To my wife I owe many thanks for the drawings of the text-figures, which are original, except where the contrary is stated in each case, and also for much help in many other directions, including the reading of the proof-sheets. To my friend Mr John Parkin, M.A., of Trinity College, I would express my thanks for much information, and for the value of his co-operation in field work in Switzerland.
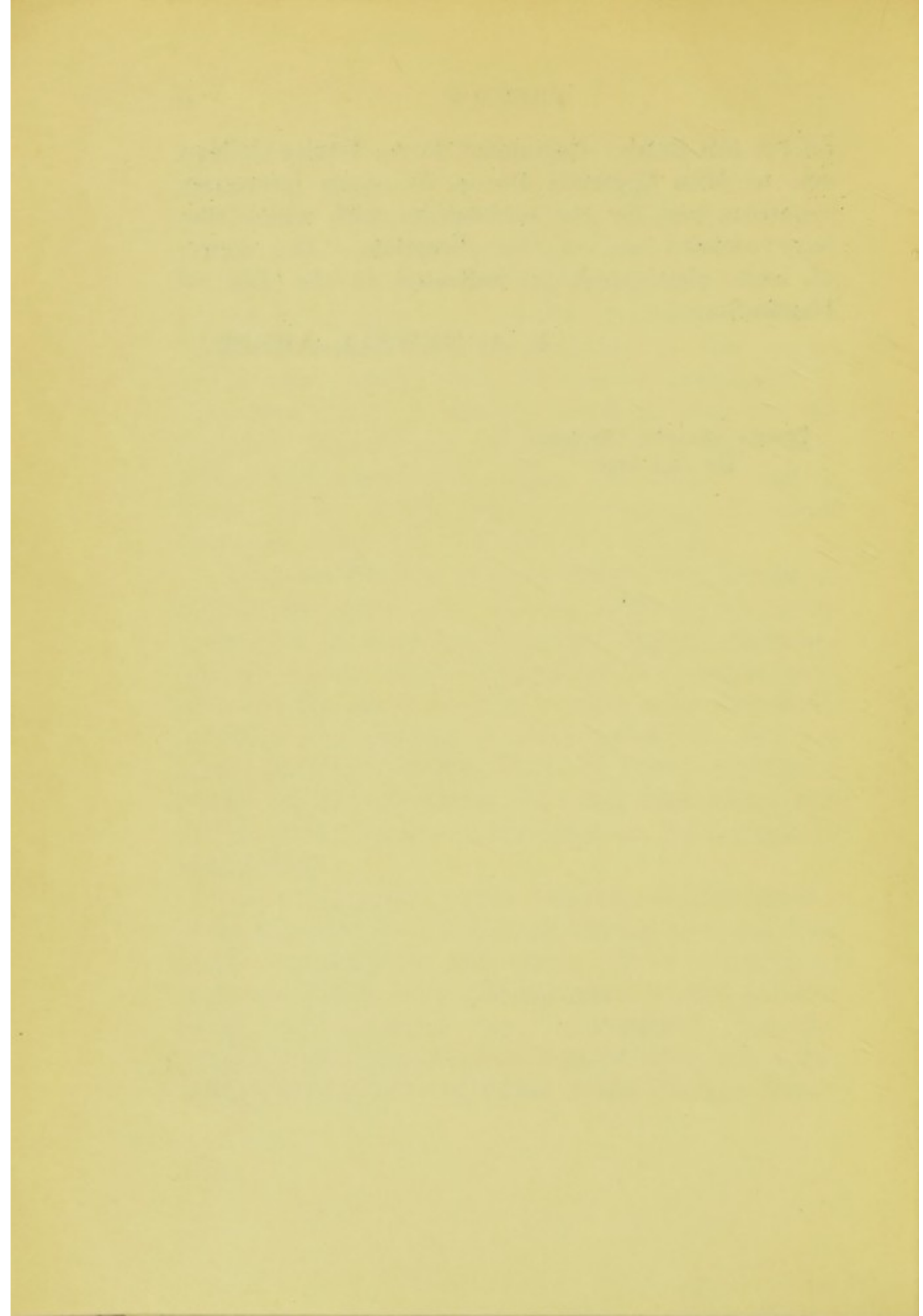
The photographs, which illustrate the letterpress, were all taken in Switzerland during the past four years, expressly for this work. In a majority of cases the plants were photographed *in situ*, and the prints and negatives are "untouched." For the larger number I must plead responsibility, but I am greatly indebted to my friend Major George Dixon

(of the 5th Border Regiment), M.A., Trinity College, and to Miss Gertrude Bacon, for many interesting negatives, and for the enthusiasm with which they have assisted me in this direction. The source of each photograph is indicated in the List of Illustrations.

E. A. NEWELL ARBER.

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CHAPTER I

INTRODUCTORY—SWISS NATIONAL FLOWERS: THE EDELWEISS AND THE ALPENROSES

NOT so very long ago—in fact, within the recollection of many—the object of a botanical study of a region such as Alpine Switzerland was merely to compile a list of the genera and species[1] of plants found within its limits. Such a catalogue, which the botanist terms a *flora*, though a highly necessary preliminary stage in the progress of our knowledge, is now no longer regarded as "the be-all and the end-all" of such enquiries. It is true that by its aid we learn the names of the plants we meet with in our wanderings among the Alps, and how to distinguish them from one another. This being accomplished, we may compare the Alpine flora of one country, such as Switzerland, with that of another, Britain; thus an extremely

[1] See footnote, p. 15.

A

interesting comparison may result. But we may seek to know more of these Alpines than a "flora" can tell us. We have come to recognise that all plants are *living beings* like ourselves, face to face with certain difficulties of existence, such as adverse climatic conditions, and competition with their neighbours. How are they adapted to meet these conditions, and so to survive in the struggle for existence? How are we to explain in these terms the various characteristics of Alpine plants, their similarities and dissimilarities to one another?

It is this newer and wider view of the vegetation of a district such as the Alps which has opened up such an interesting field for study and reflection. We pass beyond the limits of a flora, or catalogue of species, to enquire how these plants *can* live under conditions so dissimilar to those which prevail in Britain, and with which we are more familiar. We may well adopt the attitude of one of the earliest of the great German botanists, Christian Konrad Sprengel, who, in 1793, sought to unravel the origin, meaning, and uses of the various features exhibited by plants, starting with the hypothesis that the wise Author of Nature had not created even a single hair without a definite purpose.[1]

We shall adopt a somewhat similar standpoint

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[1] "Ueberzeugt, dass der weise Urheber der Natur auch nicht ein einziges Härchen ohne eine gewisse Absicht hervorgebracht hat," C. K. Sprengel, *Das Entdeckte Geheimniss der Natur, in Bau und in der Befruchtung der Blumen ;* Berlin, 1793, p. 1.

here. We have still much to learn as regards the life of Swiss Alpine plants. Many of their striking characteristics cannot be satisfactorily explained at present. However, on others we are now beginning to get some light, as the result of scientific enquiries, conducted for the most part within recent years.

In the present chapter we will endeavour to illustrate these principles by reference to some well-known Swiss Alpines. For the moment, however, we may first pause to enquire: What is an Alpine plant? This is a question which it is not possible to answer accurately. The term is an arbitrary one, and, so far as Switzerland is concerned, *an Alpine plant is best defined as one flourishing within the Alpine zone*, another term which itself implies a still more arbitrary distinction.

Switzerland, although a small country, varies greatly as regards altitude. It is well known that as we ascend towards the mountains from the lowlands of northern Switzerland, the flora changes gradually. We can recognise, as we pass upwards, at least three zones, which we may call the Lowland, the Subalpine, and the Alpine. The general character of the flora of each zone is distinct, though the zones merge gradually one into the other, and many plants may occur in two, or even all three, zones. As a rule, however, with several noteworthy exceptions, each plant flourishes abundantly in one particular zone alone, and is only feebly represented in, or even entirely absent from, the others.

The Lowland zone includes the plains and the small hills in the north and west of Switzerland. Its flora is identical, for the most part, with that of temperate Northern and Western Europe, including Britain and much of France and Germany. In some places, however, there is also a very distinct intermixture of southern plants, derived from the subtropical Mediterranean flora lying to the south of the great mountain chain of Central Europe, of which the Swiss Alps form only one link. Such an intermixture even exists in Britain, for a few plants, especially certain Heaths, also belong to the Mediterranean flora, and there has been much speculation as to how they managed to reach Britain.

In Switzerland, the Lowland zone is essentially the zone of the Vine, and it extends upwards to an altitude of 3,000 to 3,500 feet, above which grapes will not, as a rule, ripen.

The next zone, the Subalpine, reaches to about 5,000 feet, the exact height varying locally according to the physical conditions, such as exposure, situation, etc. Beech forests are the great natural feature of this zone. Many Lowland plants can still flourish at this altitude, and members of the Alpine flora creep downwards, so that the vegetation of the Subalpine zone is largely a mixture of species found also in the zone above, and in that below. In no case is there any sudden change in the flora as we pass from one zone to another—merely a gradual transition. A large number of Lowland plants become less

and less frequent as we pass upwards, and the Alpine species, little by little, become more numerous and important as characteristic features of the flora.

A few species are confined to the Subalpine region, just as some Lowland plants do not extend beyond their particular zone; but these are not sufficiently numerous to characterise the region in which they occur.

The *Alpine zone* will here be regarded as beginning roughly at a height of 5,000 feet. At this elevation the Beech, as a rule, ceases to flourish, and coniferous forests of Spruce, Pine, and Larch replace it and become important landmarks as regards scenery and vegetation. It is the plants growing above this altitude which we shall term Alpine plants, and with these alone we are concerned in this volume.

As we have already indicated, all zonal limits are purely arbitrary, owing to the exceedingly gradual nature of the change in the vegetation as we ascend the Alps. This is well illustrated by the fact that almost all the botanists who have attempted to define the Alpine zone within rigid limits, have arrived at totally different conclusions. Thus a great Swiss authority, Dr Christ, distinguishes the region above the limit of the Pine and Larch forests as the Alpine zone—a region which begins at more than 1,000 feet above that here adopted. The late Mr John Ball, another authority, divides the whole of Switzerland into two

zones : a lower, extending to the limit of deciduous [1] trees ; and an upper, including all above this limit, except a glacial region, where the soil is only free from snow for two or three months in summer. This Glacial or High Alpine region may well be distinguished as a separate zone.

Prof. Schroeter has recently published a comparative table showing how no less than twenty-five botanists, between 1808 and 1904, have attempted to subdivide Swiss vegetation in regard to altitude. No two schemes agree even remotely ; and this diversity of opinion well illustrates the impossibility of attempting to define zones of altitude at all rigidly in regard to vegetation.

The altitude of 5,000 feet, which we will, then, take as the mean lower limit of the Alpine zone for Switzerland generally, is as natural a dividing line as can be found. Not only does it indicate the average lower limit of the Coniferous forests, but at this height all the physical conditions which we term Alpine—such as shortness of the flowering season and intensity of the illumination—are typically in force. Further, the majority of the plants flourishing at or above this elevation, possess all those peculiarities of architecture, or, as the botanist terms it, " habit," which we associate especially with Alpine plants. Biologically, then, these plants are Alpine, as well as by

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[1] Trees which shed their leaves in autumn. For this and other technical terms, see Appendix I., p. 307. The Conifers, except the Larch, are all evergreen.

elevation, even if we restrict the High Alpine or so-called Glacial plants to a separate category. Many of the latter, as we shall see in a later chapter, exhibit the same peculiarities, though in a more marked degree.

The gradual nature of the change in the vegetation as we pass upwards from the Alpine to the High Alpine region is usually better realised nowadays, than the changes from the Lowland to the Subalpine and the Subalpine to the Alpine zones. In these days of mountain railways, when most travellers reach the Alpine zone by train, the transitions between the lower zones are apt to be overlooked. The slow journey on foot, still happily necessary to reach the High Alpine region, offers a far better chance of study and reflection on this point. It is thus worth while to those botanically inclined, for once at any rate, to pass leisurely, on foot, from the lowlands to the Alpine zone, as, for instance, along the Rhone valley and up either the Zermatt or Saas Thal. In this way we shall have an excellent opportunity of studying the gradual nature of the change as we ascend.

It may be here mentioned, perhaps, that care should be taken in regard to altitude in selecting a Swiss centre for botanical explorations. The great majority of Swiss health resorts [1] do not lie within the Alpine zone. Grindelwald, Caux, and Chamonix (Savoy), for instance, are 1,500 feet too low. The

[1] A list of Swiss resorts, classified according to altitude, is given in the introduction to Baedeker's *Switzerland*.

higher the centre chosen, the more interesting the flora.

With regard to the number of species of Flowering Plants (Angiosperms) found within the Alpine zone, estimates naturally vary. Ball calculated that in the Alpine region of the whole chain of the Alps, 1,117 species are found, belonging to 279 genera and 60 natural orders. In the corresponding zone of the Swiss Alps, I estimate the number of species as about 900 out of a total of 2,350 Swiss Angiosperms. Of these, some 300 are confined entirely to the Alpine zone, while roughly 250 are also lowland plants, and in many cases members of the British flora. The rest occur both in the Alpine and Subalpine regions.

We now pass to some consideration of the difficulties which a plant has to overcome in order to survive the rigours of an Alpine climate. If we are to understand and appreciate these difficulties, we must arrive at some clear conception of the internal economy of the plant itself. The plant has two duties to perform. A duty to itself, to maintain its own existence, and a duty to the next generation —reproduction. We will now briefly discuss the first of these.

The plant is a living being which may be likened to a complicated steam engine or other piece of machinery in motion. It is fashioned for one end alone—the existence of the species. All plants are built up of an enormous number of very small units, termed *cells*. The cells differ very much in form,

substance, etc., and may be either living or dead. All *living cells* contain that mysterious and complex substance known as *protoplasm*, which is the seat of vitality and of all the vital processes, such as growth. The protoplasm of one cell is in communication with that of the cells which surround it. Thus the whole plant is really a mass of protoplasm, divided up into minute compartments by *cell walls*, through which, however, it is continuous from cell to cell.

Protoplasm is a very unstable substance. It is constantly in a state of flux, some parts being built up into other substances and others broken down. It is on this fact that vitality depends.

We have therefore in each cell a machine capable of building up and breaking down, not only substances derived from without, but its own substance. In order that this machinery may work, it requires food —that is, raw material from which to manufacture a finished product.

Both in animals and plants, the food necessity is ever present, but plants obtain their food in quite a different way to animals. Animals can make use of substances of an extremely complex chemical nature, built up chiefly of the elements carbon, hydrogen, oxygen, and nitrogen.

On the other hand, the plant makes use of relatively simple substances. The food of the green plants is obtained partly from the atmosphere by means of the leaves, and partly from the soil by the roots. Whereas the Higher Animals have the power of locomotion,

and live in a single medium, the atmosphere, or in water, most of the Higher Plants are fixed, and live partly in the soil (or in water) and partly in the atmosphere. The roots buried in the soil absorb water and certain essential mineral salts, especially those of nitrogen, but not of carbon. These raw materials are passed on to the protoplasmic machinery from cell to cell. This function is known as *absorption*.

On the other hand, the leaves perform the function known as *assimilation*. They can withdraw carbon dioxide from the atmosphere. This gas passes through into the leaf by means of numerous minute pores, which the botanist terms *stomata*. This simple raw food material, with the addition of water derived from the soil by means of the roots, is first of all converted into a complex substance, such as sugar, by the aid of the special portions of the protoplasm of the leaf, which contain the green colouring matter known as *chlorophyll*. It is the chlorophyll which gives the green coloration to the majority of plants. Chlorophyll is able, in the presence of light and other favourable physical conditions, to absorb energy, which gives it the power to convert the simple gases of the atmosphere into complex sugars, which are passed on in turn to the protoplasm of the growing cells.

The protoplasm thus receives, and incorporates into its own substance, raw food material from two sources: the atmosphere, which supplies the carbon

compounds ; and the soil or water, which furnishes the other elements. The raw food material is converted into complex substances by the protoplasm itself, and these are made use of for growth, reproduction, and other vital processes. It is, in fact, the coal which keeps the machinery in motion.

Now, if the roots of an Alpine plant are buried in a frozen soil, one source of food-supply is, for a time at least, cut off, and the plant must depend on such reserves of water and mineral salts as it has in hand. On the other hand, the leaves, if covered with snow, are in darkness, and cannot assimilate, and here another source of raw material fails for a time. Plants can, however, by storing up reserves, survive for a long period, during which both sources of food-supply are cut off; but if this period is unduly prolonged for any reason, the plant, having used up all its reserves, may die, for the machinery can no longer continue in motion.

In plants, then, as in animals, food is essential to the life of the protoplasm, and is *built up* into its substance to form new protoplasm. On the other hand, protoplasm being unstable, is constantly *breaking down*, and the simpler substances which result are returned to the atmosphere. In man and all the higher animals, and also in plants, there is a twofold exchange with the atmosphere. Man breathes by means of his lungs—that is to say, he is constantly exhaling carbon dioxide and water vapour, and inhaling oxygen—a process known as *respiration*. If animals

alone existed on the earth, all the oxygen in the atmosphere[1] would have been long ago exhausted and replaced by carbon dioxide. But the whole economy of nature depends on the fact that in plants the process, in the main, is just the reverse. It is true that plants respire exactly like animals, absorbing oxygen and giving off carbon dioxide; but in the case of a green plant, we can only detect this process in the dark. This is because, in the presence of sunlight, it is masked by the opposite, and far more vigorous, process of assimilation, in which oxygen is given out and carbon dioxide absorbed.

One further essential function of plants remains to be discussed. All plants immersed in the atmosphere are constantly losing water by evaporation—a loss which has to be made good by absorption from the soil by means of the roots. This process is known as *transpiration*. It is not simply due to evaporation, but is controlled by, and intimately connected with, the vital processes of the plant.

With Alpine plants the tendency to excessive transpiration in summer is very marked, owing to the high day temperature and the dryness of the atmosphere. The water vapour passes out through the pores or stomata which occur on the leaf (Plate XXIX., Fig. 1) and sometimes on the stem and flowers also. Consequently we shall find in many

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[1] The atmosphere consists approximately of 23 parts by weight of oxygen and 77 parts of nitrogen and a very small quantity of carbon dioxide, about 3 to 6 parts in 10,000 measures.

Alpine plants special protections in connection with these organs, in order to guard against excessive transpiration.

Such briefly are the vital functions which the plant has to perform to fulfil its duty to itself—the maintenance of its own existence. We shall find that many of the peculiarities of Alpine plants are to be explained as special adaptations, in order to ensure that these functions shall not be interfered with by the influence of the severe climatic conditions, which the plant has to face. Unless we have some comprehension of the vital processes of Alpine plants, we shall naturally not possess the key to an understanding of many of the peculiarities of habit which they present, and thus it has seemed well to enter here, at the outset, into these matters somewhat at length.

The plant has also a second duty : the production of offspring. The means by which this is effected are more generally understood, and need only a passing reference here. In the plants which stand highest of all in a botanical sense, the Flowering Plants (Angiosperms), with which we are here alone concerned, the essential features of the flowers, are as follows.

The male organs—*stamens*—produce the *pollen* grains, which in turn furnish sperms, which fertilise the eggs contained in the *ovules*. The ovules are borne by and enclosed in modified leaves termed *carpels*. Both the male and female organs may be found in the same flower, or in separate unisexual

flowers, borne either on one plant or on two different plants. In a very large number of cases, the male and female organs, especially where they occur in the same flower (the so-called *hermaphrodite* flowers), are enclosed in a floral envelope or *perianth*, often differentiated into an outer series, the *calyx*, composed of *sepals*, and an inner series, the *corolla*, composed of *petals*. The floral envelope may, however, be very poorly developed in some flowers. It plays many different parts in various plants, as we shall see. It serves partly to protect the young developing sexual organs in the unopened flower-bud, and in many cases it also furnishes a conspicuous advertisement for the allurement of insects, which carry the pollen of one plant to the female organs of another, and so effect cross-pollination.[1]

It will be our object in the present volume to bear constantly in mind the influence of the severe climatic conditions of the Alpine world on the vital processes of the plant, both those relating to existence and to reproduction. We shall find that many of the peculiarities of Alpines are alone intelligible from this, the biological standpoint, which is entirely different from that of the systematic or descriptive Botanist.

We may illustrate these principles by reference to the two national flowers of Switzerland : the Edelweiss and the Alpenroses. Both will be found to show interesting adaptations to their special surroundings.

[1] Further information on the structure of the flower will be found in Appendix II.

THE EDELWEISS.

The Edelweiss, *Leontopodium alpinum*, Cass.[1] (natural order Compositæ, the Daisy family), Plate I., Fig. 1, about which so much romance has been woven, and which is commonly believed to grow only in situations almost unapproachable even to the most hardy mountaineer, must be pronounced a complete fraud in this respect. Scarcely a year passes but one hears of some fatal accident as an unnecessary corollary to the desire to gather this plant. Yet every season huge masses of Edelweiss, which must approach to tons in the aggregate, are gathered by the Swiss peasants, or even grown in the lowlands of northern Switzerland, for sale to the tourist. This sale, I suspect, is a ready one, not so much because of the interesting and unusual appearance of the plant itself, as because of its reputed associations.

Yet the Edelweiss is not a rare plant. It might almost be called common. Those who have really

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[1] Every plant has a Latin Christian name and Surname. The Surname, or generic name, indicates the *genus* to which the plant belongs, and the Christian name is the specific name, or name of the *species*. The latter is regarded as an adjective, and is placed after the noun, the generic name, the customary order in the Latin tongue. Thus *Bellis perennis*, the Common Daisy, is a member of the genus *Bellis*, and the particular species, *perennis*. The name should always be written : *Bellis perennis*, Linn. Linn. is a contraction for Linnæus, the name of the botanist who founded the species, and who is called the " authority " for the name. The necessity for quoting the authority arises from the fact that in many cases the same plant has been described by two botanists quite independently under different names, the oldest or first description being regarded as alone valid.

interested themselves in Alpine plants are aware that
it can often be gathered near many of the Alpine
centres without the trouble of forsaking a well-
made path. This is true, for instance, of some of
the hills above Zermatt and Saas. Yet if we were
to set forth in order to collect this plant, our chances
of coming across it would usually be quite small, unless
we were guided by the experience of others.[1] The
explanation is that the Edelweiss, while not a rare
plant, is exceedingly local in its distribution. It
does frequently occur among the most inaccessible
of crags, but even there it is often not to be seen.
On the other hand, it will sometimes cover a stony,
dry, almost level alp by the acre. Why its distribution
should be so local is a question which cannot be fully
answered at present. The fact remains that it is
usually restricted to the driest of situations in which
plants can flourish. Many other Alpines, such as
the Saxifrages, cling to the crevices of a cliff, but
these nearly all require some degree of moisture in
the scanty soil, or some situation well exposed to the
weather. Where the conditions are such that a
minimum degree of moisture is alone available, there
the Edelweiss will outstrip its competitors, and succeed
in the struggle for existence. Where it occurs in
surroundings in which other plants can flourish, there
it must compete against them for a bare livelihood.
Thus, as a rule, Edelweiss is restricted to the

[1] Edelweiss is usually to be found in one or more localities near all
the great Alpine centres of Switzerland in the month of August.

PLATE I.
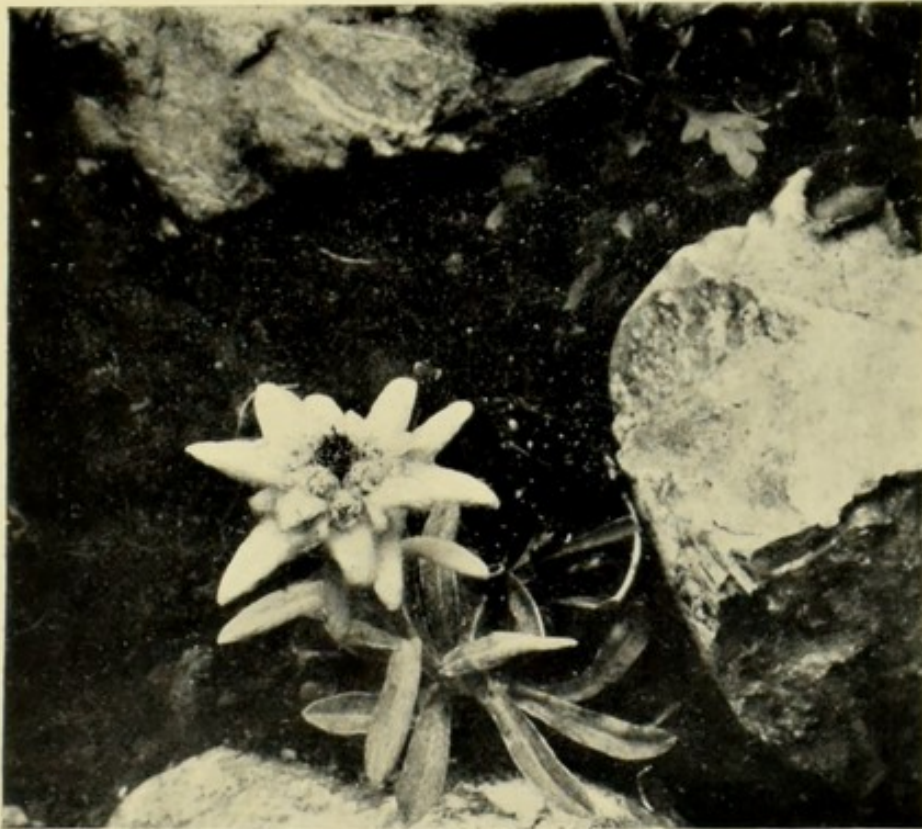
Fig. 1.—The Edelweiss (*Leontopodium alpinum*, Cass.).

Fig. 2.—The Alpine Rose (*Rosa alpina*, Linn.).
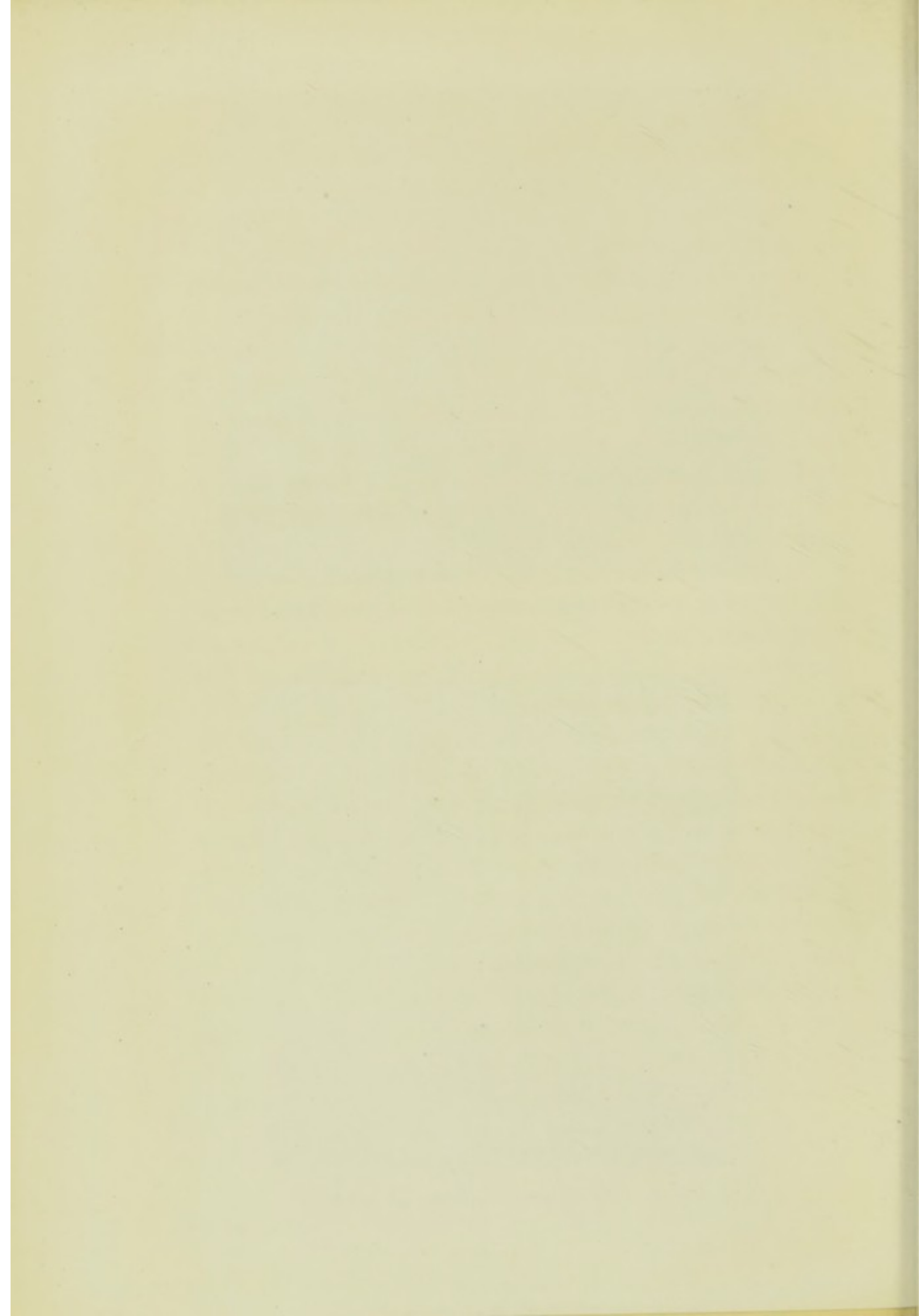
driest and barest rocks, barren of other plants ; and since such localities are relatively infrequent, the Edelweiss is a local plant, though often exceedingly abundant where it does occur. On the other hand, in places where the circumstances that prevail appear to be in every way adapted to its needs, the Edelweiss is often conspicuous by its absence.

Thus the sentimental value of the Edelweiss does not really depend so much on its rarity or difficulty of collection, as on the fact that the localities in which it grows are comparatively few and far between. It is one of the most local of Alpine flowers, a fact in itself of great botanical interest.

The Edelweiss is not a British plant, and the name, though by now almost completely anglicised, is a combination of two German words : edel = precious and weiss = white.[1] So we see that romance is bound up in the very name itself.

Let us now examine the features of this plant which give rise to the idea of whiteness. If we study a specimen with a hand-lens, we shall find it is covered, completely and thickly, with long, woolly hairs. These hairs consist of empty cells. It is one of the properties of light, that when it falls on innumerable, minute, transparent particles, we receive the impression which we term white. A good and well-known example is the foam of waves breaking on the sea-shore. Water itself is colourless, but when it is broken up into small particles or bubbles, as

[1] *Cf.* the German Edelstein = precious stone.

in the case of sea foam, our eyes experience the sensation which we call whiteness. The hair cells of the Edelweiss produce a similar effect.

The Higher Plants have, as a rule, green leaves and often green stems, and this is true also of the Edelweiss, but the green colour is here masked by the coat of hairs.

The leaves of the Edelweiss, like those of many other Alpines, are arranged in a small rosette just above the soil. A single stalk springs from the leaves bearing what, at first sight, appears to be a solitary flower, but which in reality is a very complicated structure consisting of several flower-heads, each with a large number of individual flowers. It is one of the peculiarities of the order Compositæ to which the Edelweiss belongs, that the flowers should be all massed together into one or more heads. The single heads of a Daisy or a Sunflower, for instance, are not flowers, but collections of a large number of flowers, seated on a broad receptacle. If we cut one of these heads through with a pocket-knife lengthwise, we can see the receptacle, and also separate the individual flowers from one another.[1]

At the same time, the head performs all the functions of a single flower, and is in itself an adaptation designed for that very purpose. In the Edelweiss, however, the heads are very small and yellowish in colour, and, further, they are grouped together into

[1] For a full account of the head of a Composite, see Appendix II., p. 330.

what appears at first sight to be a single head. Thus, what is apparently a single flower is really a very complicated structure. There is a large central head, composed of many flowers and equivalent to the inflorescence of a Daisy or a Sunflower, surrounded by a varying number, usually five, of other smaller heads, the whole being wrapped round by woolly leaves which are called *bracts*. These bracts are the conspicuous part of the so-called Edelweiss "flower."

But to return to the woolly coat : What is the purpose of this adaptation ? Why is it present in this plant and not in others ?

It must be remembered that the Edelweiss usually flourishes in very dry situations, where there is comparatively little moisture in the soil. In this respect it is like a plant growing in a desert. Consequently it has to husband such water as it can absorb from the soil by means of its roots with the greatest care. Were it to transpire rapidly (see p. 12)—*i.e.*, give off water-vapour—the supply would run short, and the stream of water passing from the soil to the atmosphere, by means of the root, stem, and leaves, would soon cease. Thus some contrivance must be arrived at, which will prevent an undue loss of water from the surface of the plant by evaporation. The hairy coat is this contrivance, and therein lies the great point of botanical interest presented by this plant. The fact that, not only the leaves, but the head-stalk, and even the heads of flowers, all of

which can transpire in some degree, are also clothed with a coat of hairs, shows how necessary it is to stop every leak from which water might evaporate.

A nearly parallel effect would be arrived at by wrapping the plant in cotton-wool. The air entangled in the meshes of the wool, or, in the case of the Edelweiss, between the matted hairs, checks excessive transpiration, the passage of the water-vapour being hindered. Transpiration, or loss of moisture, must of course go on to some extent, but the necessity in this and other plants, growing under very dry or desert conditions, is to check *excessive* transpiration. Among plants growing under these conditions, many different means are found by which this end is attained. In the Edelweiss it is effected by the covering of hairs, whereas in the Alpenrose, where the same necessity exists, though in a much less marked degree, the nature of the adaptation is entirely distinct.

The Edelweiss is found widely distributed in the mountains of Southern Europe, not only in the Alps, but in the Pyrenees, the Tyrol, and the Carpathians. It is also abundant in India in the Himalayas. It is a small genus of some six species, all essentially Alpine plants, though closely related to the Cudweeds (*Gnaphalium*) of the plains of Europe. Other species of Edelweiss are found in Japan, Bolivia, Tasmania, and Northern Asia, so that the genus *Leontopodium* is widely distributed.

Before leaving the Edelweiss, we may briefly notice

PLATE II.

The Common Alpenrose (*Rhododendron ferrugineum*, Linn.).
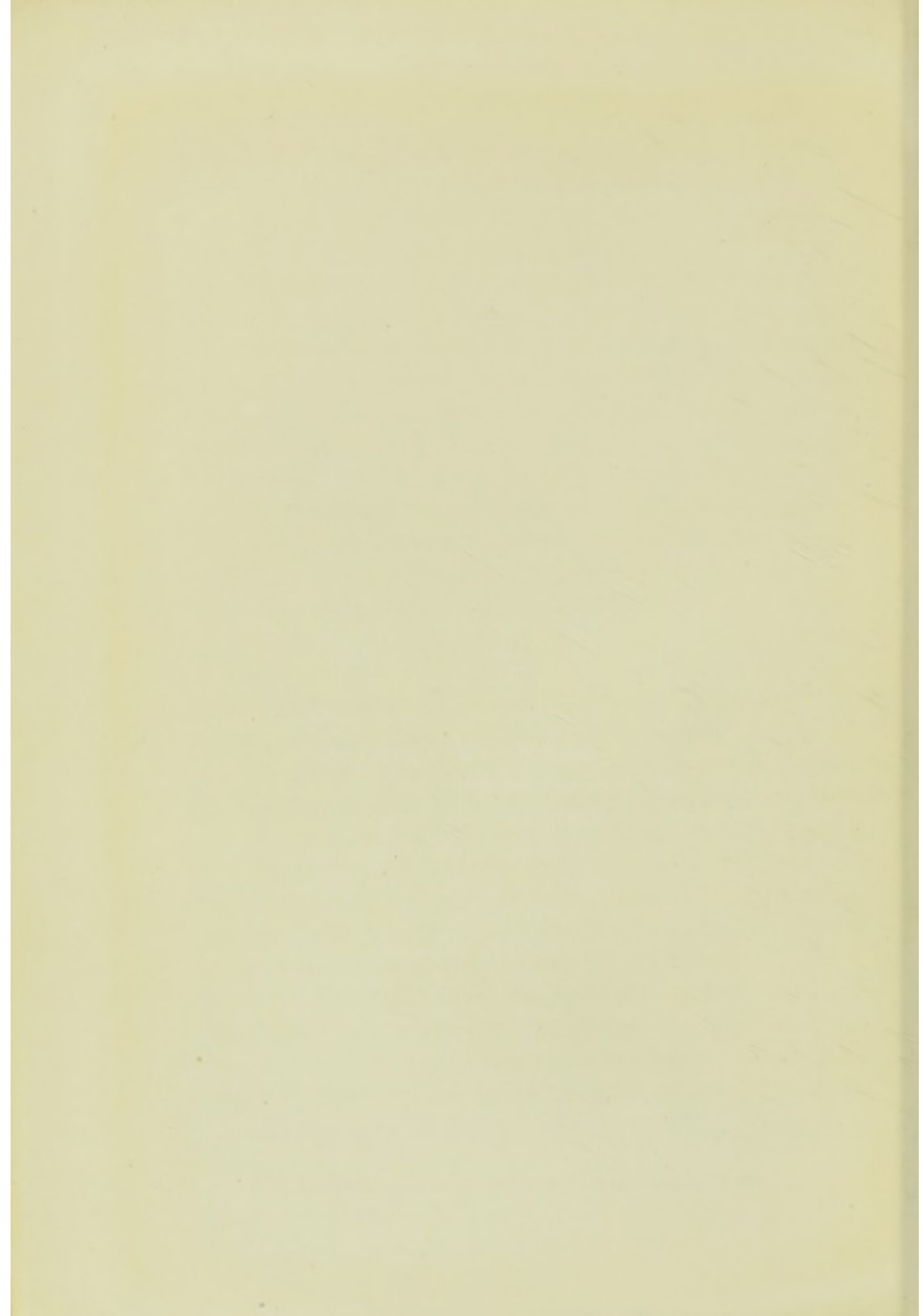
two more of its near relatives—the Everlastings, belonging to the same order—which are much more frequent in the Alps. One of these, *Antennaria dioica*, Gärtn., with white or rose-coloured heads, is fairly common with us in Britain. The other, *Antennaria carpathica*, Bl. and Fing., is a High Alpine, and has brownish heads. Both have a similar cottony coat to that of the Edelweiss, though shorter, but the woolly bracts surrounding the flower-heads, which are so prominent in the case of the latter, are very much smaller and less conspicuous.

They grow in dry, stony places, and, as in the case already discussed, their cottony coats prevent excessive loss of moisture.

The Alpenroses.

The Alpenroses, of which there are two—the Common Alpenrose, *Rhododendron ferrugineum*, Linn., and the Hairy Alpenrose, *R. hirsutum*, Linn. (natural order Ericaceæ, the Heath family)—are, equally with the Edelweiss, national flowers in Switzerland.

They are, however, very much more abundant and more easily obtained, and so are more in evidence as personal decorations, on the not-infrequent occasions on which the Swiss peasants make sport or holiday. In the little hamlet of Sils, in the Engadine, an excellent botanical centre, there are two rival inns : the Edelweiss and the Alpenrose. Both names are frequently used to designate hotels all over Switzer-

land, and possibly in other villages they may be found in as close proximity as at Sils.

The Alpenrose, it may be said at once, is merely a small-flowered *Rhododendron*, of blood relationship to the Rhododendrons and Azaleas of our English gardens, many of which were derived originally from the mountainous regions of India, especially the Himalayas. The genus is a large one, but does not occur in Britain, unless we include in it *Loiseleuria procumbens*, Linn., the Trailing Azalea.

The word Rhododendron is derived from two Greek words, signifying respectively a rose and a tree. For the Swiss species, however, the name "alpenrose" has become almost completely anglicised. At the same time, some confusion appears to exist on this point. It is often spelt or pronounced as if it were two separate words : Alpine Rose. This is a common error, and regrettable because there is in Switzerland a true Alpine Rose (*Rosa alpina*, Linn.), Plate I., Fig. 2, which flourishes commonly in shrubby places in the pastures, in much the same situations as some of our wild roses in Britain.

The true Alpine Rose is, moreover, interesting botanically as being "a rose without a thorn," since prickles are often absent from the upper part of the stems and from the leaves, though they may frequently occur near the base of the plant. Occasionally the whole shrub is well armed with thorns or prickles.

On the other hand, the single German word Alpenrose, means the "rose of the pastures." The term

alp[1] is used by the Swiss in a very definite sense, and the *alpen*, or *pastures*, are not only of great economic importance to this essentially pastoral people, but are actually owned by them in common. The alpen high above the valley (Plate III.) are the mountain pastures, which provide food for the cows during the height of summer. The word forms part of the names of such well-known Swiss resorts as the Bel Alp, the Riffelalp, both of which were originally, and are still largely, places to which the cattle migrate in search of grazing-ground in summer-time.

In Switzerland the commune is a highly developed and ancient institution, and each commune usually owns one or more alps, in the sense that its burghers have the freeborn right of pasturing their cows on certain *alpen*. Whereas in the villages the meadows are for the most part private property, the pastures, or alpen, are held in common by the inhabitants. In the spring and summer, the hay growing in the meadows is far too valuable to become the immediate fodder for the cattle, for it has to be carefully cultivated and stored up to feed them during the long winter months. Thus in summer-time the cattle belonging to the commune are sent to the pastures high up in the hills, and these are only occasionally cut with the scythe, and then late in autumn. As the summer passes, the cattle climb higher and higher from alp to alp in search of a fresh food-supply. The milk is also made into cheese in the far-away chalets perched

[1] The term "The Alps," is also derived from this word.

up on the mountain-side, where those in charge of the cows are often completely isolated for weeks from the world : so much so, that in many valleys the church bells of the principal villages are rung at twelve noon each day, to pass the time to those of the distant alpen. This is the case, for instance, at Davos Platz, where in addition the bells of St Johann Kirche are rung on Saturday evening, usually about six o'clock, to warn those on the mountains of the approach of the Sabbath.

We have dwelt on the alpen, or pastures, at some length here, for it is essential that they should be clearly distinguished from the valley meadows, cut regularly with the scythe, usually three times during the summer months. The pastures are in many respects as distinct botanically from the meadows as they are often far away from them. In the following chapters we shall discuss some of the typical Alpines of the pastures and the meadows.

With this digression we must now return to our Alpenroses. They are evergreen shrubs, two, three, or more feet in height, often occurring in great abundance in the higher pastures, among the Alpine thickets, in or on the borders of the forests, especially where they fringe the margins of the Alpine lakes. Of the two species, the Common Alpenrose, *Rhododendron ferrugineum*, Linn. (Plate II.), is by far the most abundant in Switzerland. It is easily recognised by the fact that the under-sides of the *older* leaves exhibit a rusty-brown appearance, though the

PLATE III.
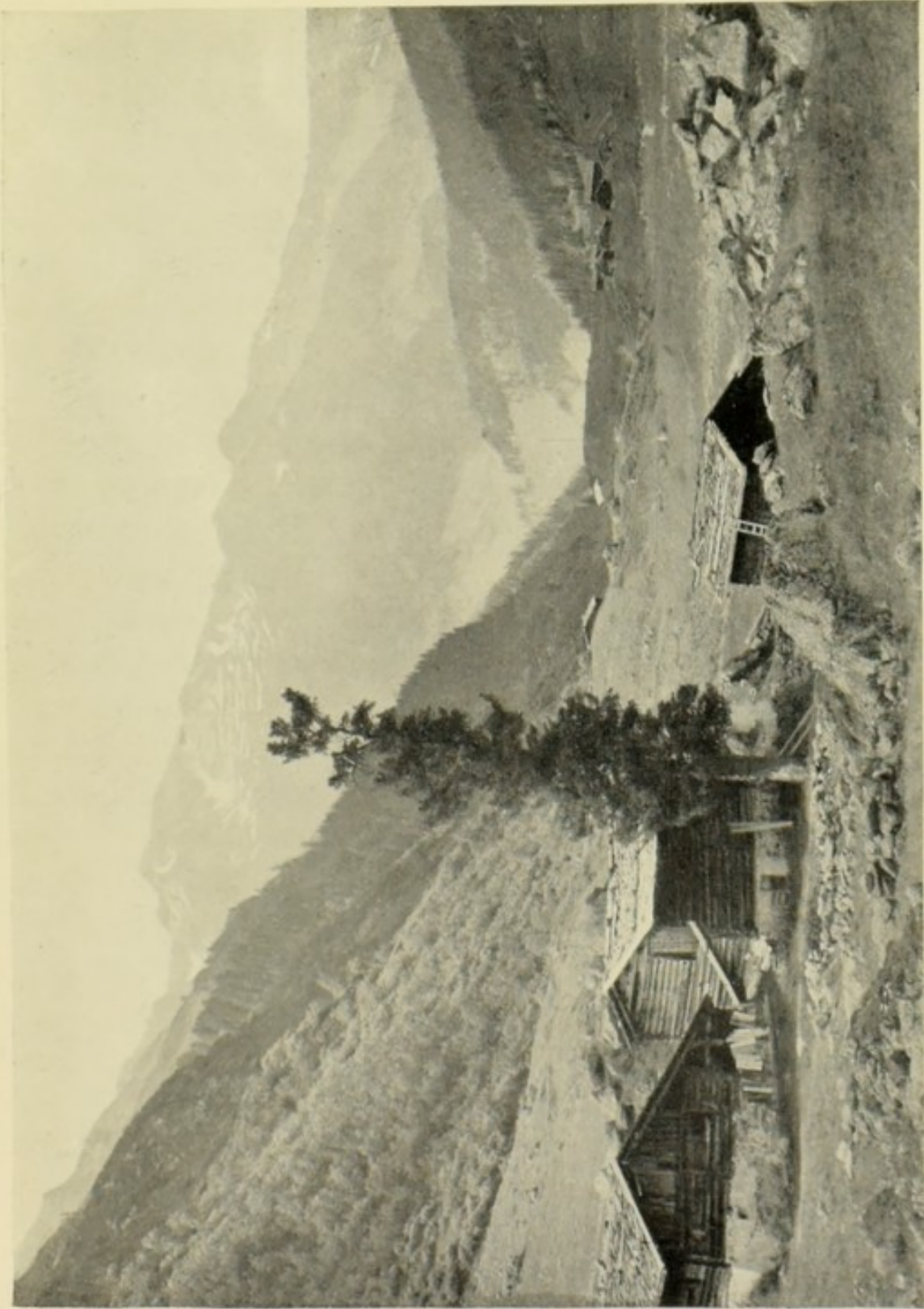
A Typical Alp or Mountain Pasture, with the Stone Pine (*Pinus cembra*, Linn.) in the Foreground (6,300 feet).

[*To face p.* 24.
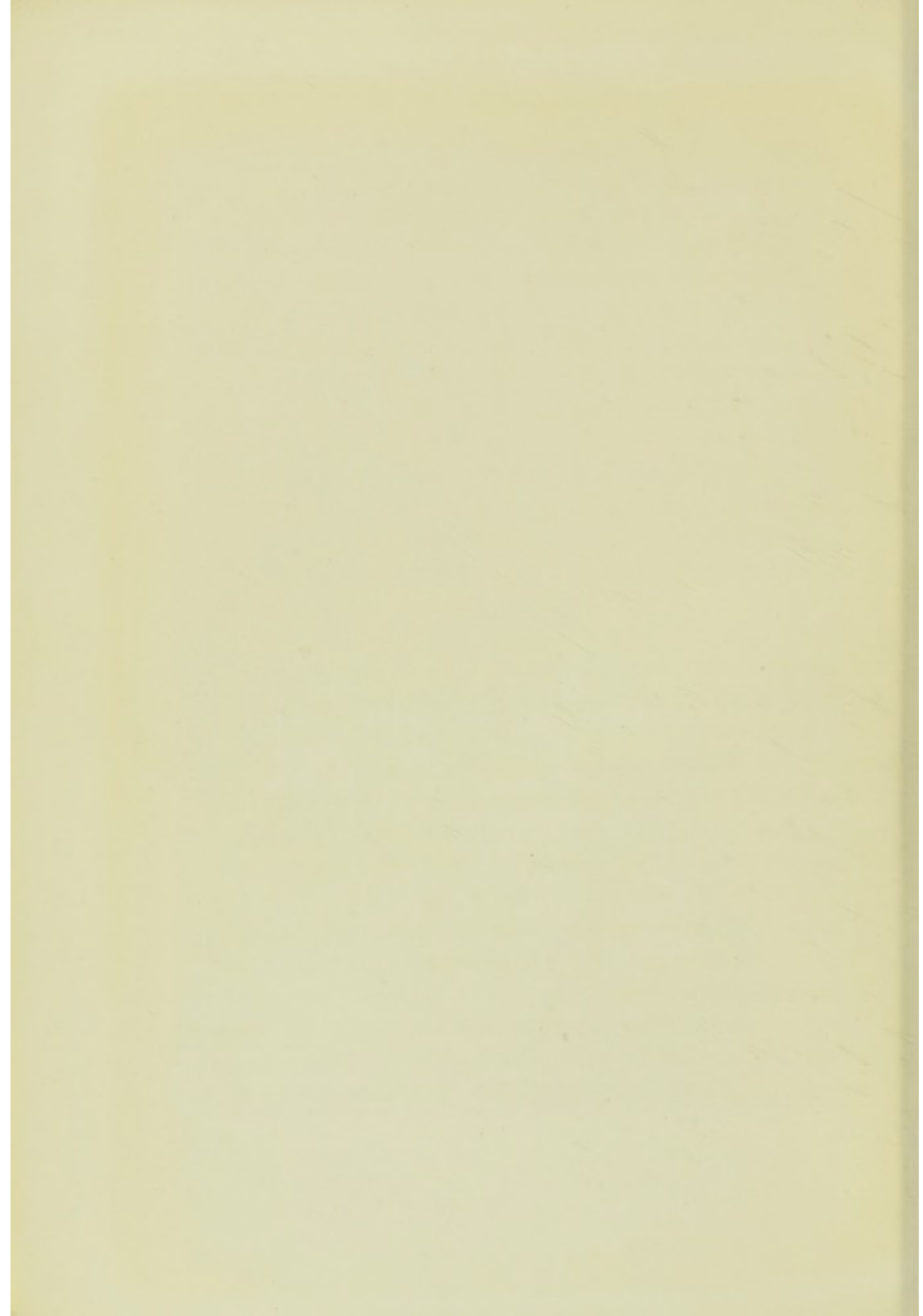
new leaves of the current year at the tips of the branches are green beneath. There are also no hairs in this species on the edges of the leaf.

The Hairy Alpenrose, *Rhododendron hirsutum*, Linn., is more common on limestone soils. At one time it was believed to be entirely confined to calcareous rocks, but it is now known that this is not the case (p. 117). This shrub is very similar in appearance to the Common Alpenrose, but all the leaves are green beneath, and are fringed with hairs along their margins. In both, the numerous stem branches are bare of leaves except near the tips.

There is nothing of much interest to add as regards the flowers of the Alpenroses. But the leaves of both species are specially protected, as in the case of the Edelweiss, against excessive evaporation (transpiration; see p. 12), though here in quite a different way and in a less marked degree. The leaves of all members of the Heath family (Ericaceæ) are evergreen—that is to say, they are not all shed at once in autumn, but new leaves gradually replace the old ones, which last in the case of the Alpenroses from three to four years, so that the shrubs are never leafless even in winter. The great majority also show some adaptation against excessive transpiration, though form of the adaptation varies greatly in different cases.

In the Common Alpenrose the rusty-brown colour of the under-side of the older leaves is the outward and visible sign of the means whereby excessive

evaporation is prevented. In the Hairy Alpenrose a precisely similar arrangement is met with : only, the older leaves do not turn brown below.

If we were to examine such a leaf carefully under a microscope, by means of thin sections cut with a razor, we should find that the lower surface is covered with a number of green or rusty brown coloured
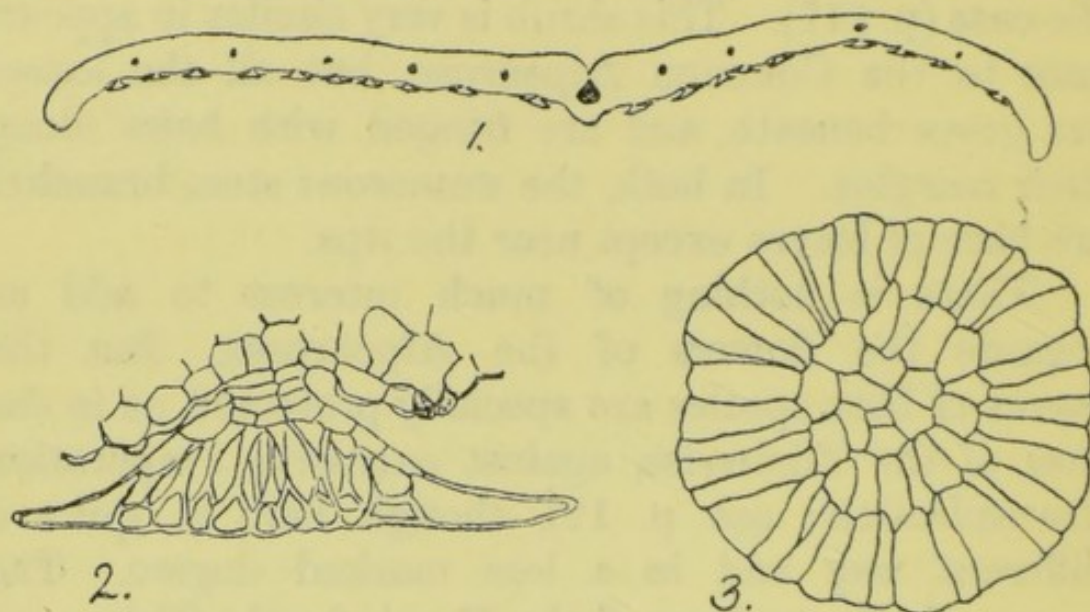
FIG. I.—The Leaf and Scales of the Common Alpenrose
(*Rhododendron ferrugineum*, Linn.).

1. Transverse section of a leaf, showing the scales on the lower surface. Magnified 14 times.
2. Transverse section through a scale, on the right side of which a stoma is seen sheltered by the scale. Magnified 190 times.
3. Surface view of a scale. Magnified 190 times.

scales. Text-fig. I., 1, shows a transverse section of a leaf and the scales below. In Text-fig. I., 2, we see a scale cut in transverse section, on the right-hand side of which a pore, or stoma, is seen sheltered by the scale. In Text-fig. I., 3, the surface view of the scale is depicted. The scales are broad, flat structures

attached to the leaf by a very short stalk. In the Common Alpenrose the lower surface of the leaf is thickly studded with these scales, while in the Hairy Alpenrose the scales are relatively fewer, and are always green in colour.

The function of the scales is to protect the pores, or stomata, which are confined to the lower surface of the leaf. In this way, the danger of excessive loss of water by evaporation from the leaves through the pores is decreased. The adaptation, though entirely different in form, is thus fashioned to the same end as that which we have just discussed in the case of the Edelweiss. It is also much less marked than in the latter, the different conditions under which the two plants grow being sufficient to account for the dissimilarities observed. Thus the Edelweiss and Alpenroses furnish excellent illustrations of how Nature attains her ends by different means.

CHAPTER II

TYPICAL FLOWERS OF THE ALPINE PASTURES—THE ANEMONES AND GENTIANS

"WHAT is the best time of year to visit the Alps in order to see the Alpine flora at its best?" is a question frequently asked. The answer is : The period of late spring and early summer, *i.e.*, from the middle of June to the middle of July, preferably the last two weeks of June. The early spring flowers begin to appear at the end of April and during May, the precise date varying somewhat with the particular season, and depending on the depth of winter snow and the period at which the spring thaw begins in earnest. These are among the most beautiful of Alpine plants, and well repay an early visit. But in June many of them may still be found in flower in the higher pastures at a height of from 6,000 to 8,000 feet and upwards. At this time of year also the fruits of the early spring species are often mature, and in many cases are interesting objects of study, too frequently neglected.

Again, at the end of June, the Alpine meadows,

with their beautiful flora, quite distinct as a whole from that of the pastures, are ripe for the scythe, though as yet uncut. Once the meadows have yielded their first crop of hay, which is usually the case early in July, or even in June, one of the great floral beauties of the Alpine valleys has for a time departed. By the end of July, and in early August, though a few summer plants such as the Pinks are now in flower, the height of the flowering season is over.

A good illustration is furnished by the Riffelberg, above Zermatt, which is almost entirely bare of blossom by the end of July, when the annual stream of summer visitors commences. Yet in June it is famous as possessing one of the richest and most varied floras in the Alps, and especially for certain plants which are rare elsewhere. On the other hand, the High Alpine region of the Gorner Grat (3,000 feet above the Riffelalp) is often by the end of July nearly free from snow, and furnishes an excellent collecting ground rich in the dwarf plants of the High Alpine zone.

It is perhaps unnecessary to add that everything is in the favour of a visitor in early summer. Greater comfort in travelling and in hotels, as well as less intense midday temperature, contribute to the enjoyment of "the season" for Alpine plants.

One of the great peculiarities of the Alpine flora is the tendency to "rush into flower" at the earliest possible moment in spring-time. With us in Britain,

the flowering period is more generally distributed throughout the spring and summer, and even extends into the autumn.

In the Alps, the great majority of plants are in flower, or have passed the flowering stage, by the beginning of July, though some continue to flower during the early summer. Moreover, a large number of Alpine plants are specially constructed with a view to flowering at the earliest possible moment, as we shall see in subsequent chapters. There are only two other floras which exhibit this peculiarity in the same degree—the vegetation of the Arctic regions, and of the Cape (S. Africa).

The chief reason which has led to this peculiarity is to be found in the shortness of the summer season in the High Alps. The flowering period is but one stage, almost the preliminary step, in the process of reproduction. At its close much remains to be done before the seeds are ripened. Time must also be allowed for their distribution, and for them to obtain a firm hold in their new surroundings, before the winter's snow rings down the curtain.

It may be of interest to note the succession of flowering among some of the earlier spring flowers. The dates naturally vary somewhat from year to year, and according to the locality.

Dr Christ states that a Swiss botanist, named Brugger, observed at St Moritz, in the Upper Engadine, the following order of flowering among the heralds of spring. In the particular year in

question, the snow on the pastures did not disappear completely until the 3rd May. Yet on 22nd March, forty-two days previously, the first Spring Gentians (*Gentiana verna*, Linn.) were in flower, and with them, or very slightly later, the Spring Potentil (*Potentilla verna*, Linn.) and the Spring Anemone (*Anemone vernalis*, Linn.) also appeared. On 2nd April, *Crocus vernus*, All., sprang into flower in the meadows, while, on the day following, the Coltsfoot (*Tussilago farfara*, Linn.) showed on the dry, stony banks. On 18th April, the Bird's-eye Primrose (*Primula farinosa*, Linn.) and the Hairy Primrose (*P. hirsuta*, All.) also appeared. By 24th April, such characteristic species in the pastures as the Bell Gentian (*Gentiana acaulis*, Linn.), the Alpine Anemone (*Anemone alpina* var. *sulphurea*, Linn.), and *Polygala chamæbuxus*, Linn., were in flower. By 18th May, the Long-spurred Violet (*Viola calcarata*, Linn.) and the Oxlip (*Primula elatior*, Jacq.) had flowered, and these were quickly followed by a host of other plants. The Alpenroses did not, however, bloom until 20th June, and even this date was quite early for these plants at an elevation of 6,000 feet.

If we make a preliminary survey of the plants to be found near some Swiss resort in an Alpine valley, about 5,000 feet in altitude, we shall find that we can classify them roughly according to the kind of locality or habitat in which they flourish. Some are rock plants, others are only found in the shade of the Alpine forests. We shall also observe that the plants

of the Alpine meadows are, for the most part, distinct from those which flourish in the pastures. We can thus distinguish certain groups or *associations* of Alpine plants, each fitted or adapted to flourish under special circumstances. On the other hand, certain Alpine species will be found to belong to more than one association, and to be widely distributed throughout the valley.

The Alpine pastures and the valley meadows are typical associations on a large scale. The Alpine forests afford another instance. The conditions of life which prevail in these three types of habitat are very different, and since certain plants flourish in one and not in the others, it may be assumed that such species are specially suited to the particular conditions under which they live, and are not adapted to the circumstances which prevail elsewhere. Conversely, those species which are generally distributed and frequent in more than one association, have remained less specialised, and are therefore to be found more widely. They, however, are comparatively few in number.

Within the great associations, such as the pasture plants or the forest plants, are a number of smaller communities, the units which build up the great associations. Thus in the pastures we find typical sub-associations in the rock plants and in the inhabitants of the Alpine marshes. In the forests, we have the plants forming the forests themselves, and other species which thrive in their shade.

In the present volume we propose to group Alpine plants according to their associations, large or small, and to discuss the more typical and interesting members of each. The first few chapters will be devoted to the plants of the pastures, beginning with some of the more characteristic and abundant genera. We shall also devote chapters to some of the smaller associations, such as the rock plants, the marsh plants, and the inhabitants of the artificial modifications of the pastures—the meadows.

We will then discuss the High Alpines—*i.e.*, the inhabitants of the highest pastures—and finally the Alpine thickets and forests and their smaller associations, the shade plants. The last two chapters will be devoted to a general summary of some of the peculiarities and other interesting features of Alpine plants, and to the theories advanced as to the origin of the Alpine flora of Switzerland.

The pasture plants form a very large association belonging to many different families. Of these, however, four are especially well represented by a large number of abundant species in the Alps, and their members contribute the most characteristic feature of this association. The Buttercup family (natural order Ranunculaceæ), represented by the Anemones, the Alpine Buttercups, and several other genera, the Gentian family (natural order Gentianaceæ) by the Gentians (genus *Gentiana*), the Primrose family (natural order Primulaceæ) by the Soldanellas, Primulas, and Androsaces, and the Bell-flower family

C

(natural order Campanulaceæ) by the Campanulas or Bell-flowers, and the Rampions, are the most typical of all Alpine orders. We shall in this and the following chapters pay special attention to these plants, and thus gain a general idea of the chief and most characteristic members of the Alpine pastures.

THE ANEMONES.

The Anemones or Wind-flowers (natural order Ranunculaceæ, the Buttercup family) are very abundant in spring in the Alps, though the number of species is not very large. The Spring Anemone (*Anemone vernalis*, Linn.) is one of the earliest plants to flower in the pastures, when the snow begins to melt. Our two British Anemones, the Wood Anemone (*Anemone nemorosa*, Linn.), so common in plantations in early spring, and the Pasque-flower (*Anemone pulsatilla*, Linn.), a much rarer plant, growing chiefly on chalk-downs and other limestone soils, both occur in Lowland Switzerland, but not in the Alpine zone.

The Alpine Anemones fall into two natural groups, of which we may take the Spring Anemone, the Alpine Anemone, and the Narcissus-flowered Anemone as typical members.

THE SPRING ANEMONE.

We will begin with the Spring Anemone (*A. vernalis*, Linn.) (Plate IV.). By the time the annual

PLATE IV.

The Spring Anemone (*Anemone vernalis*, Linn.).
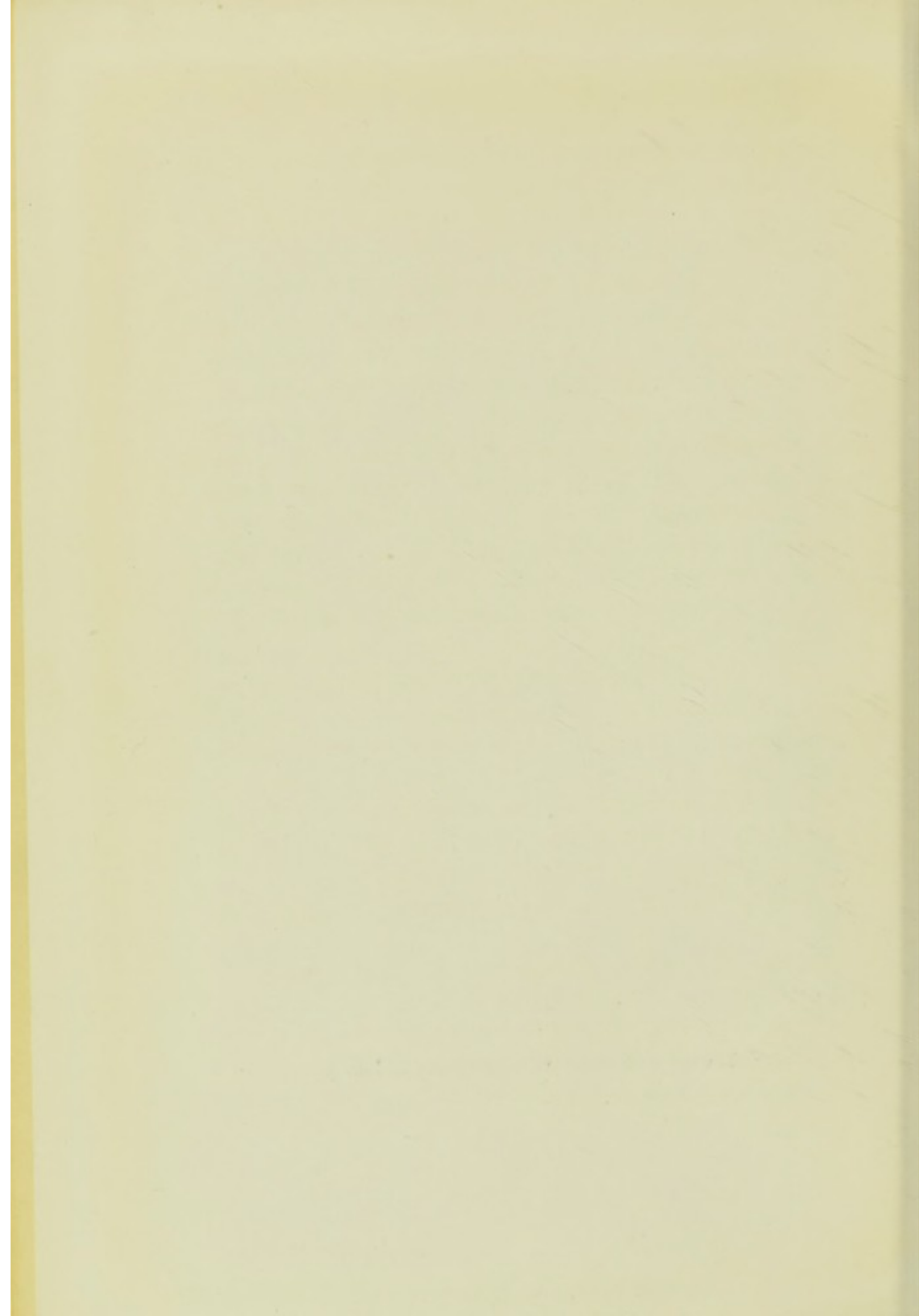
influx of tourists has reached the Alps, this plant is long past flowering in the lower pastures, and we must ascend to 7,000 to 8,000 feet, if we wish to see it in its prime.

In many respects the Spring Anemone recalls our English Pasque-flower (*A. pulsatilla*, Linn.), to which it is closely related. Just above the ground there is a small rosette of leaves, which are much cut and divided. The rather long leaf-stalks end below in a broad sheathing base. One or more solitary flowers, each mounted on its own flower-stalk, springs from among the leaves. At first, when the flowers are young, the stalks are short, and at this stage the flower itself projects but little beyond the rosette of leaves. As, however, the flower-buds mature, the stalk lengthens and carries up the flower. Just below the flower itself, we find several narrow, much-divided structures, which are really three leaves, much dissected, arranged in a circle on the flower-stalk. These form what the botanist calls an *involucre*, the presence of an involucre being characteristic of the Anemones. This structure serves to some extent to protect the young flowers.

The perianth members of the flowers, usually five or six in number, are of a beautiful, violet or pinkish-violet tint externally, though white inside. Within the perianth we find numerous stamens and ovaries, all arranged in a spiral fashion on the receptacle.

The chief interest of this plant lies in the long, silky, yellowish-brown hairs, which clothe both the

flower-stalks, the involucre segments, and the outer surface of the perianth members. These hairs add greatly to the beauty of the plant (Plate IV.). They are commonly regarded as serving to keep the plant warm during the season of melting snows. It is very unlikely, however, that this is their real use. It is more probable that they tend to lessen the risk of excessive transpiration (see p. 12) from the upper portion of the plant. It must be remembered that when this Anemone flowers, the soil in which the roots are buried is at a very different temperature from the atmosphere. The sun during the snow-melting season is hot, but the soil is still either frozen or very cold. Hence if the above-ground portion of the plant were to lose water too rapidly, the loss could not be made good by the roots. The hairs probably serve to lessen this risk in much the same way as those of the Edelweiss, discussed in the last chapter.

The fruit of the Spring Anemone (Plate V., Fig. 1) is a very common " find " in the pasturages in summer. It is not only beautiful, but botanically interesting. It is closely similar to, though smaller than, that of the Alpine Anemone, which we will shortly describe in detail (p. 39).

Before leaving the Spring Anemone, we may mention that in the Zermatt and a few other valleys of Canton Valais, another species, Haller's Anemone (*Anemone halleri*, All.), is found, which very closely resembles the Spring Anemone in many points. This

PLATE V.

Fig. 2.—Mature Fruits of the Alpine Anemone (*Anemone alpina*, Linn.).

Fig. 1.—Mature Fruits of the Spring Anemone (*Anemone vernalis*, Linn.).
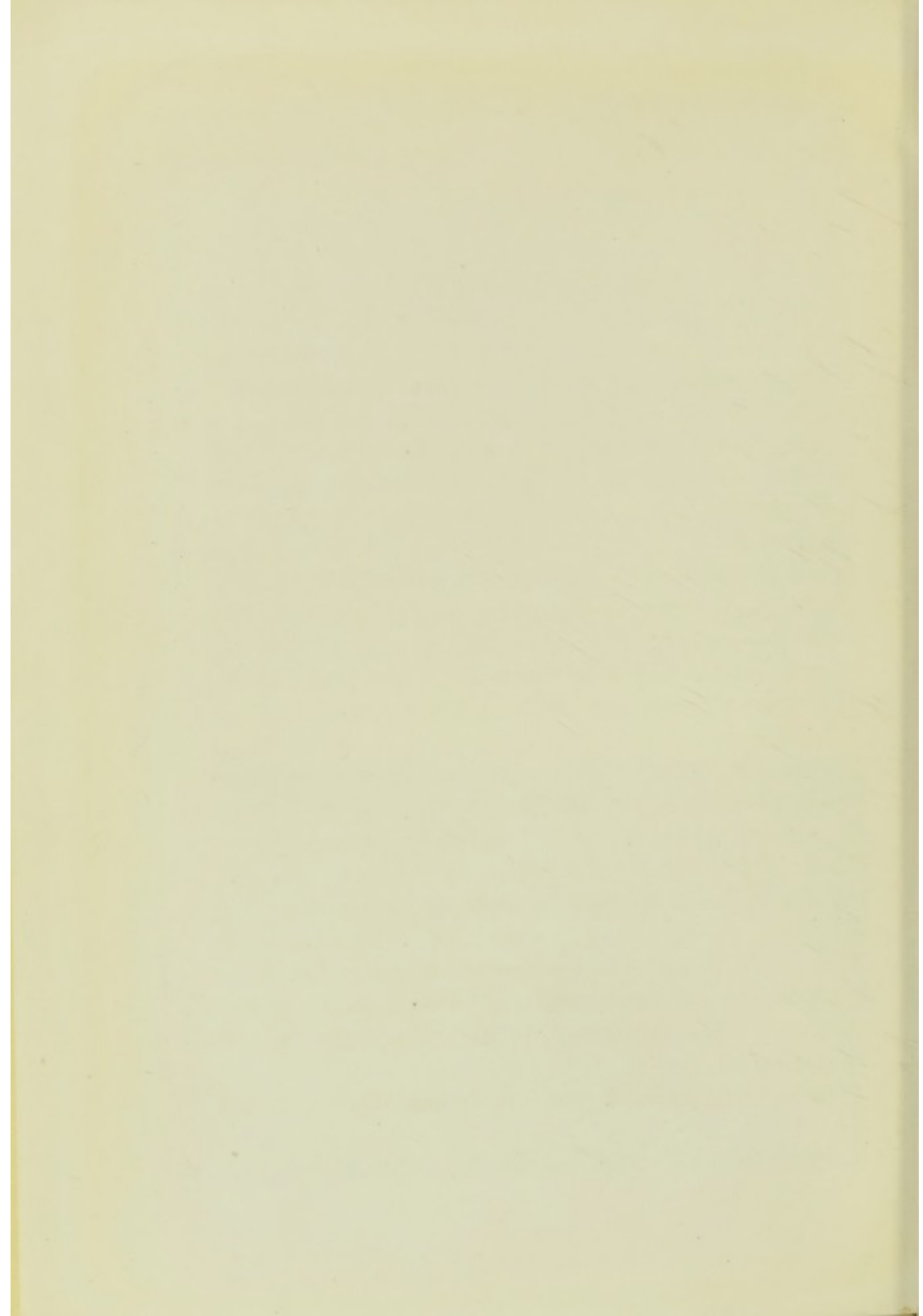
plant, however, loses its leaves in autumn, whereas those of the Spring Anemone persist throughout the winter.

THE ALPINE ANEMONE.

The Alpine Anemone (*Anemone alpina*, Linn., and its variety *sulphurea*, Linn.) (Plates VI. and VII.) is the most striking of all the Swiss Anemones, and one of the most handsome of Alpine plants. It is the large white, or more often sulphur-yellow, "Wind-flower" of the pastures. It flowers in June and July, according to the altitude, and in many districts it is exceedingly common. It varies in height from six inches to a foot or more. It has rather large, much-divided leaves mounted on long stalks, which spring from the stem just above the surface of the soil. The flowers, which are also borne on fairly long flower-stalks, are solitary. As in the Spring Anemone, there is an involucre (see p. 35) of three leaves on the flower-stalk below the flowers, but here the leaves are large and highly divided, and altogether much more like foliage leaves. In the photograph on Plate VII., Fig. 1, two young flowers just expand-ing can be seen still partly sheltered or enclosed by the involucre, exactly as we noticed in the case of the Spring Anemone. As the flowers mature, the stalks between the involucres and the flowers grow rapidly, and thus the flowers are carried up out of the involucre.

In the typical Alpine Anemone, the perianth

members are either white, or white slightly tinged with blue on the outside. In the yellow-flowered variety, *sulphurea,* which is sometimes regarded as a distinct species, the flowers are a beautiful, uniform, pale sulphur-yellow colour. Curiously enough, this variety is in Switzerland generally much more abundant than the true "alpina" with white flowers. Often, however, they may be found growing side by side. At one time it was thought that the sulphur variety flourished only on granite soils, but this is really not the case, and the difference in colour between the species and the variety bears no relation to the soils on which they grow.

The masses of these flowers (Plate VI.), forming, as it were, miniature forests of Anemones, which are often to be seen on the steeper slopes of the pastures, are among the most wonderful sights in the Alpine world. When the flowers are mature, the perianth members open out and catch the sunlight on their inner sides, thus greatly adding to their conspicuousness.

The plants are only moderately hairy, and in this respect contrast with the Spring Anemone or the Edelweiss, where the conspicuousness of the whole plant, as we have seen, is largely increased by its hairy coat.

The flowers of the Anemones are constructed much like those of a Buttercup (see Appendix II., p. 328): except that the perianth is not differentiated into calyx and corolla. If we look closely at the flowers growing in profusion on some bank in the pastures,

PLATE VI.

A Group of Yellow Alpine Anemones (*Anemone alpina*, Linn., var. *sulphurea*, Linn.).
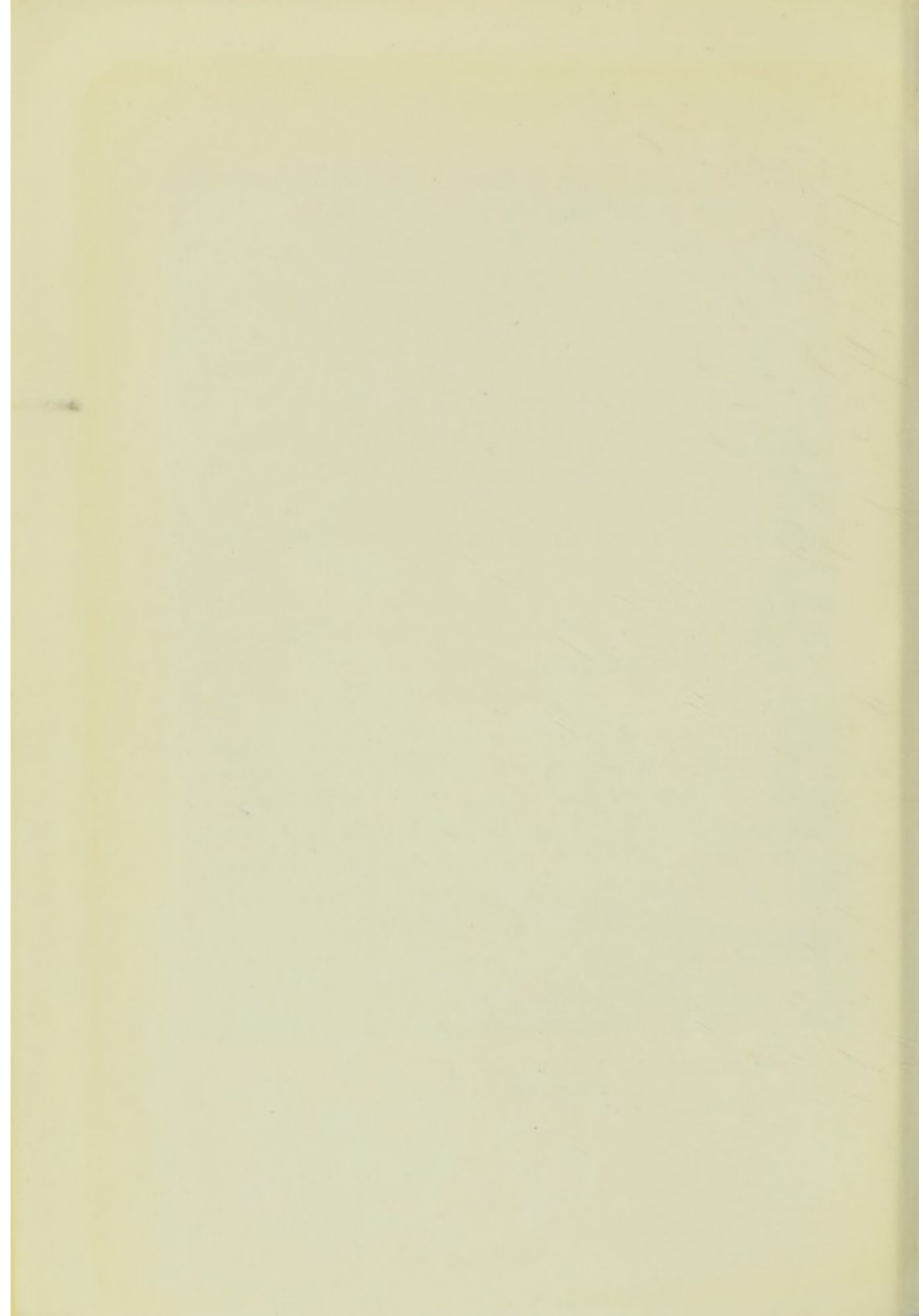
we shall find that many of them are entirely male, the ovaries or female organs having been completely suppressed, and stamens only being present. This remarkable phenomenon — the occurrence of male unisexual flowers, in addition to flowers with both sexes (hermaphrodite)—is probably far from infrequent among Alpines. It occurs in the case of the White Veratrum (*Veratrum album*, Linn.) (p. 123), another typical pasture plant, and also in the White Dryas (p. 128) and the Mountain Avens (p. 128). Its significance is not yet clearly understood, but may be connected with the fact that the flowers of the Alpine Anemone are quite devoid of honey, pollen forming the sole attraction to insects.

In the photograph on Plate VI. the lowest flower has stamens only, and two at least of the six other flowers are also male, the highest flower being typically bisexual. Two male flowers are also seen on Plate VII., Fig. 2.

The fruit-head of the Alpine Anemone (Plate V., Fig. 2) is a very beautiful structure. The individual fruits consist of a small sac below, enclosing a single seed, prolonged above into a long, feathery structure called an awn. A very large number of these awned fruits are borne in a head. It is interesting to examine different stages in the formation of this fruit (Plate VIII., Fig. 1, and Text-fig. II.). The awn grows in length exceedingly rapidly. At the beginning of the flowering stage, the ovary, which later forms the fruit, will be found to be rather small in comparison (Text-

fig. II., 1). When the flowering stage has passed
(Plate VIII., Fig. 1), the perianth members fall off
much earlier than in the case of the Spring Anemone

1.   2.   3.
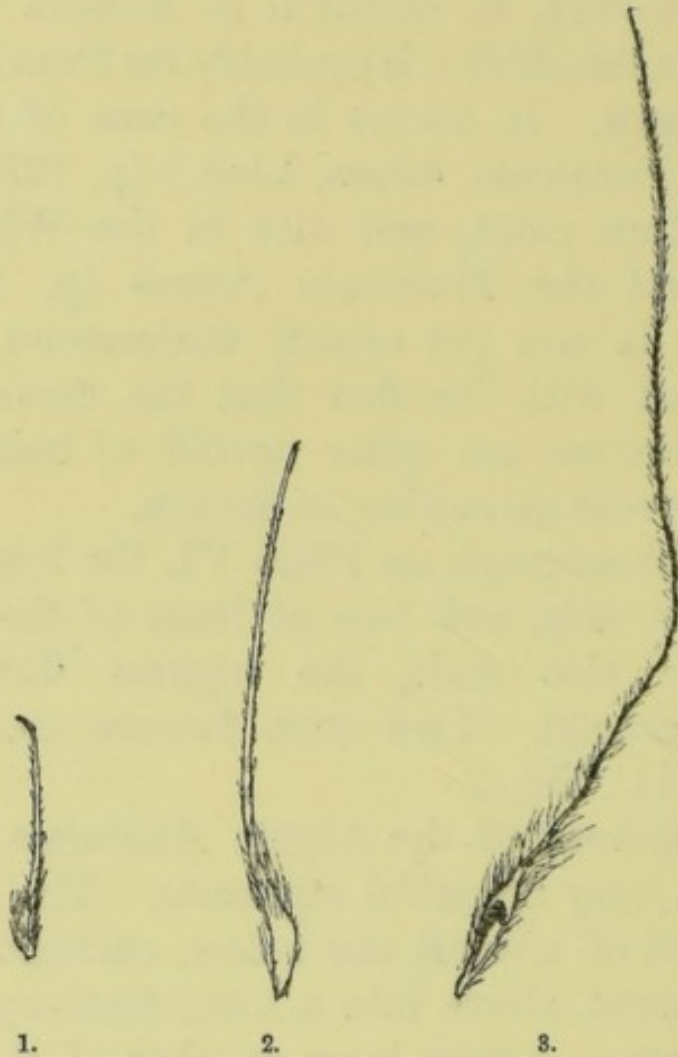
FIG. II.—Fruits of the Alpine Anemone (*Anemone alpina*, Linn.) in
various stages of development.   Magnified twice.

1. In fully-opened flower.   2. Intermediate stage.   3. The mature fruit.

(*cf.* Plate IV.), and the stamens wither.   The fruits,
or rather the awns, have begun to increase in length
(Text-fig. II., 2).   They continue to grow rapidly,
the awns developing short hairs and a spiral twist

PLATE VII.

[To face p. 40.

Fig. 2.—Male Flowers of the Yellow Variety.

Fig. 1.—Young Flowers of the White Variety growing out
of the Involucre.

The Alpine Anemone (*Anemone alpina*, Linn.).
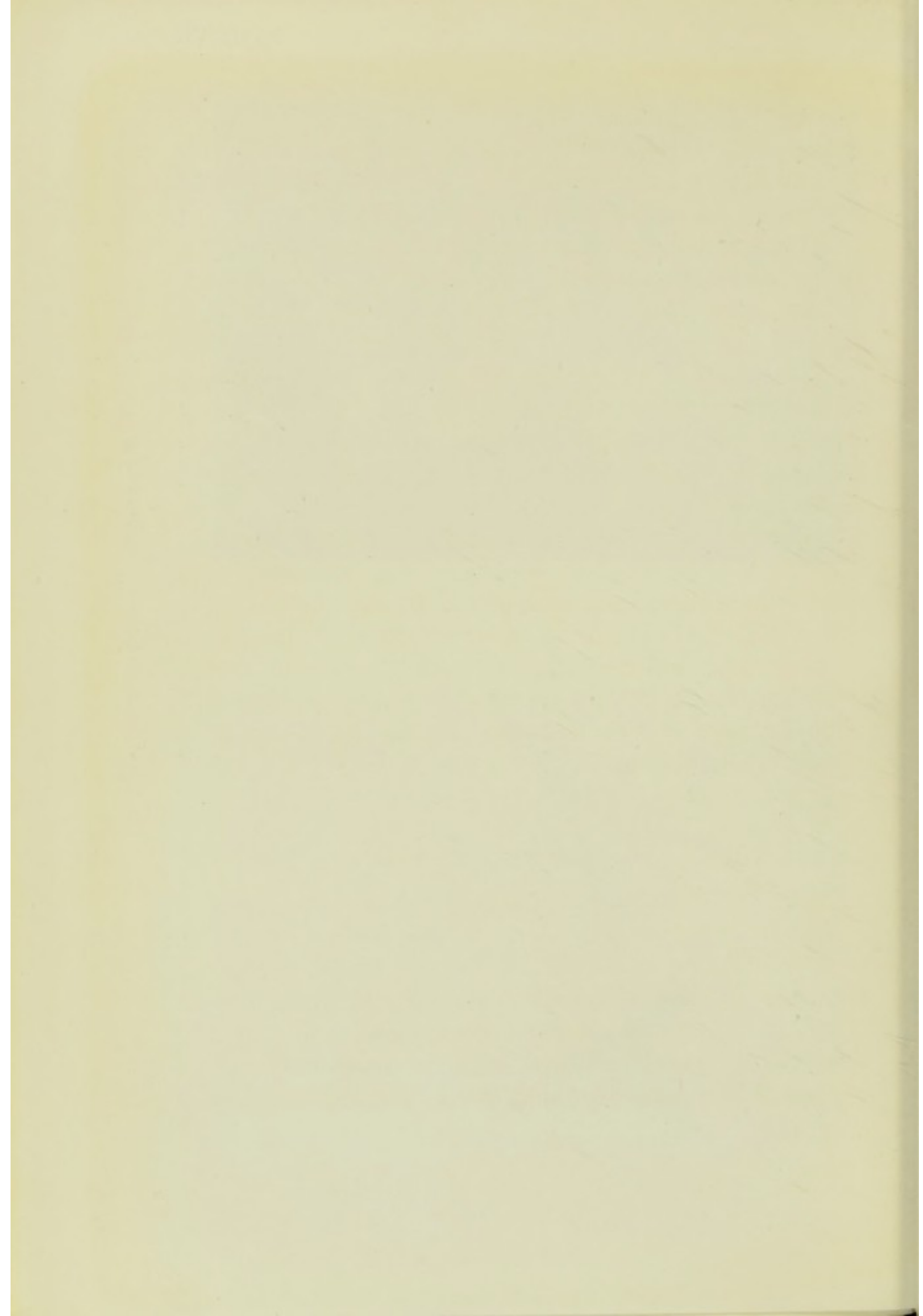
below, until they reach a length of 1 to 2 inches in the mature stage (Text-fig. II., 3). The fruits are now ready for distribution (Plate V., Fig. 2).

If we choose a ripe fruit-head on a windy day and detach the awns with their seeds, and cast them to the wind, we shall find that they are admirably adapted for travelling in the air, and will often cover considerable distances from the parent plant, in much the same manner as the parachute-like fruits of the Dandelion, with which everyone is familiar. Thus the awn is an air-flying device, and extremely effective as a means of distribution.

Awned fruits are not common among Swiss Alpines, though they are conspicuous in the case of some other Anemones, such as the Spring Anemone, the White Dryas, and the Creeping and Mountain Avens. The fruits of our common Traveller's Joy (*Clematis vitalba*, Linn.) are familiar examples of the same nature, though this plant does not occur in Alpine Switzerland.

THE NARCISSUS-FLOWERED ANEMONE.

The   beautiful   Narcissus - flowered   Anemone (*Anemone narcissiflora*, Linn.) (Plate VIII., Fig. 2) is in many respects a marked contrast to the Alpine and Spring Anemones. It is not so abundant, and is apt to be rather local in its distribution. It grows chiefly in the pastures where the flowers are thick and the grass long, and especially where the soil is fairly

moist but not wet. It differs from all the other Swiss Anemones in the grouping of the flowers into stalked heads, which the botanist terms *umbels*, the flower arrangement so characteristic of the great family of plants known as the Umbelliferæ, which includes the Parsley and Hemlock. Usually there are from five to eight flowers in the umbel, but the number varies somewhat.

The flowers are white in colour, often streaked or "blushed" with delicate rose-pink on the outside. Just below the point at which the stalks of the individual flowers unite, an involucre of three leaves is seen, which are much less divided than in the case of the other Anemones already discussed.

The Narcissus-flowered Anemone is also distinguished by the fact that the fruits are not prolonged into a hairy awn. They are, on the contrary, quite simple, resembling those of our British Wind-flower (*Anemone nemorosa*, Linn.), and are not specially adapted to travel in the air. The flowers, like those of the Alpine Anemone, are entirely devoid of honey, in which they are rather exceptional among Alpine flowers.

The Gentians.

The Gentians (natural order Gentianaceæ, the Gentian family), like the Anemones, are highly characteristic of Alpine regions, though by no means confined to them. In Britain, in addition to the Yellowwort (*Chlora perfoliata*, Linn.), the Centaury

PLATE VIII.

Fig. 2.—The Narcissus-flowered Anemone (*Anemone narcissiflora*, Linn.).
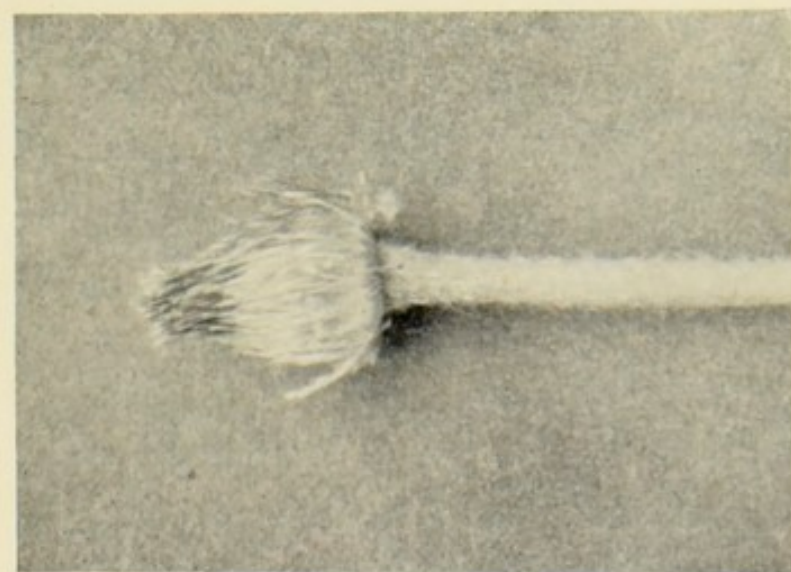
Fig. 1.—Young Fruits of the Alpine Anemone (*Anemone alpina*, Linn.).
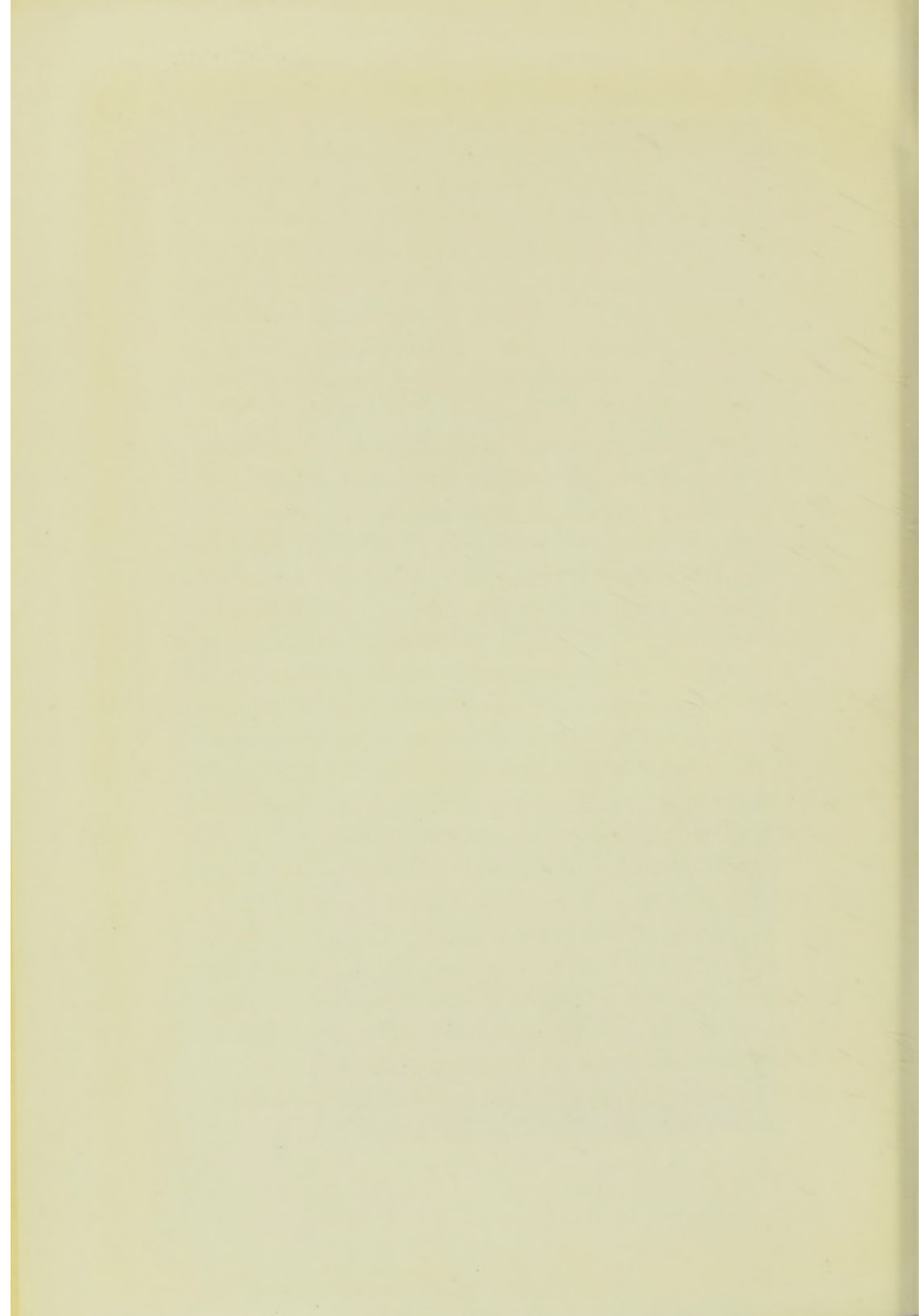
(*Erythræa centaurium*, Pers.), the Buckbean (*Meny-anthes trifoliata*, Linn.), and other genera not found in Alpine Switzerland, we have five Gentians, all of which occur in the Alps, except the Marsh Gentian (*Gentiana pneumonanthe*, Linn.), which does not extend beyond the Lowlands. One other British species, the Autumn Gentian (*G. amarella*, Linn.), is believed to be very rare in Switzerland, occurring only in the Lower Engadine.

As opposed to our five British Gentians, there are no fewer than eighteen species to be found within the Alpine zone in Switzerland, many of them being widely distributed and often abundant. Three of these are especially in evidence in the High Alpine region.

The best-known Alpine Gentians are those which possess blue flowers. But it must not be imagined that all Swiss Gentians have blue flowers, though this is true of the majority. Some species, as we shall see, have yellow or red corollas. The blue-flowered plants are, however, very much in evidence in the Alps, and this is somewhat remarkable, for blue, as a colour, is not so strikingly conspicuous as red or yellow.

The colours of Alpine flowers have been the subject of repeated investigations at the hands of botanists, especially in recent years. At one time it was thought that there was actually a larger percentage of blue-flowered plants within the Alpine zone than in the plains. This would appear probable, when we remember that, in addition to many Gentians, other blue- or purple-flowered plants are abundant,

such as the Bell-flowers, the Rampions, the Forget-me-nots, and the *Eritrichium*, many Geraniums, the Globularias, the Alpine Toadflax, certain Monkshoods, and the Opposite-leaved Saxifrage. But when we come to statistics, we find, as is so often the case, that not only are our first impressions not confirmed, but they are shown to be erroneous. Dr Fisch has pointed out that the colour proportions among Alpines are about 30 per cent. white-flowered species to 27 per cent. yellow-flowered, and 19 per cent. red-flowered and 24 per cent. violet- or blue-flowered species. In the flora of Davos, he finds that only 36·8 per cent. of the total species have red, blue, or violet flowers, which appears to be about the general average, and is quite comparable to the proportion found among species growing in the plains.

The blue-flowered Alpines are, however, specially noticeable, owing to the intense depth of the coloration and the large number of the individual flowers. It has been shown repeatedly that the pigment which is contained in the petals, and to which the colour is due, increases in intensity as we pass from the plains to the Alpine zone. While this is the general rule for all colours as well as blue, it does not hold good in every case. The flowers of some species, such as the Wood Geranium (*Geranium sylvaticum*, Linn.), are stated to be less intensely coloured in the Alps than in the plains, while in other species there appears to be no appreciable difference in the depth of the colour in the two cases.

As to the cause of the greater intensity of colour found in many Alpine flowers, it is not possible to conclude finally at present. There are two alternatives. Either it is due to the greater intensity of the illumination, or it may be a special adaptation among Alpines to serve as an insect advertisement. There is much to be said for both theories. Prof. Bonnier has made experiments subjecting various plants, under suitable conditions and with necessary precautions, to the influence of a strong continuous light. He finds that the chlorophyll, or green colouring matter of the leaves, is thereby rendered more intense, and the chlorophyll grains more numerous and more evenly distributed. If this is the case with chlorophyll, it may also be the same with the pigment granules in the petals. In many flowers, especially those with yellow, orange-yellow, or orange-red corollas, the pigment is solid and in the form of granules, or, to state it more accurately, is contained in minute specialised portions of the protoplasm (p. 9) called chromoplastids, just as chlorophyll (p. 10) is also held in small specialised protoplasmic bodies. In a large number of red, blue, and purple flowers, however, and also in some yellow flowers, the pigment is held in solution in the cell sap.

On the other hand, it is known that there is a larger percentage of flowers which are cross-pollinated by means of insects, especially by butterflies, in the Alps than in the plains. Some of these flowers are specialised to certain groups of insects—that is, they

are so constructed that only certain kinds of insects can reach the honey legitimately. It has also been proved experimentally that certain insects favour a flower of one colour, and will avoid or overlook a flower of another. Blue flowers, for instance, are, as a rule, "bee flowers," while many white flowers are visited by small flies. It is therefore possible that in many cases not only the colour, but the increased density of the pigment, met with in Alpine flowers, may be primarily due, not to the special physical conditions of the Alpine world, but to a specialisation in favour of a particular class of insect visitor.

In connection with the colours of Alpine flowers, it may be remarked that certain species which normally bear coloured flowers are occasionally found to produce white flowers. We are all familiar with the white Heather; and white forms of Alpine flowers, such as of the Common Bell Gentian or a Bearded Campanula, are equally prized on account of their rarity in the Alps. The tendency to produce occasional white flowers is greatest in those plants with blue, pink, or red flowers, and least among the yellow-flowered species. White-flowered plants will also sometimes assume a yellowish hue. In others, again, such as the Spring Crocus or the Field Pansy (*Viola tricolor*, Linn.), the colours, or rather the combinations of colours, of the flowers are always fluctuating. The causes which lie at the root of these colour-changes are complex, and are not yet fully understood. It is

thus impossible to enter into the matter here, though it may be stated that in some cases the white flowers occasionally found are instances of fresh variations; whereas in others, the lack of a colour pigment in the petals, or the development of an exceptional pigment, may represent a reversion to an ancestral type. At any rate, these variations in colour have no connection with the chemical nature of the soil, as was formerly thought possible, but they arise from deep-seated tendencies, which find their expression in the existence of the individual, and the evolution of the race.

But to return to the Alpine Gentians: we will commence with the blue-flowered species, which are universally regarded as among the most interesting of Alpine plants. These fall naturally into three groups. First we have the Gentians with star-like flowers. The corolla formed by the united petals consists of a narrow tube below, the free portions of the petals expanding above into radiating lobes, which, when the flower is open, are spread out nearly at right angles to the tube. Between the free portions of the petals, small lobes occur, each divided into two. When the flower is closed, the free portions of the petals point upwards and are twisted together. The Spring, Bavarian, and Snow Gentians belong to this group. In these the leafy stem is short, though it is quite obvious.

Next we have the Bell Gentians with very short stems, and corollas in the form of a large bell, the mouth pointing upwards to the sky when the

flower is open. The Common Bell Gentian and the Broad-leaved Gentian belong here. The former is often called the Stemless Gentian.

The third group, the Fringed Gentians, or Gentian-ellas, are usually much-branched plants with corollas shaped like those of the first group. But the entrance to the corolla tube, or the throat of the corolla, as it is termed, is closed by a fringe of scales, which are outgrowths from the inner surface of the petals.

THE SPRING AND BAVARIAN GENTIANS.

The Spring Gentian (*Gentiana verna*, Linn.) (Plate X., Fig. 1), is, as we have seen, one of the earliest flowers to deck the Alpine pastures on the retreat of the winter's snow. The Bavarian Gentian (*Gentiana bavarica*, Linn.) does not flower until later, usually in July, and is perhaps often more in evidence in the High Alpine region than in the Alpine zone. The two plants are both perennials, very similar in appearance and liable to be mistaken for one another. The underground stems produce numerous, very leafy shoots, and flowering shoots ending in a single flower of an intense azure-blue, especially in the case of the Bavarian Gentian. In the Spring Gentian, the leaves are more or less elliptical in shape and pointed. The leaves on the flowering shoot are arranged in one or two pairs, which are smaller than those forming the rosettes close to the ground. The Bavarian Gentian has blunt, spoon-shaped or egg-shaped leaves, and

three or four pairs of leaves on the flowering shoots, nearly similar in size to those below.

The chief feature of interest presented by these two Gentians is the intensity of the blue coloration of the flowers, a feature in which they are perhaps only rivalled in the Alps by *Eritrichium nanum* (p. 183).

The flowers are scentless. Their method of fertilisation is essentially similar to that of the Bell Gentian, which we shall describe in detail shortly. Both the Spring and Bavarian Gentians are adapted to cross-pollination by the agency of butterflies and moths, the Hawk-Moth (*Macroglossa stellatarum*) being their most frequent and important visitor. The insects are attracted by the brilliant coloration, and by the honey secreted at the base of the ovary. The small double-toothed lobes or appendages between the free portions of the petals serve to protect the entrance to the corolla tube and to keep out "unbidden guests," which can perform no service to the plant by effecting cross-pollination.

THE SNOW GENTIAN.

The tiny little Snow Gentian (*Gentiana nivalis*, Linn.), fully-grown specimens of which almost resemble in size the seedlings of many other plants, is interesting as being an annual, and not a perennial, like the majority of Alpine Gentians. The whole plant is very slender, and does not exceed 4 to 6

D

inches in height. The stem is simple or branched, and bears a few small leaves, the upper ones arranged in pairs. It ends in a small solitary flower, like that of the Spring Gentian, but smaller.

The Snow Gentian, like the Spring Gentian, is a British plant, though it is rare with us, and is only found on a few of the higher Scotch mountains. In the Alps it is a very common plant in the pastures, and is not, as perhaps the name Snow Gentian implies, by any means necessarily confined to high elevations. In fact, its upward range ceases at about 9,900 feet, while it is much commoner at elevations of 5,000 to 6,000 feet. It is thus not a High Alpine plant at all.

The flowers of this species are extraordinarily sensitive to sunlight. They are nearly always closed unless the sun is shining very brightly, and, the moment the sun disappears behind a cloud, the flowers may shut with considerable rapidity. They thus sometimes open and shut many times in the course of an hour, changes in temperature acting as a signal to the plant to open or close its flowers. It should also be observed that when the flowers shut, not only are the free portions of the petals held erect, but they twist together in a spiral.

THE COMMON BELL GENTIAN.

We now pass to consider the Bell Gentians, which have the largest corollas of the blue-flowered Alpine Gentians. We will take the Common Bell Gentian,
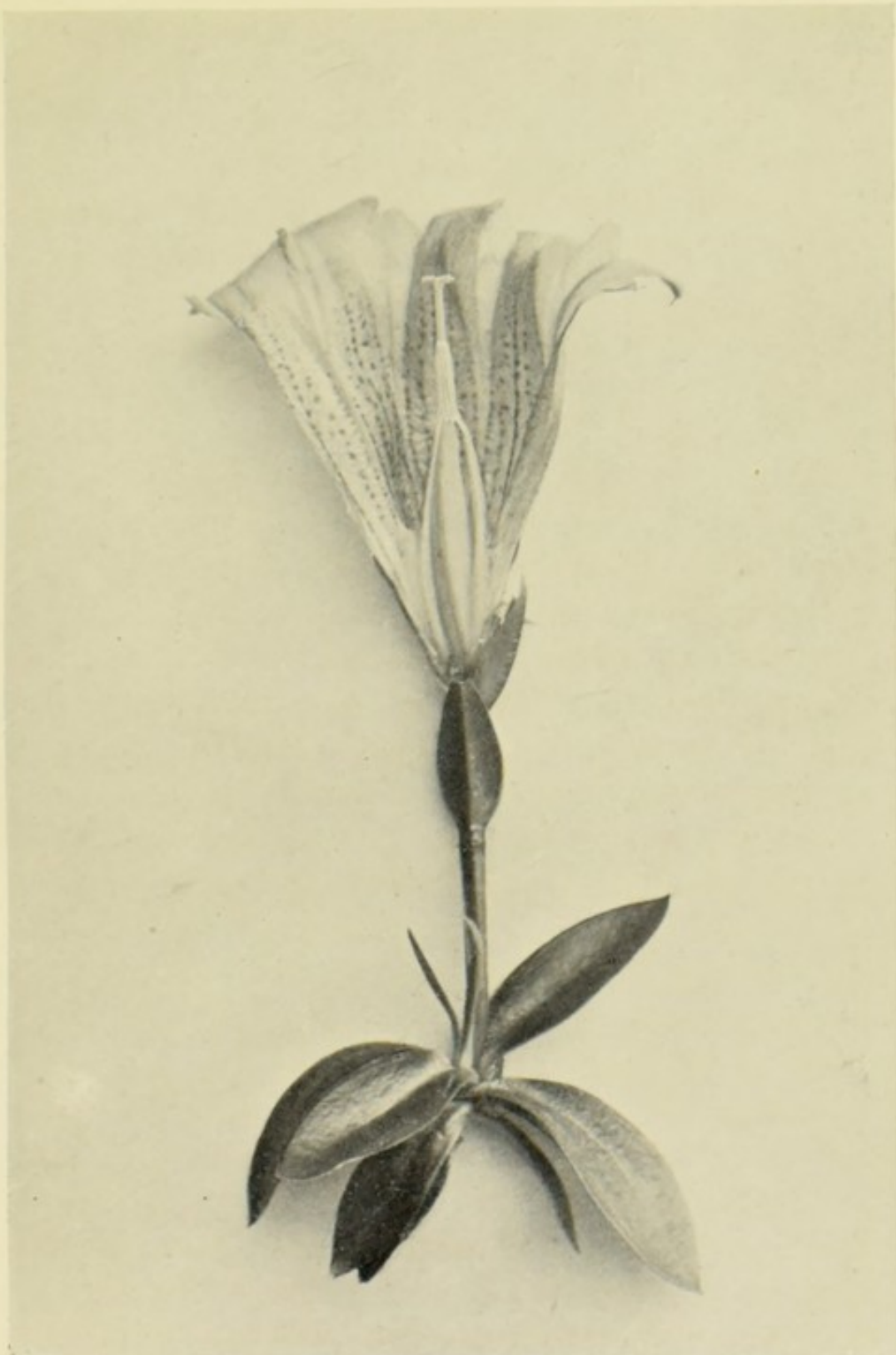
PLATE IX.

A Plant of the Common Bell Gentian (*Gentiana acaulis*, Linn.), the Corolla
cut open to show the Stamens and the Ovary.
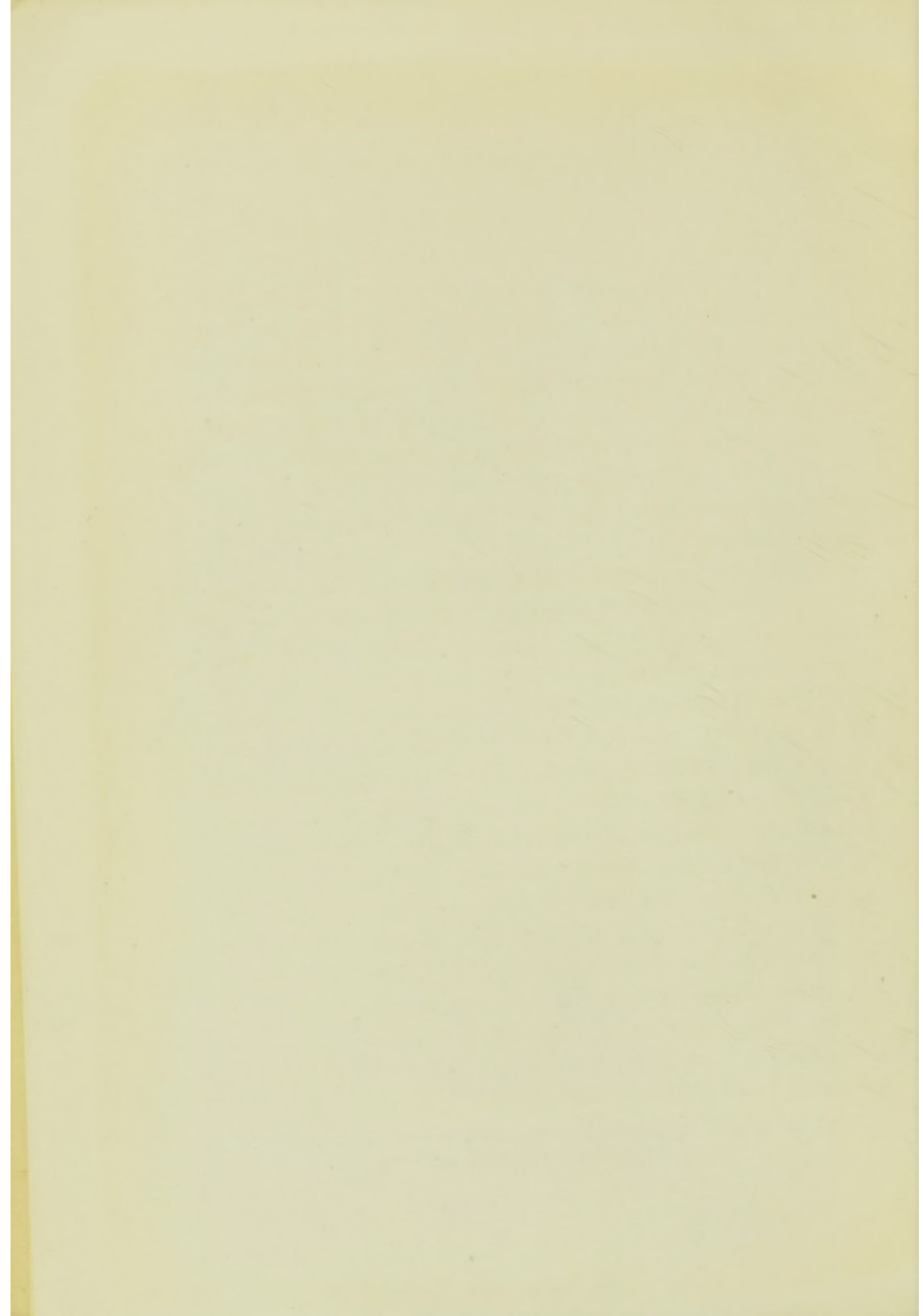
often called the Stemless Gentian (*Gentiana acaulis,* Linn.) (Plate IX.), as a typical example. The plant is quite unmistakable, and is especially frequent on limestone soils. The stem is very short, though not absent altogether, as the somewhat unfortunate specific name implies. The leaves are arranged in a beautiful little rosette on the stem, just above the surface of the ground. From the rosette springs a single flower, of large size, mounted on a stalk which varies from 1 to 4 inches in length. The flower is of a deep blue colour, and is shaped like a church-bell, the mouth of the bell being turned upwards, facing the sky.

There are no other Swiss Gentians at all similar to the Common Bell Gentian, with the exception of *Gentiana excisa,* Presl. (= *G. latifolia,* Gren. and Godr.), and *G. alpina,* Vill., both of which are probably only varieties of the same plant, though by some they are regarded as distinct species.

The large size of the flowers of the Common Bell Gentian prompts us to peep within the bell, and to study the form of the male and female organs, which we shall find are full of interest. First of all, we will slit open the corolla from base to summit with a needle, or a pin, in the manner shown in Plate IX. The photograph also shows the rosette of rather leathery leaves, and the flower-stalk with its two pairs of smaller leaves. Outside the bell and attached at its base, we find a tubular calyx composed of five small, green leaves united together. The five

petals forming the bell are almost completely fused, the recurved portions at the edge of the open bell being alone free.

Internal to the corolla we find five stamens, which spring from the base of the bell. Their stalks are quite free from one another, but the pollen-producing organs, the anthers, are united together in a ring closely embracing the style or upper portion of the ovary. In the photograph the ovary is seen between the stalks of the stamens, and the style, with its two stigmas, above the united anthers.

The union of the anthers, and their close proximity to the style, is part of a simple and interesting mechanism for ensuring cross-fertilisation, by the agency of some insect visitor, which will carry the pollen of one flower to the stigmas of another. Cross-fertilisation is essential to most of the Flowering Plants, and is brought about either by animal, especially insect, visits, or by wind transference. The result of cross-fertilisation is renewed vitality to the stock. While self-fertilisation may be the rule in a minority of plants, yet in the majority, as Charles Darwin showed, continuous self-fertilisation is harmful, for the stock weakens and the seeds tend to become sterile, and the plant may even become totally extinct. At the same time, many plants which are usually cross-fertilised are capable of occasional self-fertilisation when by some accident the chance of cross-fertilisation has been missed.

In a large number of flowers adapted to cross-

fertilisation, special contrivances exist which tend to make self-fertilisation impossible. A very simple method is the arrangement whereby the male organs ripen and shed their pollen before the stigmas are mature. This happens in the case of the Bell Gentian. A close examination of a flower such as that seen on Plate IX., or, better still, a comparative study of several flowers in different stages of development, some quite young and hardly open, others fully mature, will enable us to follow the details clearly.

The Bell Gentian is fertilised by humble-bees. A bee, visiting a young flower in search of the honey secreted at the base of the ovary, has to push its way through one of the spaces between the stalks of the stamens. The anthers at this stage are quite ripe and dehisce each by means of two long slits. They open outwards—*i.e.*, towards the corolla and away from the ovary. In the young flower, the stigmas are not mature, but the pollen is ripe ; and when a bee forces its way between the anther stalks, it shakes a cloud of pollen dust out of the anthers on to its own back. Later, when the bee seeks another flower in a more advanced condition, in which the pollen has all been shed, but where the stigmas are mature, it deposits some of the pollen on them, when it enters the flower. If by any chance the pollen of a flower should reach the stigma of the same flower, it is usually ineffective, because the stigmatic surfaces are not ripe.

Kerner states, however, that self-fertilisation may

take place in the following manner and circumstances. The ordinary method, described above, depends to some extent on the occurrence of fine sunny weather, when the flowers are mature. If the summer is wet, bees are not on the wing and the flower remains closed. In this case the pollen, when mature, falls to the bottom of the bell and there accumulates. Later, when the stigmas are ripe, the stalk of the flower lengthens, and the closed bell, instead of pointing directly upwards, is inverted. The pollen falls down along the grooves inside the folded bell, and thus, when the bell is shaken by the wind, reaches the stigmas, and the plant is self-fertilised. This process may also occur at night, when the flowers are always closed.

Thus the difference in the position of the bell of this Gentian, whether held vertically upright or pointed earthwards, has an important biological significance. The two positions may be observed in almost any large patch of this plant in the Alps.

THE FRINGED GENTIANS, OR GENTIANELLAS.

We now reach our third group of blue-flowered Gentians, the Fringed Gentians, or Gentianellas, which possess a fringe of much-divided scales just inside the throat of the corolla. The Field Gentian (*Gentiana campestris*, Linn.), a fairly common British plant, and the Delicate Gentian (*Gentiana tenella*, Rottb.), a somewhat rare High Alpine, are the two chief representatives of this group in Alpine Switzerland.

PLATE X.

Fig. 2.—The Flowers of the Field Gentian (*Gentiana campestris*, Linn.).
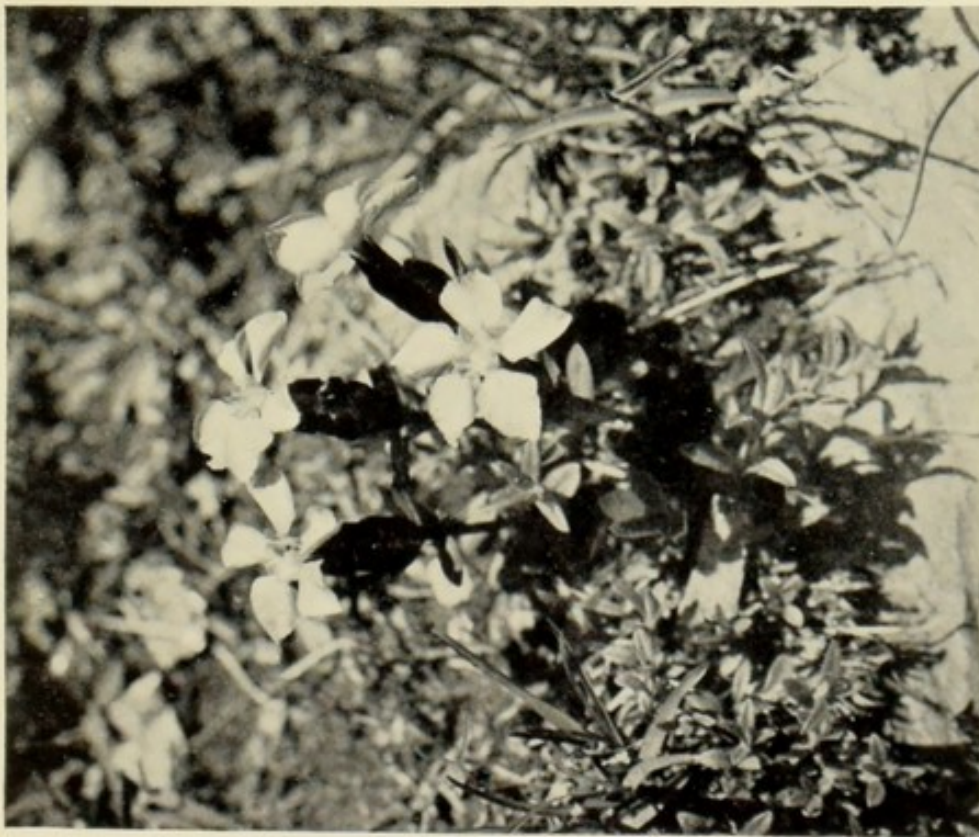
Fig. 1.—The Spring Gentian (*Gentiana verna*, Linn.).

[*To face p.* 54.
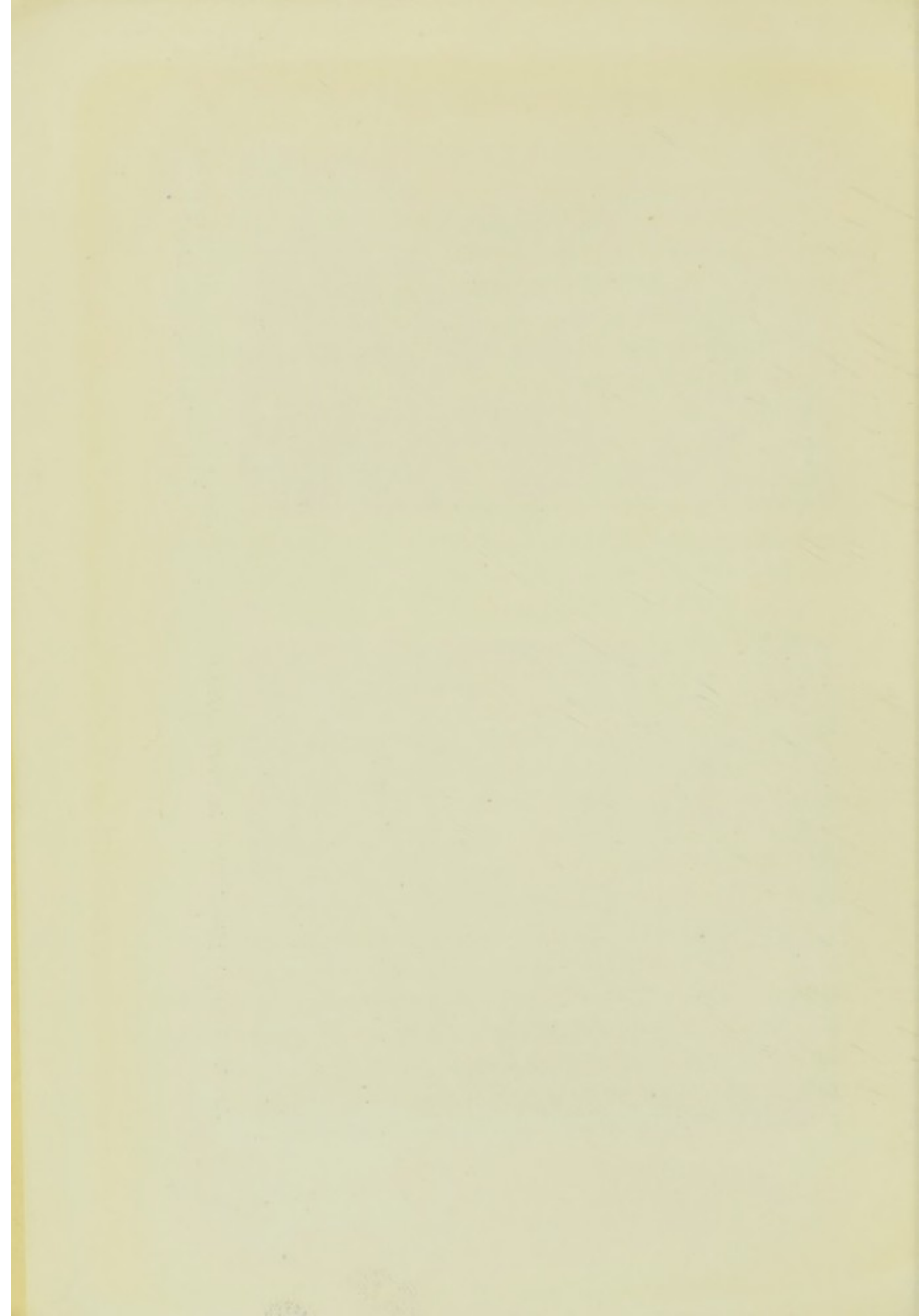
Both are much-branched plants bearing many flowers, as a rule, and the sepals and petals are only four and not five in number in each case, a character which easily distinguishes them from the other Alpine Gentians.

THE FIELD GENTIAN.

The Field Gentian (*Gentiana campestris*, Linn.) (Plate X., Fig. 2) is a many-flowered annual plant, with a rather peculiar calyx. Two of the sepals are much broader than the other pair.

The blue fringe of scales at the mouth of the corolla is very conspicuous, and is deeply cut into long, narrow segments (Text-fig. III.). Its probable object is to keep out "unbidden guests"—that is, certain small insects, especially creeping insects, which might visit the flower in search of honey or pollen,

FIG. III.—The Flower of the Field Gentian (*Gentiana campestris*, Linn.).

Showing the scale-like outgrowths from the throat of the corolla. Magnified 3 times.

but are of no service to the plant as cross-pollinators. The flower is specially adapted to bees and butterflies, which alone are powerful enough to force aside the fringe closing the throat of the corolla, and possess a sufficiently long proboscis or tongue to reach the honey secreted by the nectaries at the base of the corolla

tube. The arrangement for cross-fertilisation here is similar to that described in the case of the Common Bell Gentian: except that both the anthers and stigmas are ripe at the same time, or the stigmas may mature slightly before the anthers.

The flowers of the Field Gentian, like those of the Snow Gentian, are extremely sensitive to light. They are usually closed in the absence of bright sunlight.

THE DELICATE GENTIAN.

The Delicate Gentian (*Gentiana tenella*, Rothb.) resembles the Snow Gentian somewhat in habit. It is a dwarf plant, with a small rosette of leaves on the surface of the soil, from which numerous erect branches arise, often comparatively long and leafless. Each branch ends, as a rule, in a single flower.

Scales occur at the mouth of the corolla tube, which are similar to those found in the Field Gentian, but shorter and less finely divided. The fertilisation of the flower is effected by the same agency, and the scales appear to perform the same function as in those found in the Field Gentian. In the Delicate Gentian, both the male and female organs mature simultaneously.

THE YELLOW- AND RED-FLOWERED GENTIANS.

The Swiss Alpine Gentians with yellow and red flowers differ in many remarkable respects from the blue-flowered species, which we have just been con-

sidering. The habit is quite dissimilar. The plants are all perennials, and very much larger. The long, leafy stems are rarely less than a foot high, and often reach several feet in length. The opposite pairs of leaves are large, and the flowers are arranged in whorls in the axils of the higher, alternating pairs of leaves. These plants possess a stout root-stock below ground. Two species have yellow, and two red, flowers. They frequently form large colonies in the stony pastures.

The Yellow Gentian.

The Yellow Gentian (*Gentiana lutea*, Linn.) is quite dissimilar in several respects from all the other Swiss Gentians. The yellow petals are almost entirely free from one another, and not united into a tube. The honey is secreted from an annular swelling at the base of the ovary, above the points of attachment of the stalks of the stamens.

The Yellow Gentians are tall plants arising from a stout root-stock below ground, which is often 2 to 3 feet in length, so that the total length of the plant is sometimes nearly 6 feet. The upper portion of the root-stock is the stem, which is covered with numerous ring-like scars, marking the points of attachment of the leaves of former summers. These root-stocks often attain to a considerable age, forty-three years being recorded in one case. It is also stated that the plant is several years old before it produces any flowers.

The roots of *Gentiana lutea* contain a bitter substance, which is used in medicine as a tonic. Similar substances are also obtained from *G. punctata* and *G. purpurea*, the roots being often collected in Switzerland for this purpose. The Swiss also make a liqueur, Gentian brandy, from some species.

The leaves are large and rather like those of *Veratrum album*. They are about 10 inches long, and 2 inches at their broadest. The yellow flowers are borne from three to nine in a whorl. The petals are free and spreading. The anthers and stigmas mature about the same time, and so, no doubt, some self-fertilisation takes place.

The flowers of the Yellow Gentian are regarded as approximating closely to the primitive type of Gentian flower, from which the blue-flowered and other species have been evolved, largely by specialisation to particular groups of insects. Here the petals are free, whereas in all the other species they are united to form bells or long tubular corollas, adapted to fertilisation by long-tongued insects, such as humble-bees and butterflies. The yellow colour is also a primitive feature, whereas blue is a derived colour, and is especially attractive to certain groups of insects, such as bees.

The nectary is also more primitive in *Gentiana lutea* than in any other species. In other Gentians it is found at the base of the corolla—that is, farther from the entrance to the flower and out of reach except to those insects possessing long tongues.

PLATE XI.
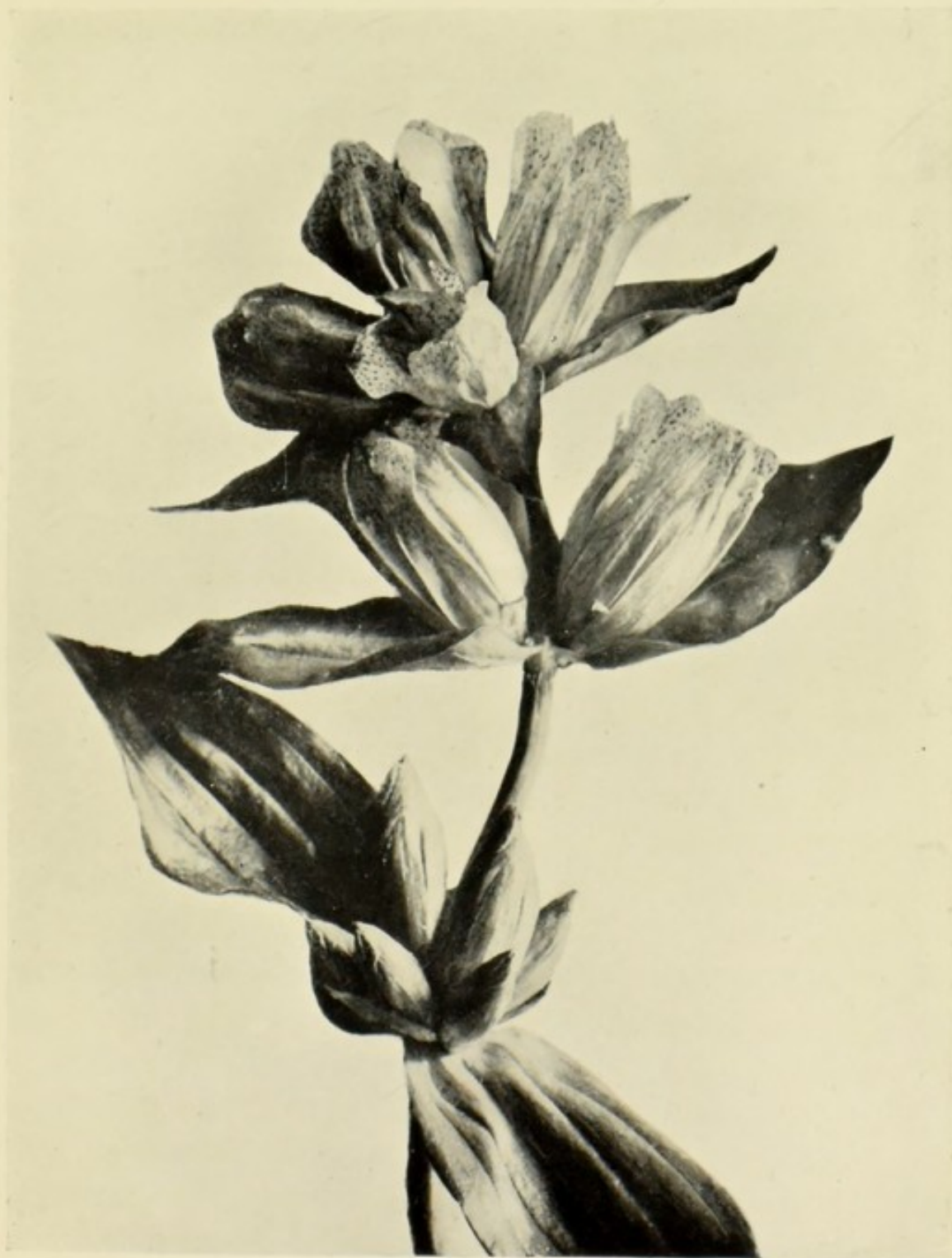
The Flowers of the Spotted Gentian (*Gentiana punctata*, Linn.).
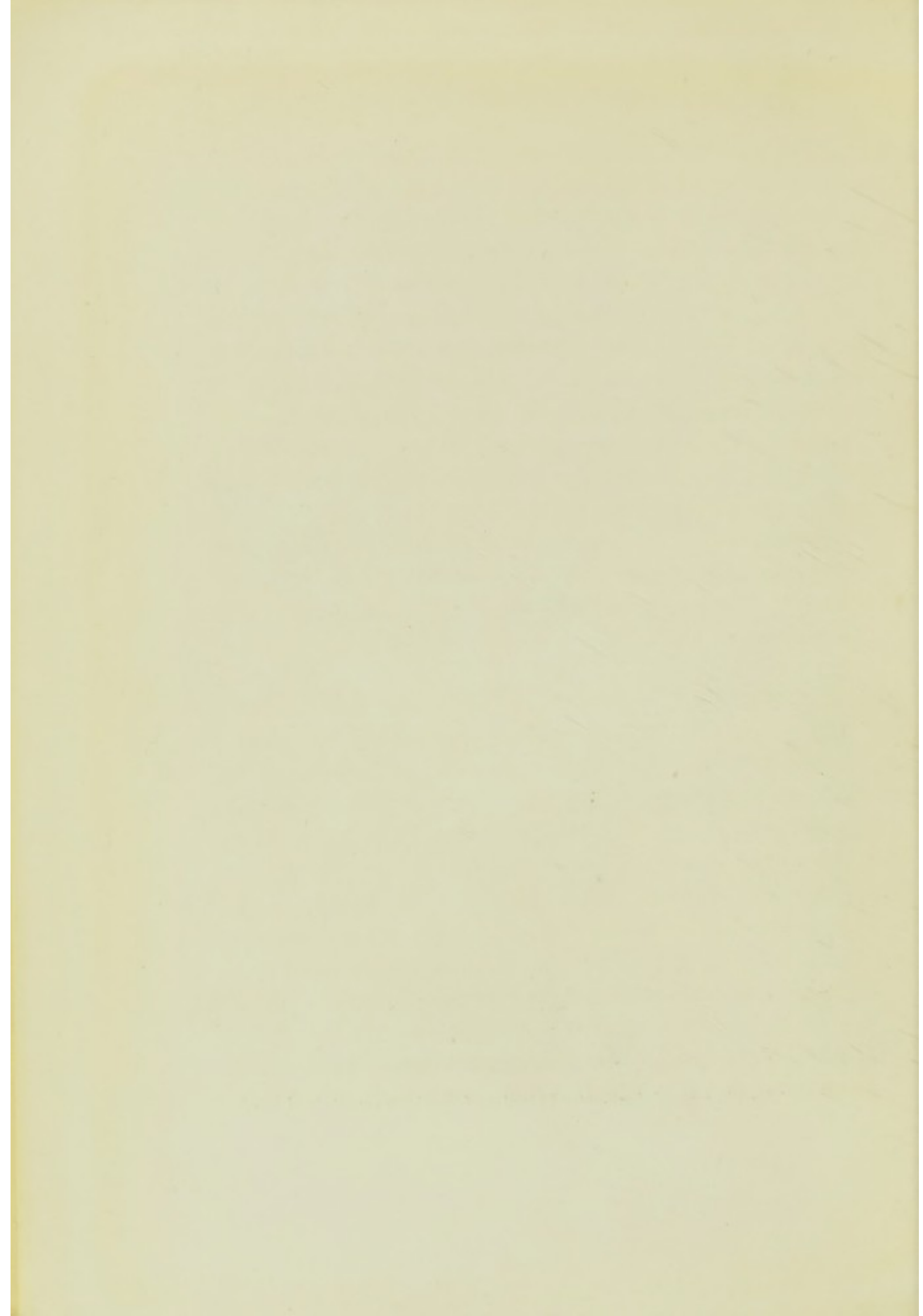
The various contrivances which tend to close the mouth of a tubular corolla, such as scales at the throat, which we have noticed in discussing the blue-flowered species, are all less primitive devices to keep out unbidden guests, and adaptations in favour of particular kinds of insect visitors. Whereas the flowers of the Yellow Gentian are open to almost all comers and the honey is not protected. A very different state of affairs is met with in the Field Gentian, as we have seen, where a long, narrow tube, closed with scales at the mouth, must be penetrated before the honey is reached.

Again, the fact that in the Yellow Gentian the anthers and stigmas ripen simultaneously, and not at different periods, points to a greater degree of primitiveness than that met with in the other species.

The Spotted, Purple, and Hungarian Gentians.

The remaining Swiss Gentians with yellow and red flowers possess many points of similarity in habit to the Yellow Gentian. The Spotted Gentian (*Gentiana punctata*, Linn.) (Plate XI.) has yellow flowers, ornamented with reddish-brown or purple spots. The petals are all united to form a bell, and the calyx is also bell-shaped, with five very dissimilar teeth. The Purple Gentian (*Gentiana purpurea*, Linn.) has also a bell-shaped corolla, red outside and yellowish within, but the calyx is incompletely united on one side. The Hungarian Gentian (*Gentiana pannonica*, Scop.), which is less abundant in Switzer-

land than the preceding species, has a dark red bell corolla, spotted with black, and a bell-shaped calyx, the teeth of which are bent backwards.

In the union of the petals into a bell-shaped corolla, in the position for the nectaries at the base of the corolla, and in the colour of the flowers—the evolution of red or purple from yellow—these flowers show a marked advance on the primitive features met with in *Gentiana lutea*. The male and female organs also ripen at different periods, and not simultaneously, as in the Yellow Gentian.

CHAPTER III

TYPICAL FLOWERS OF THE ALPINE PASTURES
(*continued*)

THE SOLDANELLAS, THE PRIMULAS, THE ANDROSACES, THE SAXIFRAGES, THE CAMPANULAS, AND THE RAMPIONS.

IN the present chapter we will consider some of the other genera characteristic of the Swiss pastures, beginning with the members of the Primrose family—the Soldanellas, Primulas, and Androsaces, and then passing to the Saxifrages, the Campanulas, and the Rampions.

The Primrose family (natural order Primulaceæ) is very well represented in the Alpine zone, one of the most interesting genera being the Soldanellas.

THE SOLDANELLAS.

The Soldanellas, or, as the Germans call them, " Alpenglöckchen " (the little bells of the pastures), are among the earliest flowers to bloom in the pastures when the snow begins to melt ; they are often extremely

abundant. They also occur on the margins of woods, flowering from the first sign of spring until June or July.

The genus is not found in Britain. In the Swiss Alpine zone there are two common species: the Alpine Soldanella (*S. alpina*, Linn.) and *Soldanella pusilla*, Baumgarten, which we may call the Small Soldanella. The former bears two to three flowers on each flowering shoot (Plate XLII., Figs. 2 and 3), the large, pale lilac flowers being bell-shaped and drooping. The petals are deeply fringed, the fringe extending for half the entire length of the corolla. In the Small Soldanella, the fringe is shorter, and does not exceed one-third of the length of the petals, and only one flower is, as a rule, borne on each flower-stalk. The bell-like corollas are here usually violet in colour. The leaves of both species are thick, dark green, heart-shaped structures, mounted on long stalks, which arise from the stem just below the surface of the ground. The leaves persist throughout the winter, and are recumbent on the soil. Below ground there is a fairly stout stem giving off numerous roots.

Like the Crocus, which we shall discuss in a later chapter devoted to meadow flowers, the Soldanellas often bloom before the winter's snow has melted. A photograph of Soldanellas flowering in the snow is shown on Plate XII. The flower matures gradually during the winter months. At first it is quite a small object, down among the bases of the leaves. Long before the snow has begun to melt, the plant

PLATE XII.
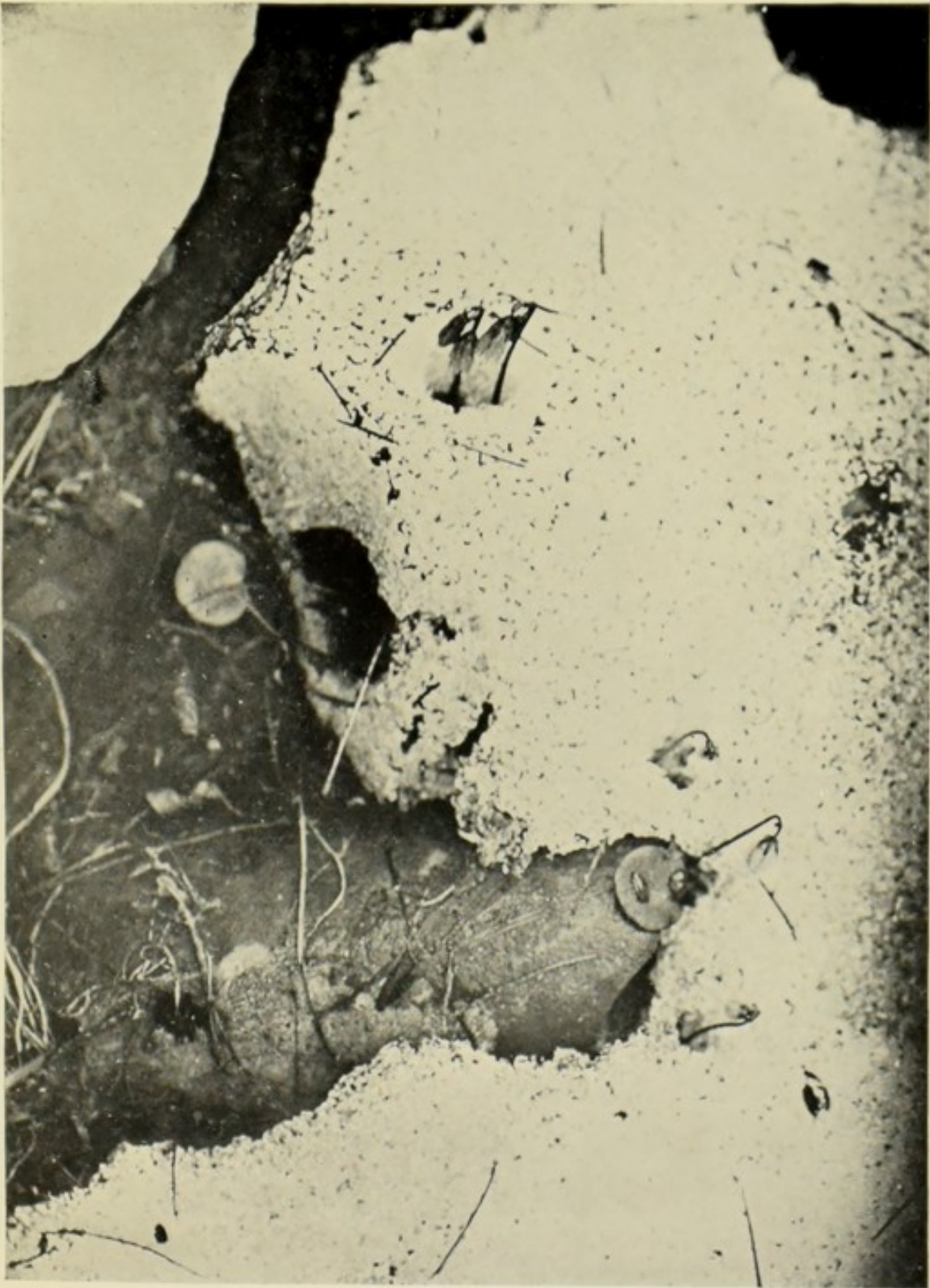
The Alpine Soldanella (*Soldanella alpina*, Linn.) Flowering in the Snow.
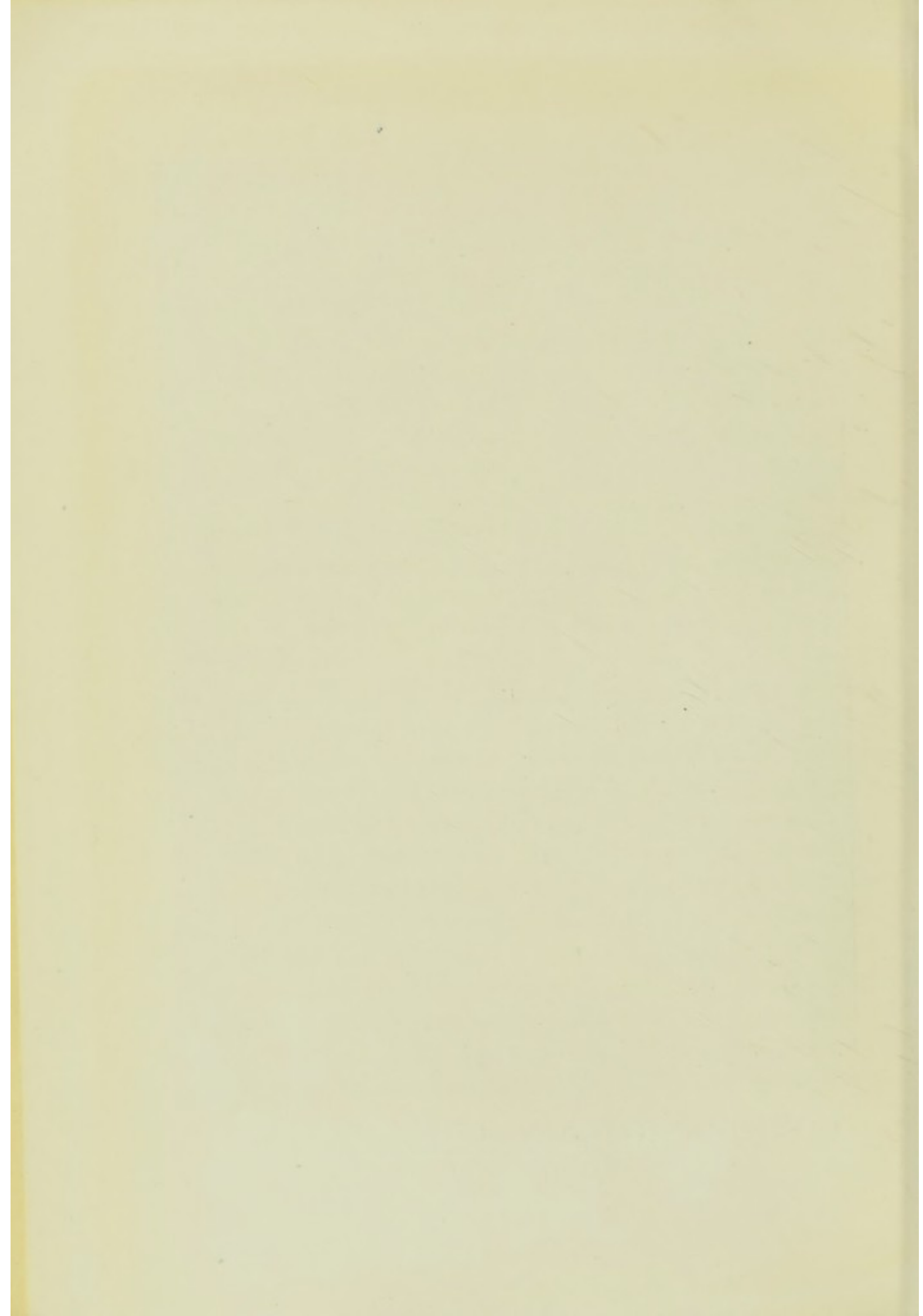
is at work. The energy for growth is supplied by the reserve food material stored up during the previous autumn, not only in the underground stem, but in the leathery, evergreen leaves themselves. As the flower matures, the flower-stalk is pushed up through the snow. It was formerly thought, on the authority of the great Austrian naturalist, Kerner, that the plant had the power of melting the snow and forming a little dome-shaped cavity above the flowers. It was believed that the heat necessary to melt the dome was derived from the respiration (p. 11) accompanying growth, that is, the conversion of the raw food material into the substance of new tissues. We are not, however, quite sure now whether this plant really has the power of melting the snow above it. No doubt dome-shaped cavities often occur above the plant. One of these is seen cut across, in the middle of the photograph on Plate XII., and rather to the left-hand side, on the margin of the snow. It is also a matter of common observation and experiment, that young developing flower-buds do set free considerable heat, their temperature rising sometimes as much as 2° to 3° Centigrade above that of the atmosphere. There was, therefore, much inherent probability that Kerner's account was correct. However, it is now doubted whether the heat set free by the developing plant is sufficient to melt the snow above it, and cases have been observed where there is no dome-shaped structure to be found. What does appear to be clear is, that once a dome-shaped

structure is formed above the plant, to whatever cause we may attribute its origin, the flower-stalk grows rapidly and pierces it before the sun has melted it away from above. The flower-stalks have thus, under certain conditions at any rate, the power of piercing the snow. It will be observed that the stalk of the individual flower is arched, and that the bell-shaped corolla droops from it. In the passage upwards to the light, the bell is thus saved from injury, for it is the arched flower-stalk which actually bores through the snow.

We have here a good example of a common feature among Alpine plants—the tendency to flower at the earliest possible moment in the spring. The summer season is very brief, and the period before the plant is again buried in the snow all too short for the work which lies in front of it.

The leaves, in which, as we have seen, are stored the reserves for spring growth, are exhausted and perish after the plant has reached the light. New leaves are formed later in the season, and in them are laid by the fresh reserves for the following winter.

The flowers of the Alpine Soldanella are worth examining closely (Text-fig. IV.). The five stamens spring from the corolla, as in all members of the Primrose family, and when mature are firmly pressed against the style or upper portion of the pistil. The pollen, even when mature, is thus closely held between the inner surface of the anthers and the style. When, however, an insect, visiting a flower in search of the

honey secreted by the nectary at the base of the corolla, inserts its proboscis between the style and the obliquely placed stamens, the moment the former is separated from the latter a shower of pollen falls on to the insect's head. This, as likely as not, is
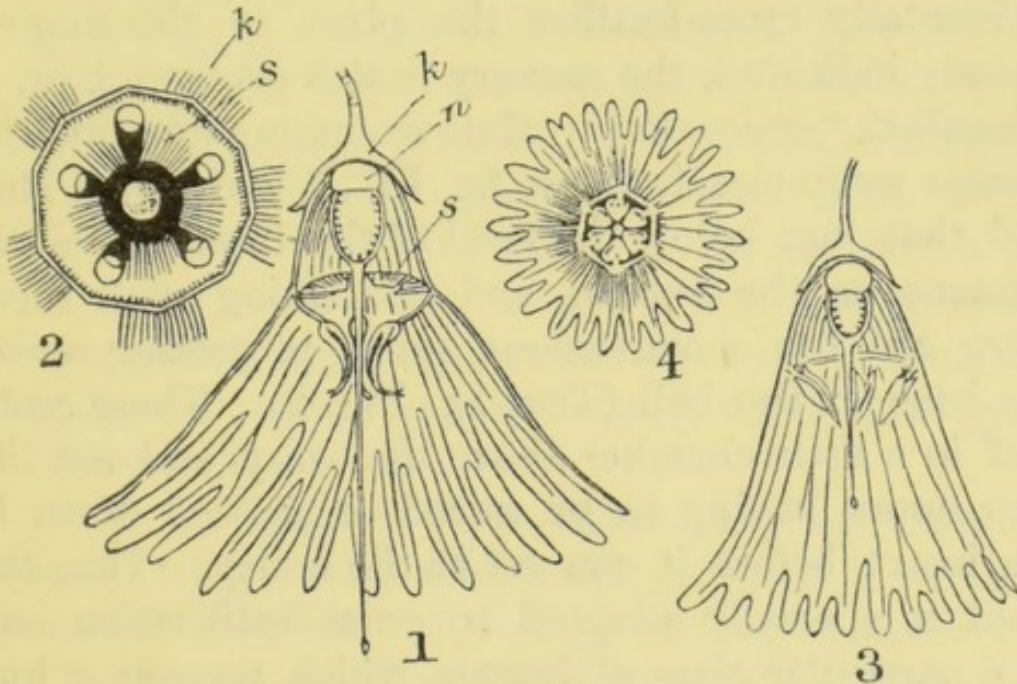
FIG. IV.

1 and 2. The Alpine Soldanella (*Soldanella alpina*, Linn.).

1. Longitudinal section of the flower. 2. Section across the flower on the level of the scales ; *s*, scales ; *n*, nectary ; *k*, calyx. Fig. 2 shows how the ring of five scales closes the entrance to the lower portion of the flower.

3 and 4. The Small Soldanella (*S. pusilla*, Baumg.).

3. Longitudinal section through the flower. 4. Section across the flower in the plane of the anthers. (All after Schroeter.)

carried to another flower of the same species, and placed on the stigma at the tip of the style as the insect enters the flower.

The interior of the flower of an Alpine Soldanella can only be approached by flying insects. The drooping position of the bell, with mouth directed

E

downwards, and possibly also the fringed edge, bars access to insects crawling upwards from below by means of the flower-stalk. But, in this plant, as it were, to make doubly sure that only insects with a long and stout proboscis shall reach the honey, and incidentally cross-fertilise the plant in the manner already indicated, the nectary is also protected, or, as it is called, " concealed." If we examine a flower of this species more closely (Text-fig. IV., 1 and 2), we shall find that just below the level of the insertion of the stamens on the corolla, and alternating with them, there are five membranous scales projecting across the base of the bell (Text-fig. IV., 2). These scales roof in a little chamber above the ovary, and act like trap doors, having to be raised or pressed down by the insect before it can get at the honey. Thus this plant is specially adapted to cross-fertilisation only by a particular class of insects which possess a long and strong proboscis.

In the Small Soldanella (Text-fig. IV., 3 and 4) these scales are absent, and the tips of the stamens are not produced into horns, as in the Alpine Soldanella.

The Primulas.

We are familiar in Britain with several Primulas, especially the Primrose, Cowslip, and Oxlip. All of these also occur in Switzerland, but the Oxlip is the only one which is commonly met with, within the Alpine zone, at comparatively low elevations. In

addition to these three species, there is another less commonly known British plant, the Bird's-eye Primrose, which occurs in the north of England, especially on the hills. Of all the Swiss Alpine Primulas, this is by far the most abundant.

In Alpine Switzerland there are also several Primulas of great interest and beauty which do not occur wild with us. Of these, the Auricula, the original parent of our cultivated Auriculas, stands first. It has yellow flowers and characteristic leaves, which are thick, fleshy, and dusted with a white waxy powder. It thus stands in strong contrast to the Primrose and Cowslip, so common in this country, which have green wrinkled leaves.

Next we have the rare Alpine, the Long-flowered Primula, with leaves which are green and wrinkled above, but covered below with a waxy powder like that found on both sides of the leaf of the Auricula.

Lastly, we have five other Alpine species with violet or rose-coloured flowers, and leaves which are green and not powdery.

We will commence with the Oxlip (*Primula elatior*, Jacq.). The individual flower-stalks are all mounted on a long common flower-stalk, the whole forming an umbel, in the manner which we have already noticed in the case of the Narcissus-flowered Anemone. This arrangement of the flowers is characteristic of the Primulas, and occurs even in the Primrose (*P. vulgaris*, Huds.), where, however, the common flower-stalk is short, and sunk beneath the

level of the soil. For this reason it is often over-looked.

The Oxlip is a good plant on which to observe the very interesting adaptation to cross-fertilisation known as *heterostylism*. If we slit open with a needle or pin the corollas of a number of flowers, we shall be able to distinguish two types. One set will
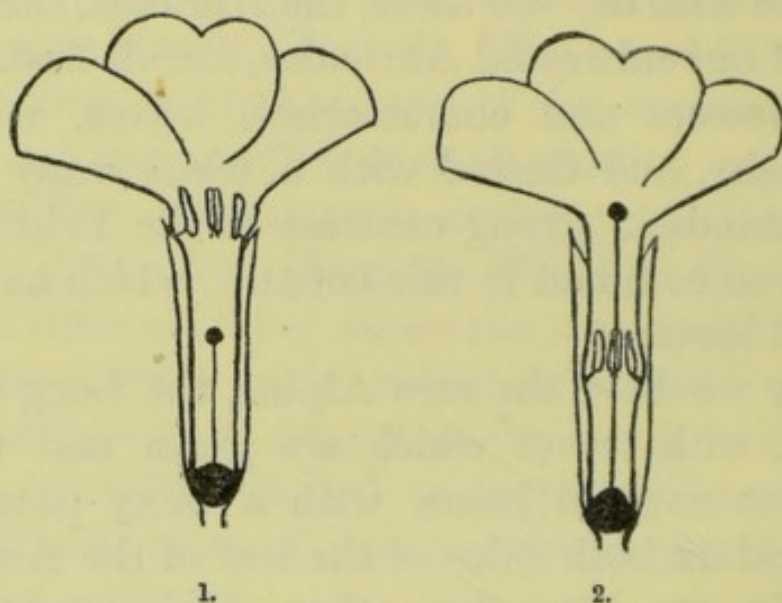
FIG. V.—Diagrammatic Views of the Heterostyled Flowers
of a Primula.

1. Flower with short style and high stamens.
2. Flower with long style and low stamens.

be found to possess a long style (the prolongation of the ovary) extending almost to the throat of the corolla tube (Text-fig. V., 2), and five short stamens, seated on the corolla itself, near the base of the corolla tube.

Other flowers will be found to be the exact opposite (Text-fig. V., 1). The style here is very short and the stamens are very long, and occupy the same

PLATE XIII.

The Bird's-eye Primrose (*Primula farinosa*, Linn.).
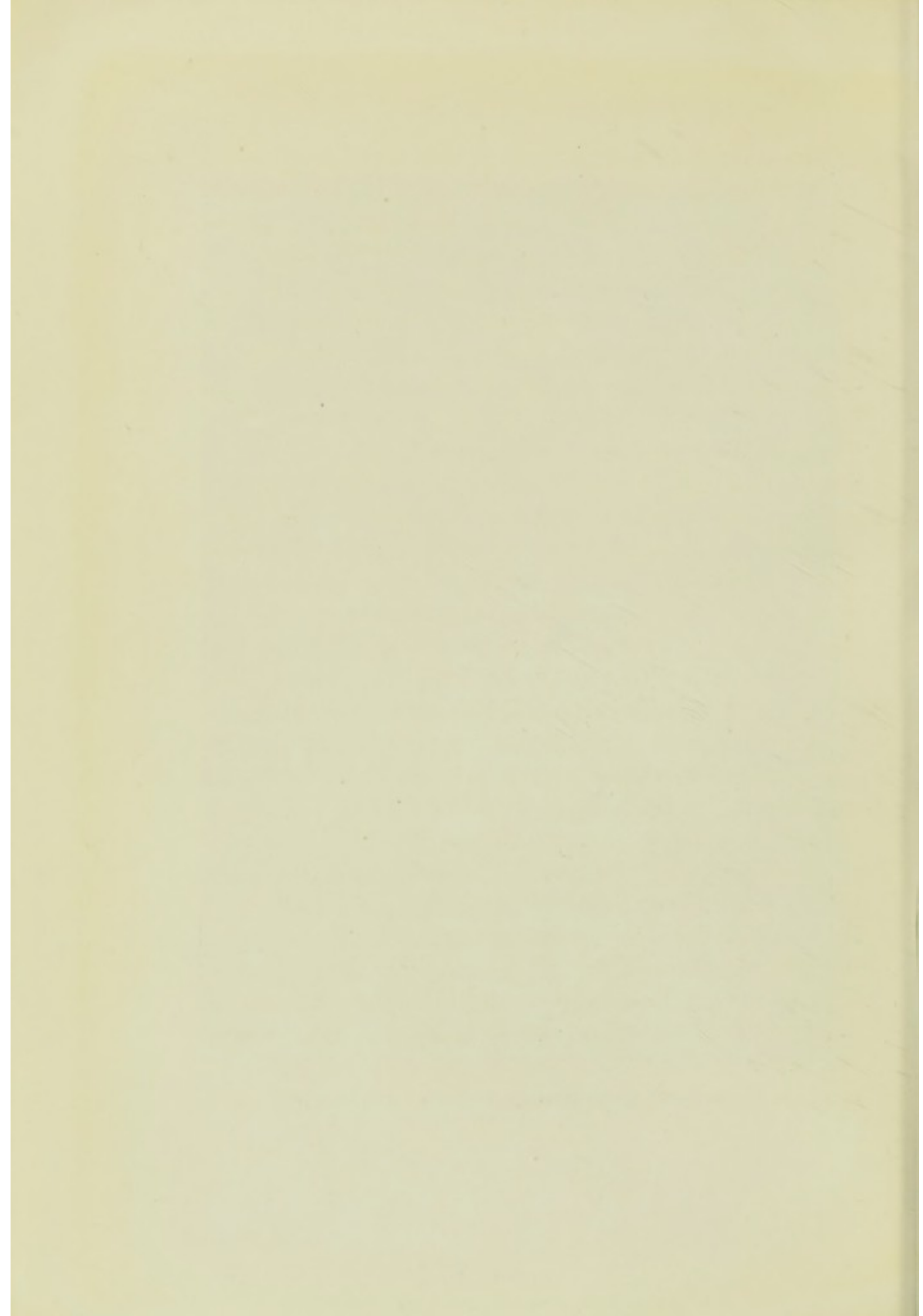
relative position as the head of the style in the first set of flowers. The great naturalist, Charles Darwin, showed that these differences constitute a special mechanism or contrivance to ensure cross-fertilisation. For example, a bee, visiting a long-stamened flower, would get dusted with pollen around the base of its proboscis or tongue, and this pollen could not fail to be deposited on the stigma of the next long-styled flower it visited. Darwin found by experiment that a full yield of seed is only obtained when the pollen from a flower with long stamens is transferred to the stigma at the top of a long-styled flower, or when the pollen from short stamens is transferred to a flower with a short style. This is "legitimate pollination." If by any chance illegitimate pollination takes place— that is, from a short stamen to a long style, or *vice versa* —the seeds that result are few, and more or less steri'e. A similar adaptation is met with in other Alpine Primulas, including *P. farinosa*, and also in one of the Androsaces. In some Lowland plants, for example in *Lythrum*, three kinds of flowers occur with different lengths of stamens and styles.

The Bird's-eye Primrose, *Primula farinosa*, Linn. (Plate XIII), is so called because the pale lilac flowers have a yellow "eye" or ring round the throat of the funnel-shaped corolla. This plant is one of the earliest spring blossoms in the damper pasturages, where it flowers in countless millions. The leaves are green and smooth above, but are covered below by a white, mealy wax or bloom.

Kerner states that the wax on the lower side of the leaf tends to protect the plant by hindering the access of water to the minute pores or stomata which exist on the lower surface of the leaves of the rosette, placed close to the ground. Were the leaves to become saturated with water, the gases of the atmosphere would no longer have free access to the leaf, and thus the whole internal economy of the plant would come to a standstill. The presence of a layer of wax prevents the lower surface from becoming easily wetted. This can be demonstrated by immersing a leaf in water for a few minutes. It will then be found that whereas the upper surface, where there is no wax, is easily wetted, the lower remains quite dry.

The Auricula (*Primula auricula*, Linn.) (Plate XIV., Fig. 1) is, as we have said, one of the original parents of our cultivated Auriculas. The Primulas, as a whole, are very apt to form hybrids—that is, crosses between, not two individuals of the same species, but of two different species. Our garden Auriculas are all derived from a cross between *P. auricula*, Linn., and *P. hirsuta*, All., which gives a hybrid (*P. pubescens*), and this is the stock from which yet other hybrids can be obtained.

The hybrid, as we should expect, combines the characters of both parents. The corolla limb is partly yellow and partly red or violet, the yellow colour being derived from the Auricula, the red or violet from the other parent. The question of the inheritance of characters in hybrids is a very interesting one, and

PLATE XIV.
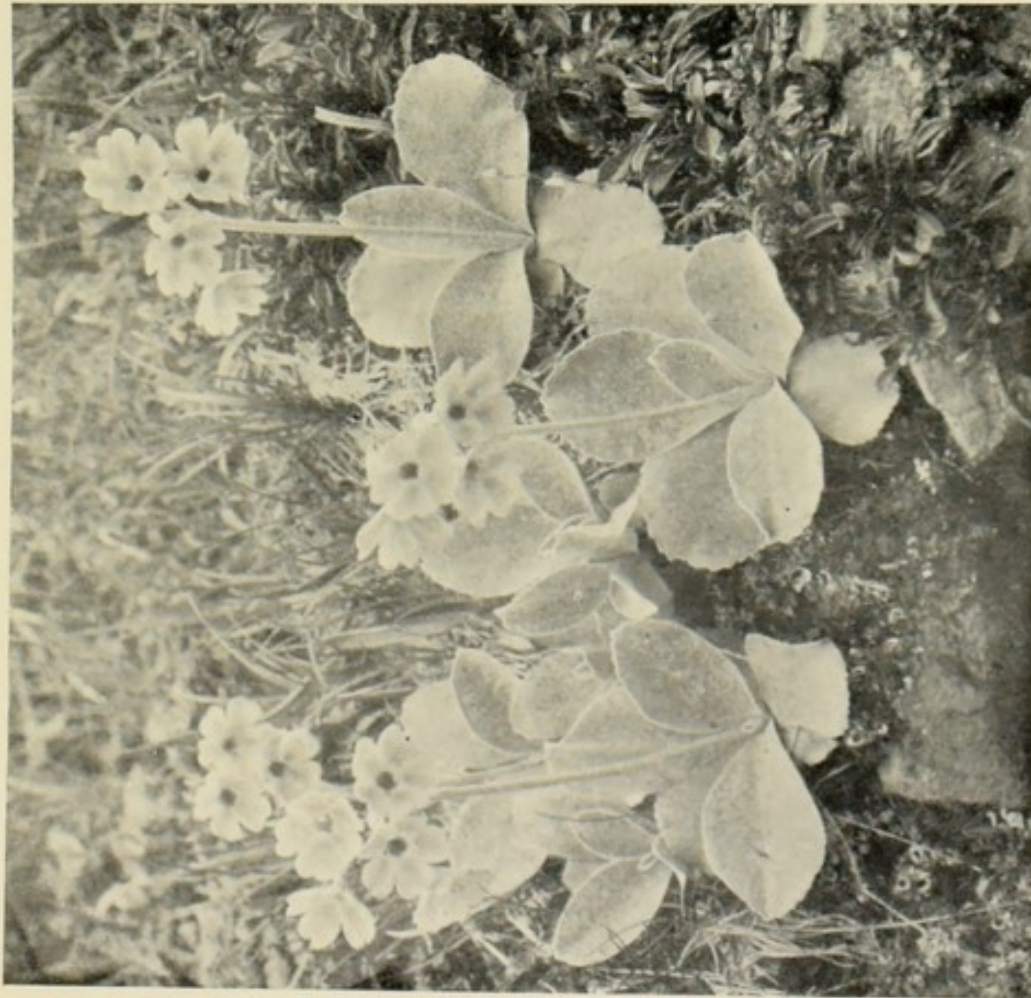
FIG. 2.—The Dwarf Androsace (*Androsace chamæ-jasme*, Willd.).

[*To face p.* 70.

FIG. 1.—The Auricula (*Primula auricula*, Linn.).
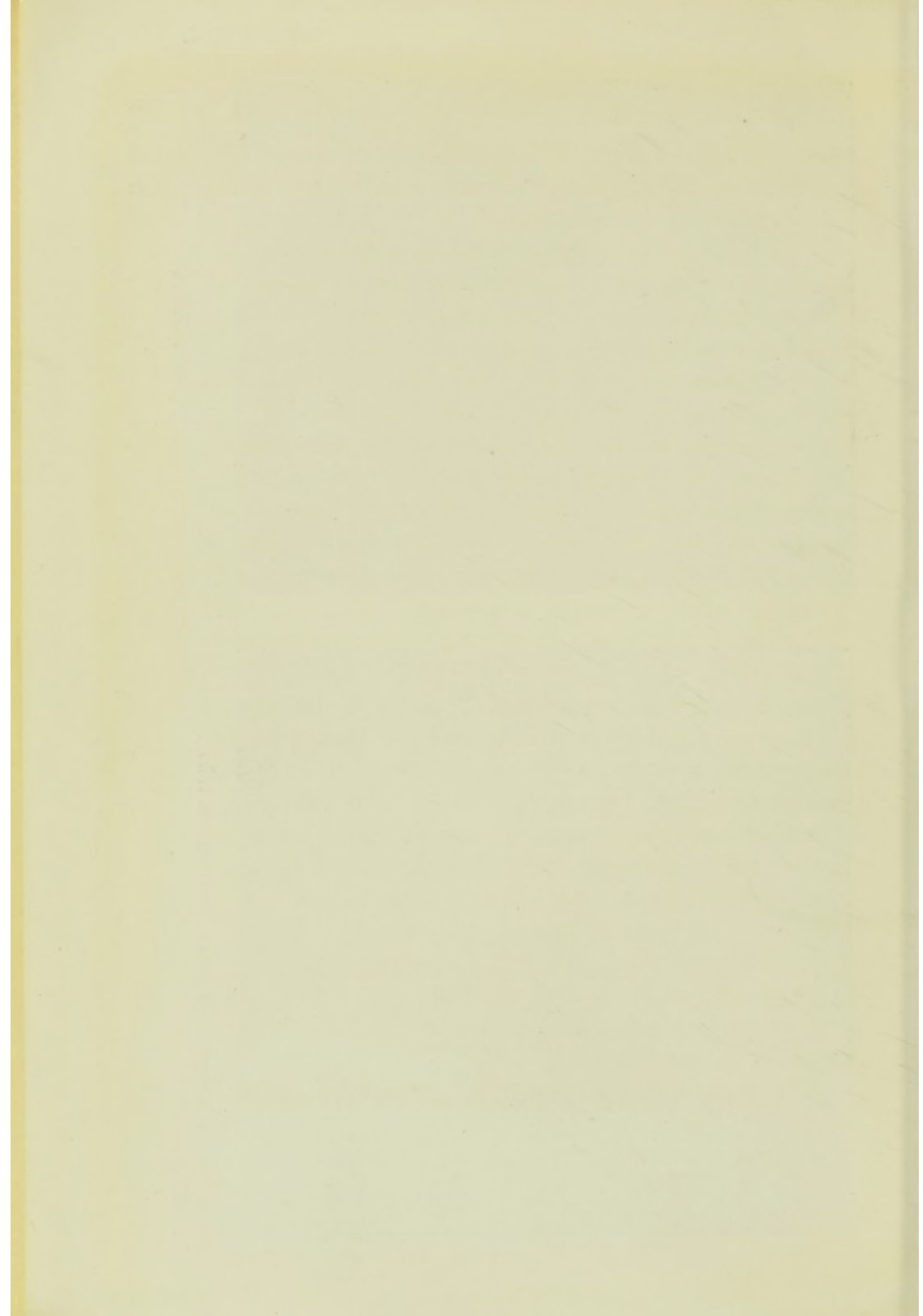
much research has recently been done on this point. It would, however, involve a too lengthy botanical preface to permit us to discuss it here.

The Auricula flourishes chiefly on limestone soils, in fairly dry situations. It is extremely abundant in June, for instance, on the terraces of the natural rock garden of the Engstlen Alp (Canton Berne), where the limestone rocks are weathered into fantastic shapes, owing to their solubility and lack of resistance to decay under the influence of atmospheric agencies. This pasturage resembles an artificial rock garden covering thousands of acres in extent, and in the crevices of the decayed limestone crags many an Alpine plant of interest flourishes in addition to the Auricula.

The rosette of leaves of the Auricula placed close to the ground is well protected against the danger of undue evaporation of moisture, under the hot suns of early summer, by the waxy covering or mealy bloom, with which both the upper and lower surfaces are thickly dusted. The leaves themselves are really green, though the colour is masked by the mealy powder. In addition, there are special tissues for water storage within the substance of the leaf, as its thick semi-succulent nature would lead one to imagine. It will be noticed that the waxy bloom is not confined to the leaves, but also occurs both on the common and the individual flower-stalks, as well as at the throat of the corolla itself.

The Long-flowered Primula (*Primula longiflora,*

All.) is a rare plant, occurring chiefly in the Engadine and in the Zermatt and Saas valleys. It is remarkable for the length of the corolla tube as compared with the calyx. It is believed to be the only European Primula which does not possess long-styled and short-styled flowers (see p. 68). The leaves are similar to those of the Bird's-eye Primrose, the lower surface being covered with a waxy powder.

Of the other species of Swiss Primulas, there is little of interest to relate. Their leaves do not possess a mealy powdering on either surface, and their rose- or violet-coloured flowers have relatively short, common, and individual stalks. The Hairy Primula (*P. hirsuta*, All.) and the Entire-leaved Primula (*P. integrifolia*, Linn.) are the commoner species.[1] In the former the leaves are thickly covered with sticky glandular hairs, while in the latter they have only a few such hairs on the margins. The Hairy Primula has strong-scented flowers, and in the autumn the glandular hairs on the leaves turn bright red in colour. It flourishes on bare rocks, especially in granitic and gneissic regions. As we have already remarked, it is one of the parents of the cultivated Auricula.

THE ANDROSACES.

Closely allied to the Primulas are the Androsaces, also members of the order Primulaceæ, and charac-

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[1] Three other species, *P. viscosa*, All., *P. œnensis*, Thom., and *P. glutinosa*, Wulf, are found in Canton Graubunden. They are distinguished with difficulty from the above and from one another.

teristic plants of Alpine habitats. The genus does not occur in Britain. These plants are well known to horticulturists for their aversion to the plains, it being very difficult, if not impossible, to cultivate some of them in England. In the Swiss Alps there are some eleven species, all much alike in external form. Several of them are confined to the High Alpine region, for the genus as a whole is strictly Alpine.

The habit (Plate XIV., Fig. 2) is quite like that of a Primula; only, the plant as a whole is much smaller. There is, just above the ground, the same little rosette of leaves, from which springs a common flower-stalk ending in an umbel of flowers. The corollas resemble those of the Primula in shape. The flowers are, however, distinguished by the fact that between each of the five lobes of the petals, we find a little scale, not unlike that which we have already noticed in the case of some Gentians. These five scales tend to narrow the entrance to the mouth of the corolla. The Androsaces, except Vital's Androsace, do not possess long-styled and short-styled flowers (p. 68).

In the High Alpine species, the umbel is frequently reduced to a single flower. This is a marked feature in plants, which in the lower Alpine regions possess inflorescences of several flowers. As we ascend higher and higher, the number of flowers in the inflorescence decreases, and finally only one remains. This is the case in the Saxifrages, the Harebells, and many other genera besides the Androsaces.

The flowers of most of the Swiss species are white,

often with a yellow or red "eye." In one species, however (*A. carnea*, Linn.), they are rose coloured, and in another (*A. vitaliana*, Lap., Plate XXXVII., Fig. 1) they are yellow. It often happens, however, that the flowers of species which are usually white may be rose-coloured.

The commonest and most widely distributed species is *Androsace chamæjasme*, Willd., the Dwarf Androsace (Plate XIV., Fig. 2), in which the whole plant except the flowers is covered with long hairs, especially on the edges of the leaves. The Obtuse-leaved Androsace, *A. obtusifolia*, All., and the Red-flowered Androsace, *A. carnea*, Linn., are also common, especially in western Switzerland. They have short hairs on the leaves and flower-stalks, but are otherwise very similar in habit.

The Saxifrages.

The Saxifrages (natural order Saxifragaceæ) are among the most characteristic of Alpine plants. Though the individual flowers are often rather small and not very showy, they are rendered conspicuous by the mass of bloom borne by each little colony of these plants on some rocky shelf (Plate XV.).

Britain is rich in Saxifrages, possessing no fewer than thirteen species, some confined to our highest mountains, others common in the meadows and woods of the Lowlands. Two of these occur in Alpine Switzerland, where there are also to be found about eighteen other species. Of these eighteen,

PLATE XV.

A Bank of the Rough Saxifrage (*Saxifraga aspera*, Linn.), with the Rock Catchfly (*Silene rupestris*, Linn.), and a Rampion (*Phyteuma*, sp.).

[*To face p.* 74.]
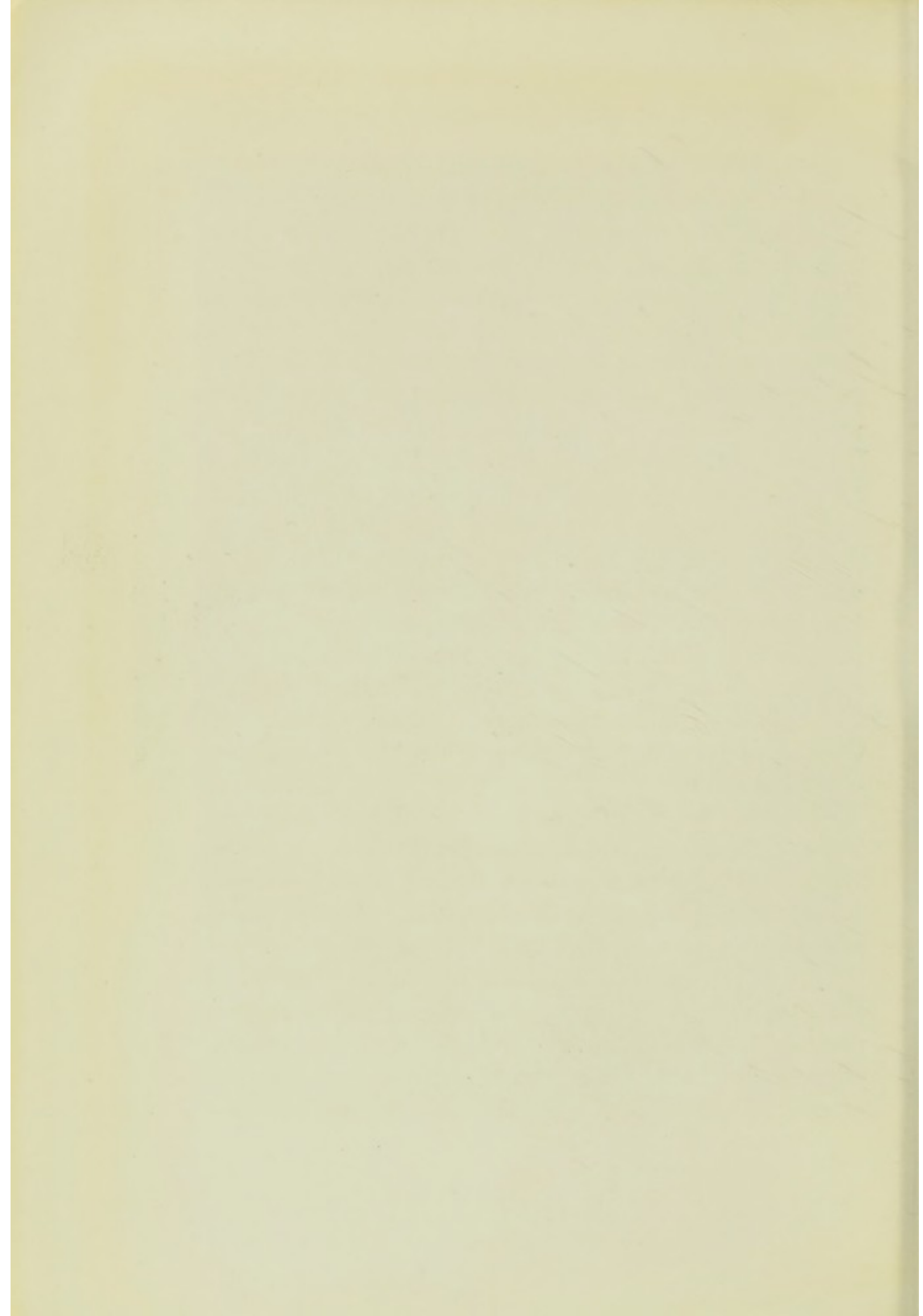
some seven are confined to the High Alpine region, and these we will reserve for a later chapter.

The habit of many of these Saxifrages is quite typical of that of the majority of Alpine plants. The plant is, so far as possible, buried in the scanty soil, especially the roots and the very short stem. Above the soil, one or more compact rosettes of leaves are pressed close to the surface of the ground. These characteristic rosettes often form a beautiful leaf-mosaic (Plate XVI., Fig. 1), each leaf being arranged in regard to its neighbours so as to cut off as little light from it as possible. The really conspicuous part of the plant is the flowering shoot, which often bears several leaves and numerous flowers, and may vary from a few inches to a foot or more in height.

The individual species are not, as a whole, very dissimilar, and in some cases may only be distinguished with difficulty from one another. These plants are thus perhaps less interesting than those of many other Alpines.

The Alpine Saxifrages may be divided into two groups, the first of which, containing some six species, has undivided leaves, bearing a row of conspicuous, white chalk-glands along the margins. These glands are clearly seen on Plate XVI., Fig. 1.

In *Saxifraga aizoon*, Jacq. (the Evergreen Saxifrage) (Plate XVI., Fig. 1), the leaves are strap-shaped, and each chalk-gland lies in a little notch on the edge of the leaf. The glands themselves are really invisible to the naked eye. All that we see here are

the little heaps or accumulations of calcium carbonate or chalk, which mark the position of the glands. We have already shown (p. 10) that the leaves of all plants have numerous but very minute pores or openings, by which the atmosphere has free entrance into the substance of the leaf itself, and by which the gases evolved by the internal mechanism of the leaf pass back to the atmo-
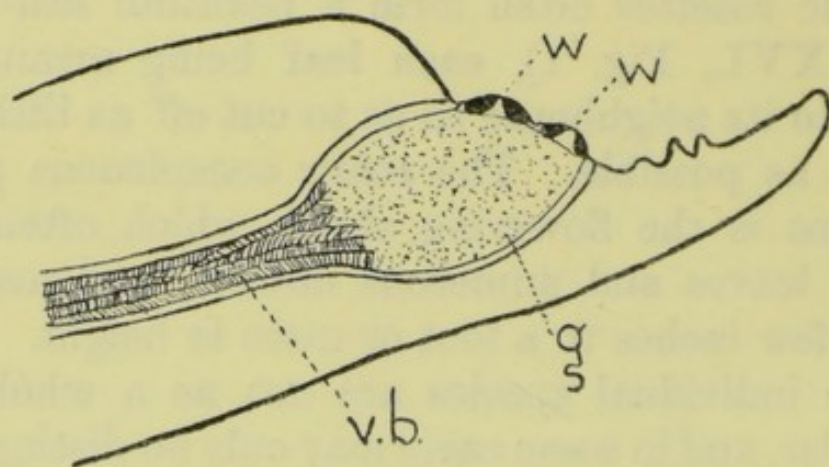
FIG. VI.—Section through a Chalk-gland on the edge of a Leaf of a Saxifrage.

w, the water stomata; *g*, the chalk-gland; *v.b.*, the vascular bundle of the leaf. Highly magnified.

sphere. In most plants these pores or stomata can be opened and closed. The chalk-glands or water stomata of the Saxifrages, on the contrary, are differently constructed, and remain always open. In order to prevent an undue amount of water-vapour escaping from the leaves — a matter of great importance to plants which, like the Saxifrages, grow in dry situations with but a limited supply of moisture in the soil—a small quantity of calcium carbonate in

PLATE XVI.

FIG. 2.—The Rock Catchfly (*Silene rupestris*, Linn.).

[*To face p.* 76.

FIG. 1.—Leaf Rosettes of the Evergreen Saxifrage (*Saxifraga aizoon*, Jacq.).
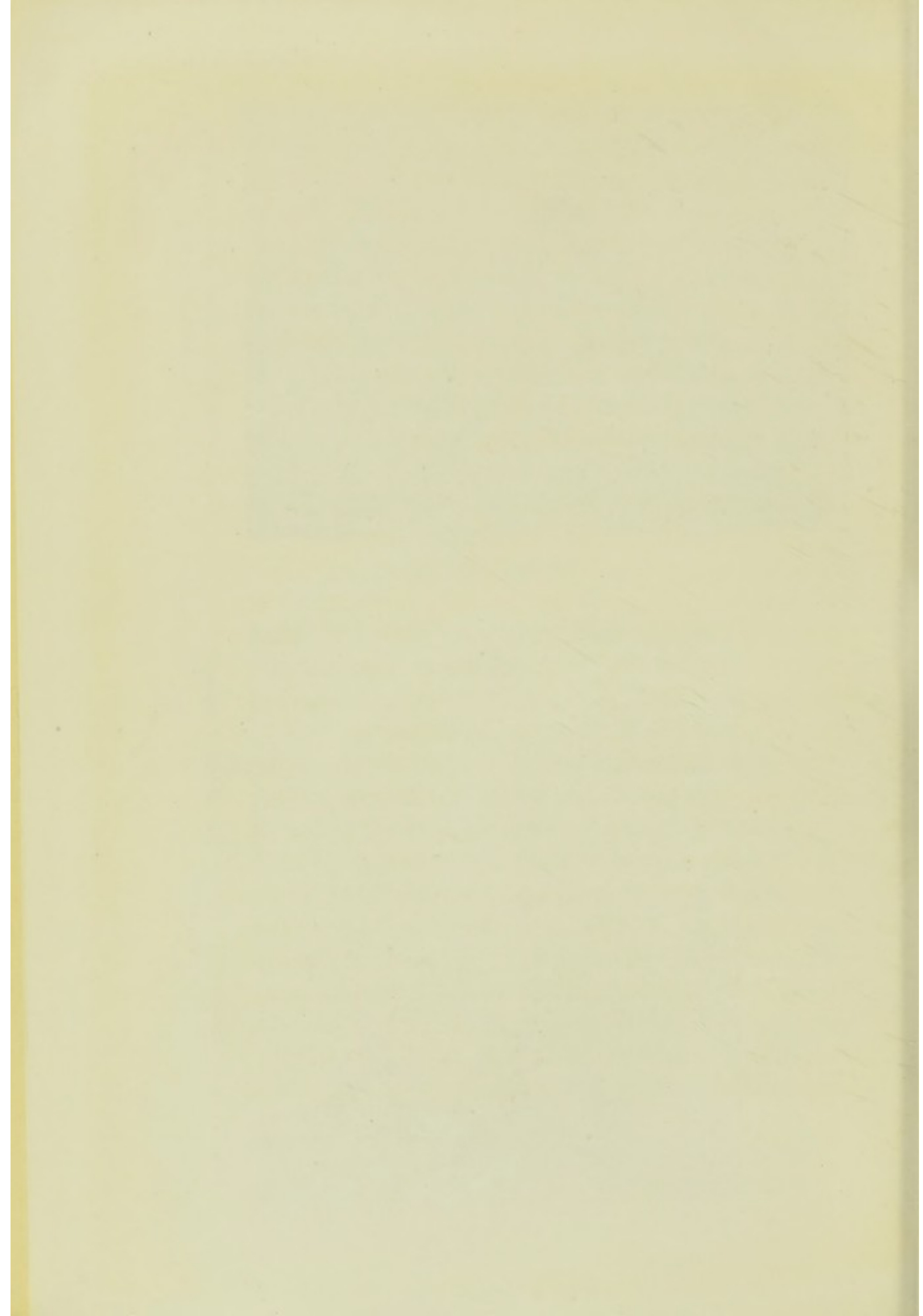
solution is secreted by the leaf, and this exudes at the pores. As the water evaporates, the chalk crystallises out, and blocks the mouth of the pore. In warm weather and in direct sunlight, the opening of the pore is almost completely closed in this manner. At night, however, when the temperature is lower, more water is secreted, which dissolves some of the calcium carbonate, and thus a freer passage for the gaseous exchange is afforded. In this way the chalk-glands control the rate at which the leaves lose water to the atmosphere.

It is a curious fact that Saxifrages with chalk-glands may often be found growing in abundance on rocks composed of granite or on schists, which contain very little or no lime. Yet by means of their roots these plants can obtain from the soil sufficient lime or chalk to render the incrustation-mechanism of the leaves quite efficient. The roots of plants have a peculiar property, known to botanists as " selective capacity," which enables them to gather in or absorb a sufficient quantity of a substance in the soil, even when it exists only in extremely minute quantity. Thus plants can appropriate, if they need it, a considerable quantity of one particular substance, to the exclusion of others. For instance, sea-weeds absorb from sea-water sufficient phosphorus—one of the essential elements to the life of all plants—though the amount of phosphorus in sea-water is so excessively small that it is quite impossible to estimate it. Closely allied to the Evergreen Saxifrage is the Thick-

leaved Saxifrage, *S. cotyledon*, Linn., which is the largest and most magnificent species occurring in Switzerland. It is not, however, common, except on granite rocks in Transalpine Switzerland and the St Gotthard region. It occurs also on the slopes of the Brévent, above Chamonix, where the tall-branched flowering shoots, 2 feet high, are conspicuous objects. Its leaves possess chalk-glands like those of *S. aizoon*.

The Purple Saxifrage (*S. oppositifolia*, Linn.) is a British plant of frequent occurrence in our mountains. In Switzerland it is common in stony and rocky places, especially in the High Alpine zone, and not infrequently is much in evidence in the Alpine region also. It is easily distinguished from all other Swiss Alpine Saxifrages by the solitary purple flowers, and the very small evergreen leaves placed in crowded pairs opposite one another. Each leaf has a single chalk-gland, situated at the blunt, somewhat thickened tip. The small creeping stems are much branched, and form a cushion composed of little tufts of leafy shoots (see p. 186) which seldom rise more than an inch above the surface of the ground. Only one flower is borne at the end of each branch, and these flowers, huge in size in comparison with the leaves (Plate XXXVI., Fig. 1), form a conspicuous advertisement to attract the insect world, especially butterflies. Thus cross-fertilisation is ensured.

There is also another but much less frequent

Alpine Saxifrage with purple flowers and opposite leaves. This is the Two-flowered Saxifrage (*S. biflora*, All.). Here, however, the flowers are not solitary, but borne two to five together, and the leaves are more distant from one another. Otherwise the resemblance to *S. oppositifolia* is marked.

We now turn to another series of Saxifrages, in which, instead of a single chalk-gland existing at the tip of the leaf, as in *S. oppositifolia* and *S. biflora*, or a line of glands occurring all round the edge, as in *S. aizoon* and *S. cotyledon*, we find only a limited number of chalk-glands, usually situated near the tip. The Glaucous Saxifrage, *S. cæsia*, Linn., is the commonest of these species, *S. diapensioides*, Bellard, being rarer and confined to the Canton Valais. The leaves of *S. cæsia* are borne in rosettes of a bluish-green tinge, and are bent or arched backwards almost from the base. Otherwise this plant is in no degree remarkable as compared with other Saxifrages.

The species of Saxifrage in which chalk-glands are absent from the leaves are more numerous, but are not, for the most part, deserving of special notice. The greatest contrast which they present is chiefly in the leaves. The Yellow-flowered Saxifrage (*Saxifraga aizoides*, Linn.), a frequent British Alpine, is also common, especially in damp places, in Switzerland. The leaves are narrow, rather thick, quite smooth and shining, and are not arranged in rosettes. The flowers are worth noticing on account of their red pollen and yellow honey nectaries. The sepals and petals are

both yellow and about the same length, so that at first sight the flower appears to have ten petals.

The Star-leaved Saxifrage (*S. stellaris*, Linn.) has thin egg-shaped or oblong leaves, toothed at the top, and borne in tufts near the ground, while the flowering shoots are entirely destitute of leaves. A small flower-leaf or bract is found at the base of each flower-stalk. The petals are white, two yellow spots occurring on each. It is a British plant, not uncommon in our mountains.

The Saxifrages last mentioned, and also the Round-leaved Saxifrage (*S. rotundifolia*, Linn.), are members of this genus which love damp, shady spots, and thus differ in their choice of habitat from many of the other Alpine species, which flourish on dry stony ground, or on exposed rocky ledges. This difference is indicated by their leaves, which are much larger and thinner.

The Round-leaved Saxifrage (*S. rotundifolia*, Linn.) has large, thin, heart- or kidney-shaped leaves, lobed and toothed, and white petals spotted with yellow and red. It is often a foot or more in height and much branched. The numerous flowering shoots bear leaves similar to those below, but smaller. The flowers of the Round-leaved Saxifrage are interesting from the manner in which the stamens shed their pollen, one by one—a peculiarity which is, however, shared by many other plants, including the Grass-of-Parnassus (p. 216). When the flower first opens, the stamens are as yet unripe, and they bend backwards

with the petals. Then in a day or so, one of the ten stamens becomes erect and moves in towards the centre of the flower, where it remains until it has shed its pollen on to the back of any insect that may visit the flower in search of honey. At the end of twenty-four hours or more, it bends back to its original position, and not till then does the next stamen begin to go through the same performance. After all the ten stamens have shed their pollen one by one in this way, and not until then, the two stigmas of the ovary mature. Thus the female organs of the flower cannot be fertilised by the pollen of the same flower.

As a typical example of the Saxifrages inhabiting dry stony places, we may instance the Rough Saxifrage (*Saxifraga aspera*, Linn.) (Plate XV.), which is widely distributed in the Alps. It has a very near relative, the Moss-like Saxifrage (*S. bryoides*, Linn.), which is perhaps only a High Alpine variety of the former. The flowering shoots of the Rough Saxifrage are leafy, and the thick leaves are rough with long hairs.

Further, many of the leaves bear large leaf-buds in their axils, which in the High Alpine (*S. bryoides*) are as long as the leaves themselves. The flowers of this species are also interesting botanically, from the fact that the ovary is superior or free from the calyx tube, whereas in the majority of Saxifrages the ovary is more or less united with the calyx tube.

The Rough Saxifrage, like all the other Swiss

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Alpine species, except *Saxifraga controversa*, Sternberg, is a perennial plant. The latter species is quite exceptional in being an annual.

The compact form of the colony is especially noticeable here, and is due to the fact that in the Alps a great struggle for existence is everywhere in evidence. Other plants tend to intrude into a colony of Saxifrages or other Alpines, and to rob them of their possession of the soil. In fact, what may be not unfairly termed plant slums, comparable as regards crowding to the worst slums of our great cities, though infinitely more beautiful, are to be seen on every hand in the Alps. Wherever the ground is unoccupied, there is strong competition among the neighbouring plants to seize upon it and to establish themselves, to the exclusion of others. The competition, however, is not only for the possession of the soil, but also for light and air — matters of equal importance to the plant. The photograph on Plate XV. shows a bank of the Rough Saxifrage, and is a typical example of an Alpine plant slum. The colony of the Saxifrage is here holding its own very successfully, although other plants have intruded into it. At the right-hand corner flowers of the Rock Catchfly (*Silene rupestris*, Linn.) (see Plate XVI., Fig. 2) are evident, and in this region a struggle between these two plants is in progress. Towards the left-hand side, two plants of a Rampion are seen with heads of flowers borne on long stalks. These are being overwhelmed by the advance of the

Saxifrage colony. Their leaves are arranged in the form of rosettes, pressed close to the ground, and it is absolutely essential for the welfare of the plant that the leaves should remain fully exposed to the light and air. In this case, however, they are being fast engulfed by the advancing colony of the Saxifrage with its tall growth of flowering shoots, which form a miniature forest.

THE CAMPANULAS, OR BELL-FLOWERS.

The Campanulas, or Bell-flowers (natural order Campanulaceæ), are very much in evidence in the Alps, and add appreciably to the strikingly large number of blue-flowered plants in that region.

The common British Harebell (*Campanula rotundifolia*, Linn.) (Plate XVII., Fig. 1) merits the distinction of being one of the most abundant of all Alpines in every sort of locality within this zone. In the Davos Valley, for instance, the intense blue of its flowers is noticeable, both in the meadows, on the higher and lower pasturages, and on the margin of the Pine forests; in fact, almost everywhere.

The specific name *rotundifolia*, or round-leaved, is often regarded as a misnomer, for the leaves visible at the time of flowering are all long and narrow. The first-formed leaves of the young seedling, or *cotyledons*, as the botanist terms them, of which there are two, and a few of the leaves which succeed them are, however, rounded or heart-shaped. The cotyledons

of the Harebell thus differ entirely in shape and form from the mature leaves of the adult plant, and this is also the case in many other plants. It has been found that i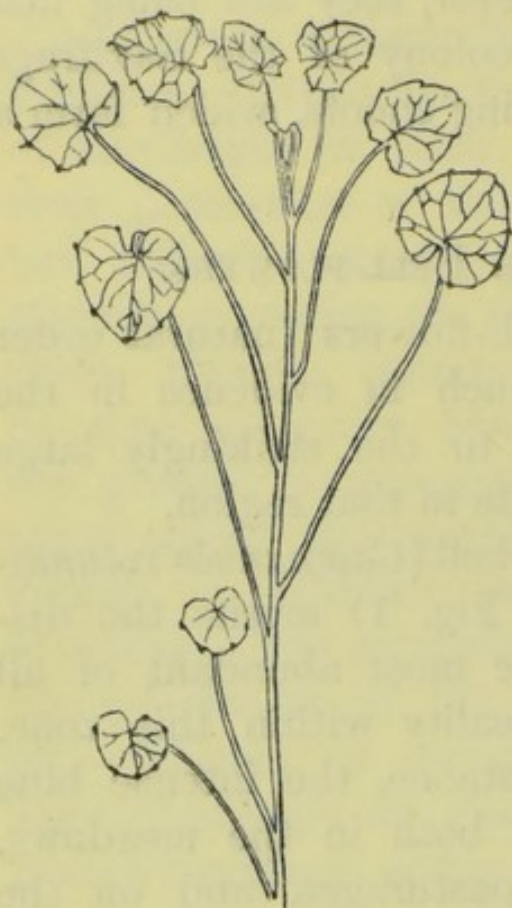n the Harebell these leaves are really shade-leaves (see p. 247) adapted to the conditions which prevail when the young seedling is forcing its way up to the light between its tall neighbours in whose shade it starts its existence. If a Harebell is grown from the seedling stage throughout the whole summer in a really shady place, all or many of its leaves may be heart shaped (Text-fig. VII.). The long, narrow leaves, on the other hand, with which we are more familiar, are sun-leaves, adapted for full exposure to the summer sunlight.

Fɪɢ. VII.—A Plant of the Round-leaved Campanula (*C. rotundifolia*, Linn.), grown in diffuse light. All the leaves are cordate, like the seed-leaves. (After Goebel.)

In many Alpine valleys, as at Saas, another species, *Campanula Scheuchzeri*, Vill., named after the celebrated Swiss geologist of Zurich, occurs in place of our British Harebell. Scheuchzer's Bell-flower is not a British plant, although it is so like our Harebell. The flowers
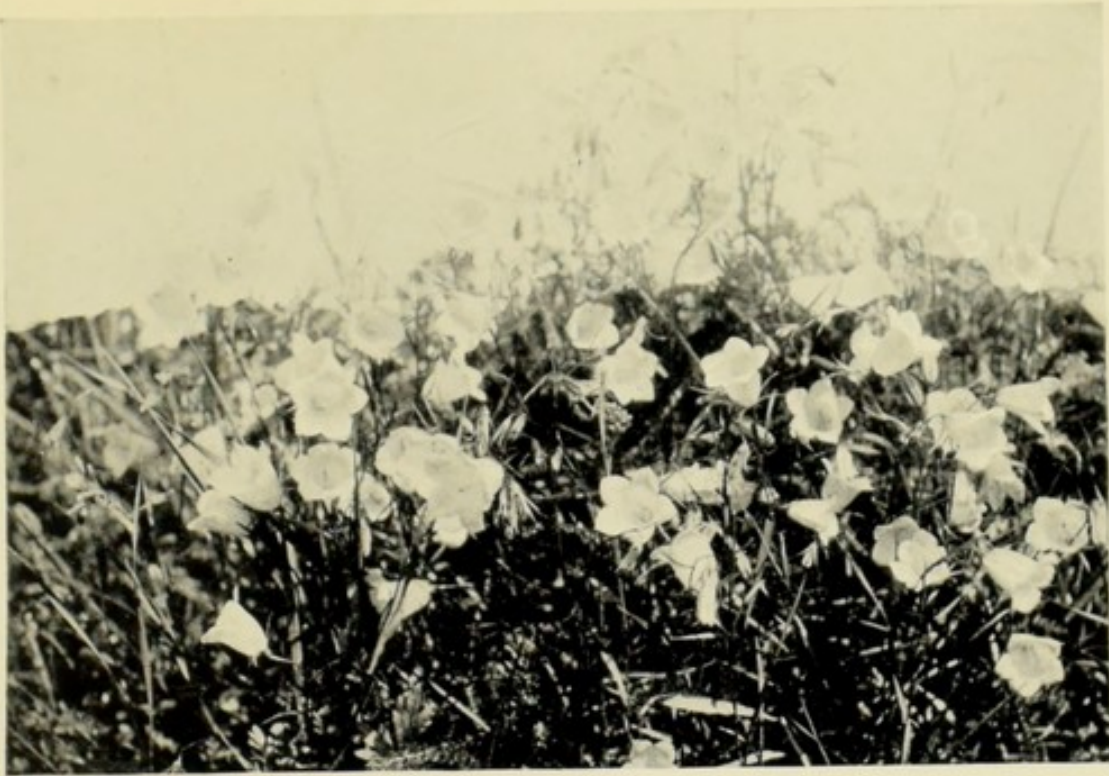
PLATE XVII.

Fig. 1.—The Harebell (*Campanula rotundifolia*, Linn.).
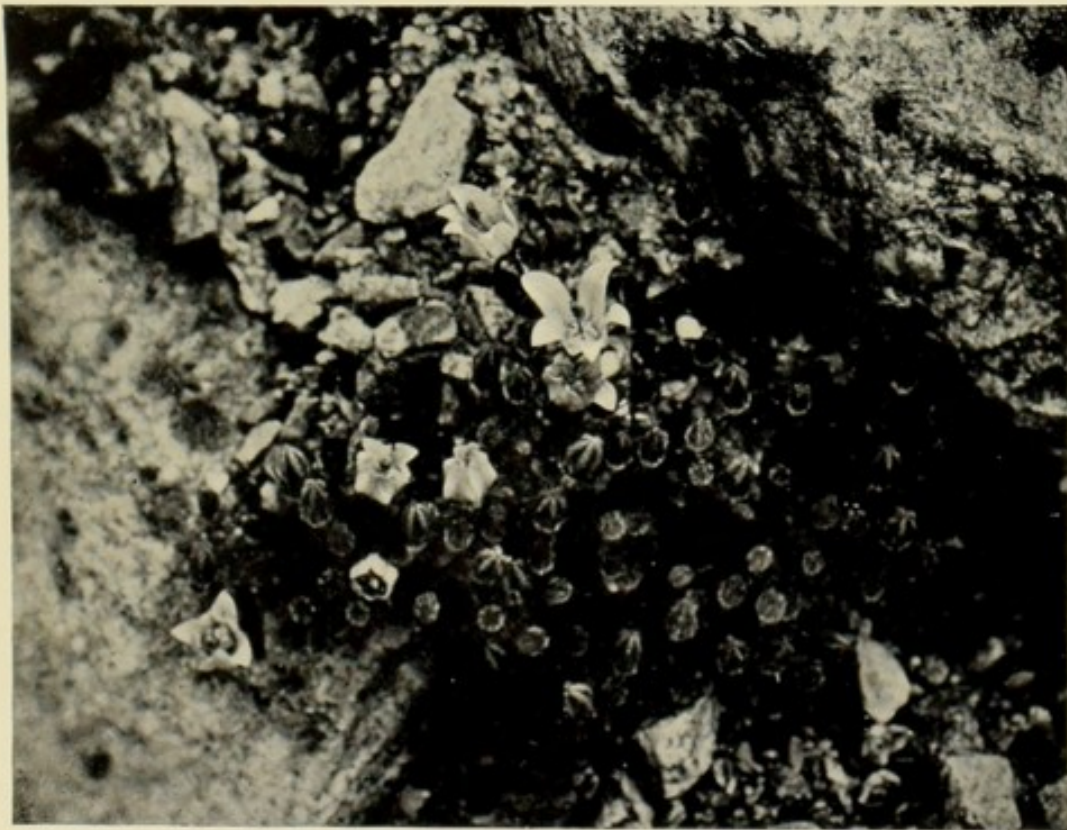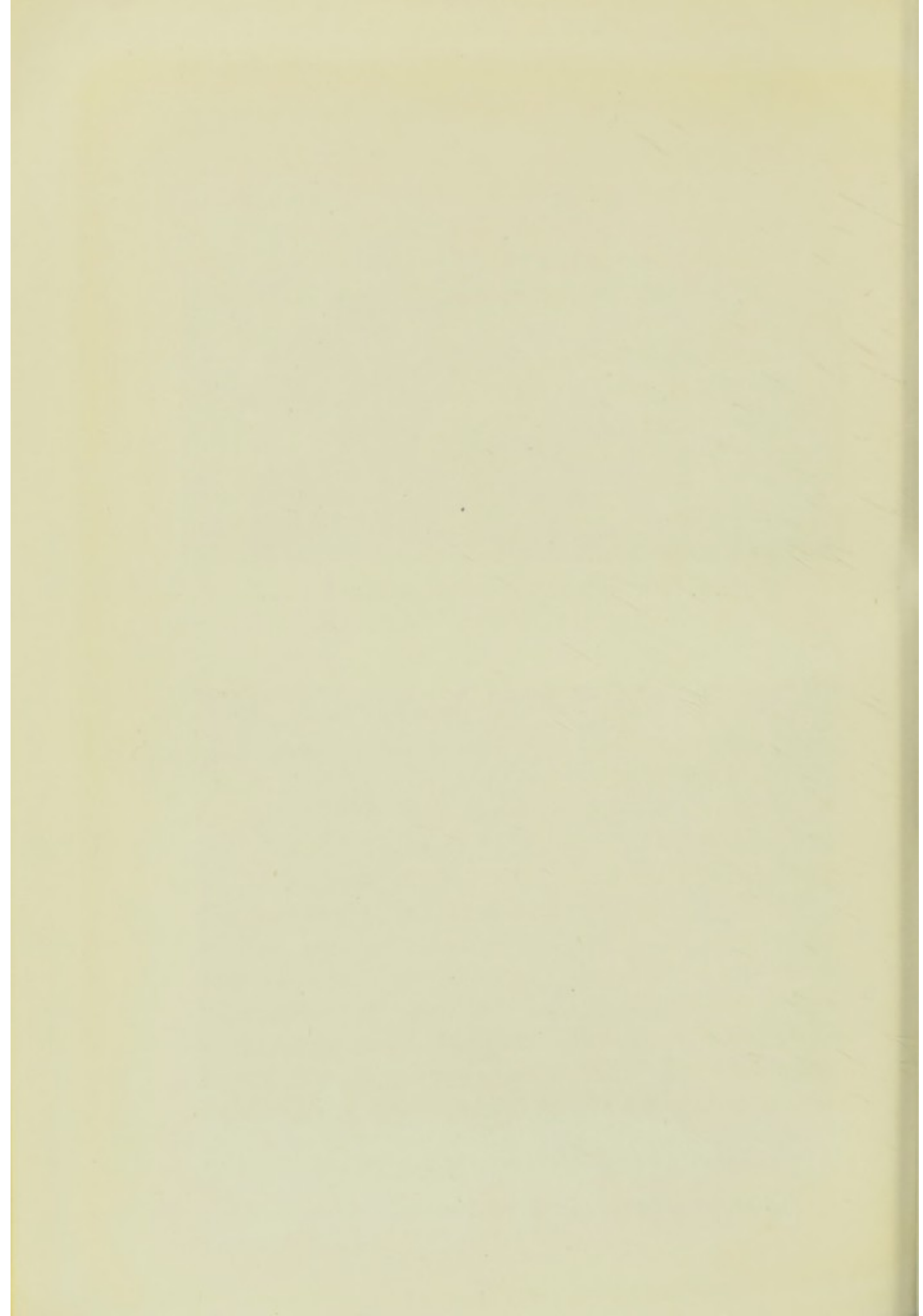

Fig. 2.—The Mont Cenis Campanula (*Campanula cenisia*, Linn.).

are larger, and the flower-stalks less branched, and bearing only one to five flowers on each plant. The flower-buds droop in this species, whereas in the Harebell they are almost erect.

The flowers of either species are worthy of examination. The drooping position of the corolla, the mouth being directed downwards, serves both to protect the pollen and to prevent the entrance of unbidden guests (see p. 275) in the shape of crawling insects, which serve no purpose useful to the plant. For, to most Alpines, though not all, cross-fertilisation by means of insects, which carry the pollen or male generative dust from one flower to fertilise the female organs of another, is quite essential. In the case of the Bell-flowers and the Rampions, we shall find, if we examine the flowers, that a special mechanism, termed the "mechanism of the stylar brush," exists, which is adapted to ensure cross-fertilisation, and also guards against the possibility of self-fertilisation. Thus we see that an intimate relationship and interdependence exists between these plants and members of the insect world. We shall later discuss other examples (p. 268).

If we examine an unopened head of a very young flower (Text-fig. VIII., 1), dissecting away the corolla, we shall find the five anthers of the stamens completely covering the style. The anthers at this stage are united at their margins, though their stalks at the base remain free. The nectar or honey, which attracts insects, is secreted by the ovary, which is completely

covered in by the ring of united anthers. The anthers ripen before the ovary, and shed their pollen on the inner side, on to the style, which in this region is studded with little hairs, called collectively the stylar brush, to which the pollen adheres.
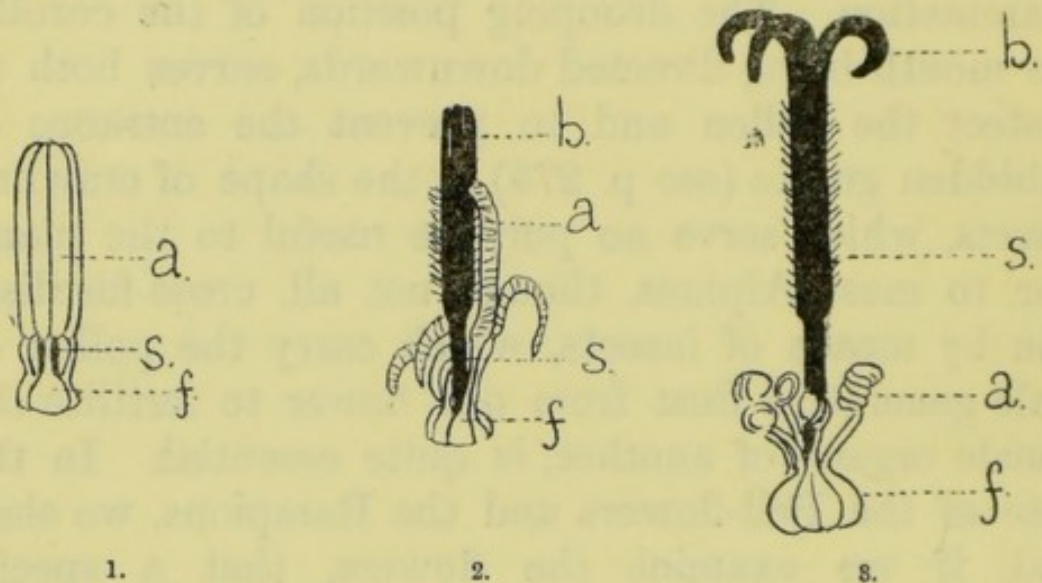

Fig. VIII.—The Stamens and Carpels of Scheuchzer's Bell-flower (*Campanula Scheuchzeri*, Vill.), illustrating the mechanism of the stylar brush. Enlarged.

a=anther; *f*=filament; *s*=style; *b*=stigma.

1. United anthers surrounding the style in the unopened flower.
2. The anthers separating and curling backwards.
3. The empty anthers coiled in tight spirals, the style, with the stylar brush, bearing pollen, and the three stigmas beginning to unfold.

Let us now examine a flower which is just opening (Text-fig. VIII., 2). We find the style has begun to lengthen, and the anthers, having shed their pollen on to the brush, are bending away from one another. The separation and downward curvature of the anthers occur suddenly, if the slightest touch is given to the stamens when the flower is just opening. Thus, if an insect visits the flower at this stage, it is

pretty sure, when seeking the nectar, to come in contact with the stylar brush, and to dust its head with pollen, which it carries to another flower. If the anthers have not all begun to curve, the touch of the insect proboscis will cause them to bend backwards.

In a still older flower, the style, with the brush, has greatly elongated and further has opened at the tip into three little flaps, which curve slightly backwards (Text-fig. VIII., 3). It is on the upper or newly exposed faces of these flaps that the stigmatic surface lies, on which the pollen from another flower is deposited by an insect visitor. The pollen fertilises the ovules in the ovary below. The five stamens at this stage are coiled into tight spirals.

We see that by this arrangement self-fertilisation is almost impossible. The pollen on the stylar brush cannot reach the stigmatic surfaces above it, except by insect agency, and an insect visiting a flower is likely to touch the stigmas with pollen brought from another plant, as it enters the flower; while, as it leaves, the projecting flaps prevent the pollen of the same flower being deposited on the stigmatic surfaces.

The mechanism of the stylar brush is found not only throughout the order Campanulaceæ, but also in the very large family of Composites. It is, however, most favourably studied in the Bell-flowers on account of the comparatively large size of the organs.

If we should find ourselves among the Alps in late summer or in autumn, the fruits of the Campanulas or

Bell-flowers will, on examination, prove instructive objects. The fruit has the form termed a *capsule*, and contains many seeds. Just as the flower is directed mouth downwards, so the fruit is inverted. The base of the capsule becomes the top and its apex the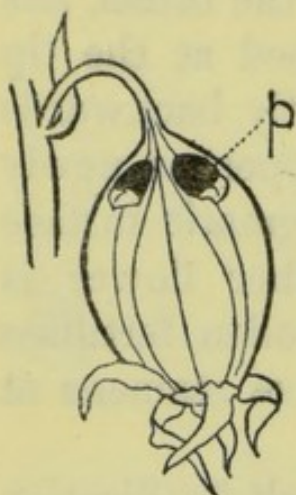 bottom of the fruit. The capsule remains attached to the plant, and instead of the walls of the ovary or capsule splitting apart and thus exposing the seeds, as is the case in many other plants, for instance, the Violet (p. 162), three to five small triangular flaps or valves will be found near the base— that is, at the top of the inverted fruit. These flaps are very sensitive to moisture, closing in wet weather, and curling backwards when the air is dry. When the seeds are ripe and the air dry, the valves curl backwards, and the seeds are shaken out of the capsule by the wind, through the triangular clefts, often with considerable force, and they are thus spread to a considerable distance from the parent.

Fig. IX. — A Fruit (Capsule) of *Campanula*. Enlarged.

p, The valves at the base of the fruit through which the seeds escape.

We have so far only discussed *Campanula rotundifolia* and *C. Scheuchzeri*. There are, however, some seven other species to be found in the Alpine zone, and one occurring rarely in the High Alps. None of the British species, with the exception of the Harebell, are found above 5,000 feet in Switzerland. Many of
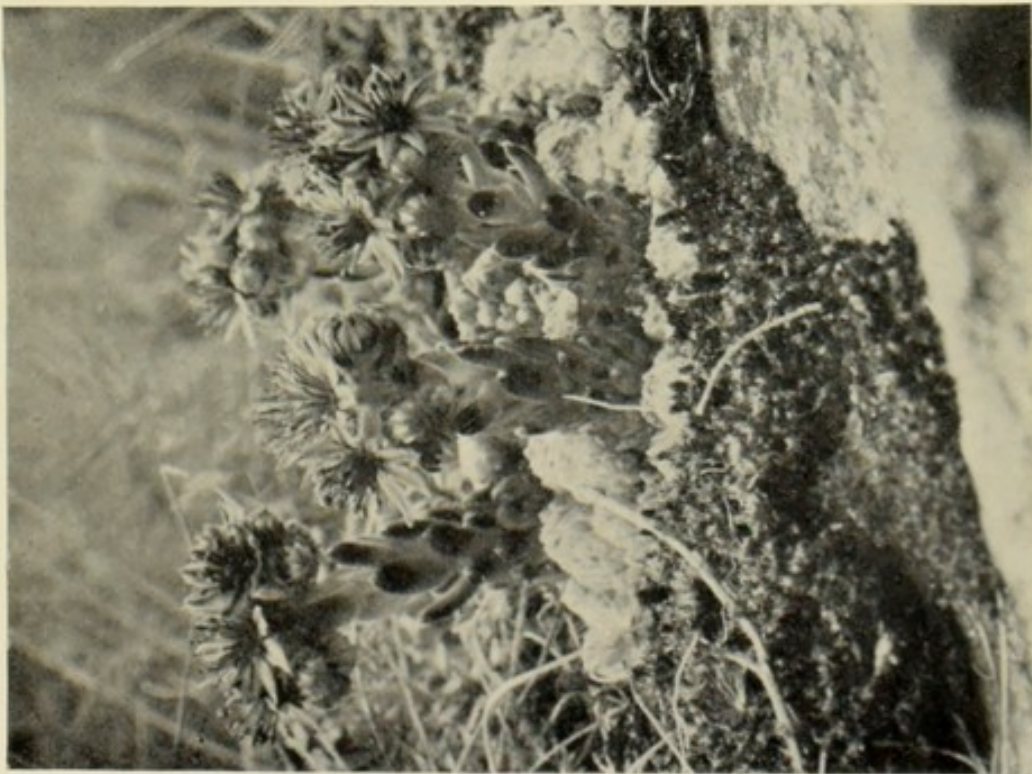
PLATE XVIII.
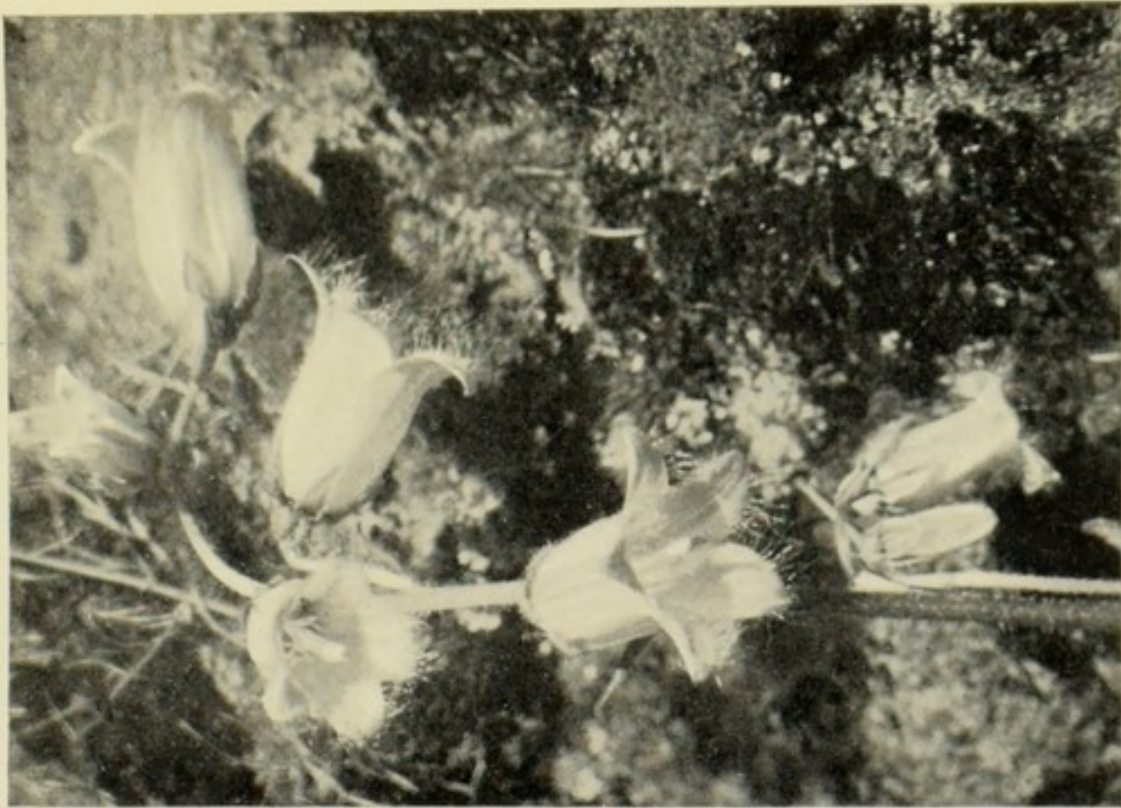
FIG. 2.—The Bearded Campanula (*Campanula barbata*, Linn.).

[*To face p.* 88.

FIG. 1.—The Spider's Web House-leek (*Sempervivum arachnoideum*, Linn.).
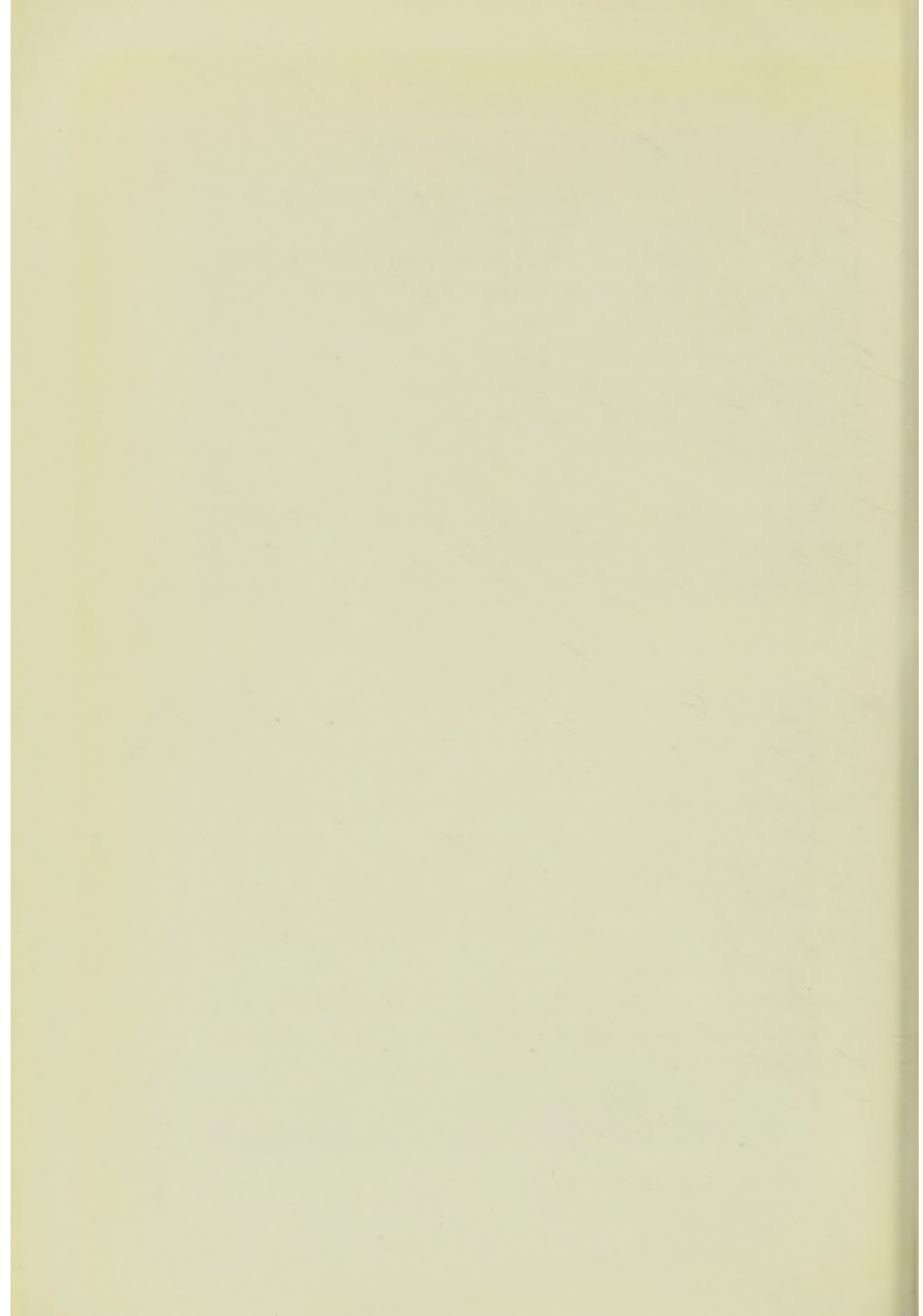
them, however, occur in Lowland and Subalpine Switzerland, where other fine Bell-flowers are also conspicuous.

Another Alpine species, which is very common, is the Bearded Campanula (*C. barbata*, Linn.) (Plate XVIII., Fig. 2). It is frequent in the pastures and in shady spots in July. In contrast to the intense deep blue colour of *Campanula rotundifolia*, and especially *C. Scheuchzeri*, the bell of the Bearded Campanula is of the most delicate shade of pale Cambridge blue. Between each of the calyx-lobes there is a little triangular appendage, turned backwards against the base of the bell. The edge of the lobes of the corolla is also fringed with a beard of hairs, hence the specific name "*barbata*." These hairs project over the mouth of the inverted bell (Plate XVIII., Fig. 2), and it seems probable that their function, like that of the five little triangular, backwardly directed appendages of the corolla, is to prevent the entrance into the bell of small creeping insects in search of nectar, which might otherwise crawl along the flower-stalk and rob the honey. Such unbidden guests (p. 275) would be of no service to the plant, for they would probably not visit another flower of the same species, and thus no cross-fertilisation would result.

The three Campanulas above described are the commoner Alpine species. *C. cenisia*, Linn.[1] (Plate XVII., Fig. 2), is a somewhat rare High Alpine form,

[1] The Mont Cenis Campanula.

occurring on rocky places at Mattmark and elsewhere at an elevation of about 7,000 to 10,000 feet. Each stem bears only a single erect flower, the corolla of which is deeply divided. It is interesting to compare the dwarf habit and solitary flowers of this species with the larger, much-branched flowering shoots of the Campanulas growing at lower elevations.

The rarest of all the Swiss Bell-flowers is *Campanula excisa*, Schleicher, confined to a few valleys in the cantons of the Valais and Tessin. It may be collected in the Saas Thal, on the Simplon, in the Binnen Thal, and in a few other localities. The Incised Bell-flower is so called from the fact that the base of each of the lobes of the corolla is cut away in a beautiful curve, and its flowers are thus easily distinguished from those of the other Alpine species. The precise object or advantage of this peculiarity does not appear to be known at present.

We will notice one further Alpine Campanula— a very remarkable one. It must not be imagined that all Bell-flowers have blue flowers like the Harebell. There is one Swiss species, the Tufted Campanula (*Campanula thyrsoidea*, Linn.) (Plate XIX.), in which the flowers are pale yellow, and the whole habit is quite unlike that of the other Alpine Bell-flowers. The plant has a rosette of hairy leaves close to the ground, from which springs a stout stem 6 inches to a foot in height, bearing numerous closely-set leaves and ending in a dense spike of yellow flowers.

PLATE XIX.
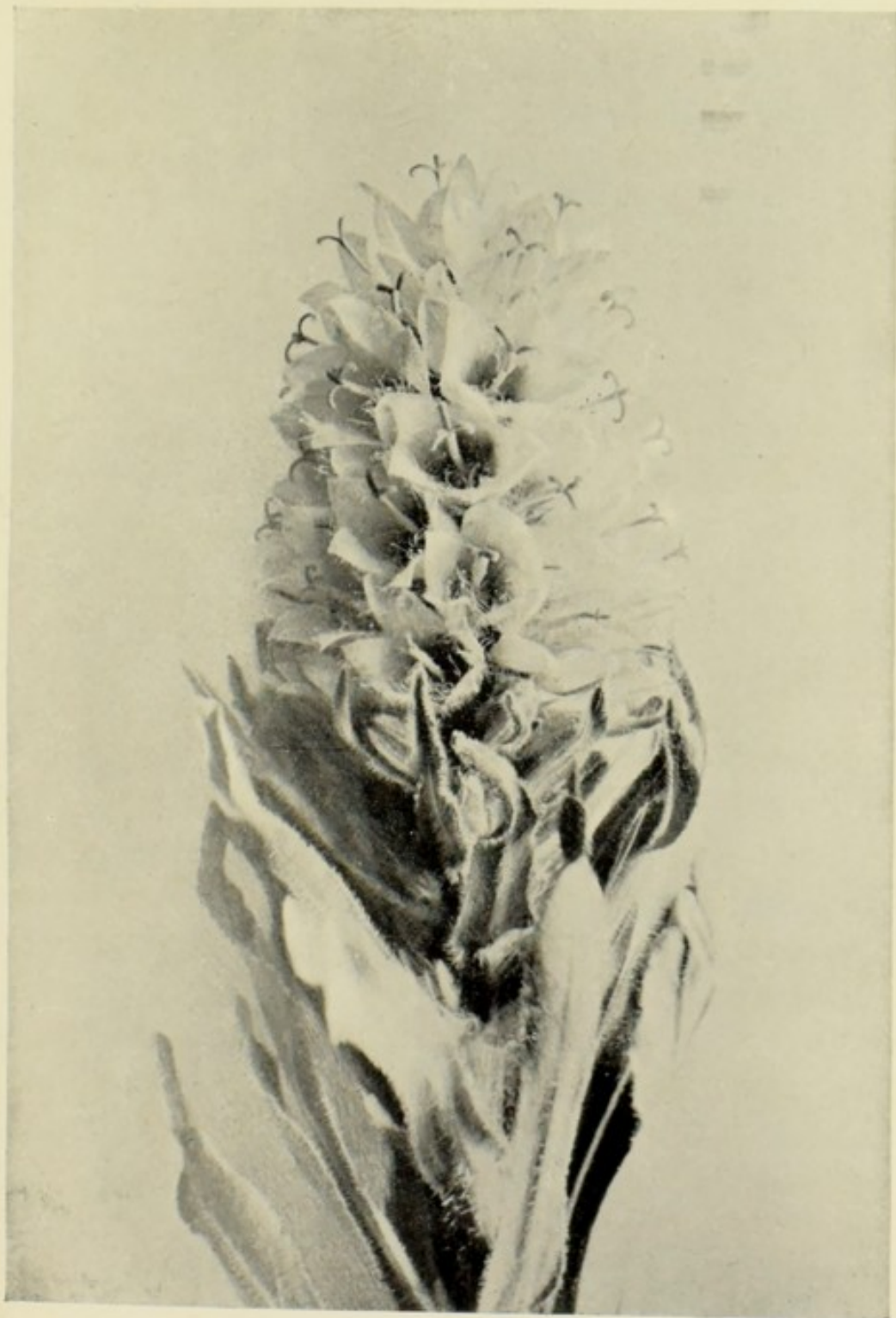
The Tufted Campanula (*Campanula thyrsoidea*, Linn.).
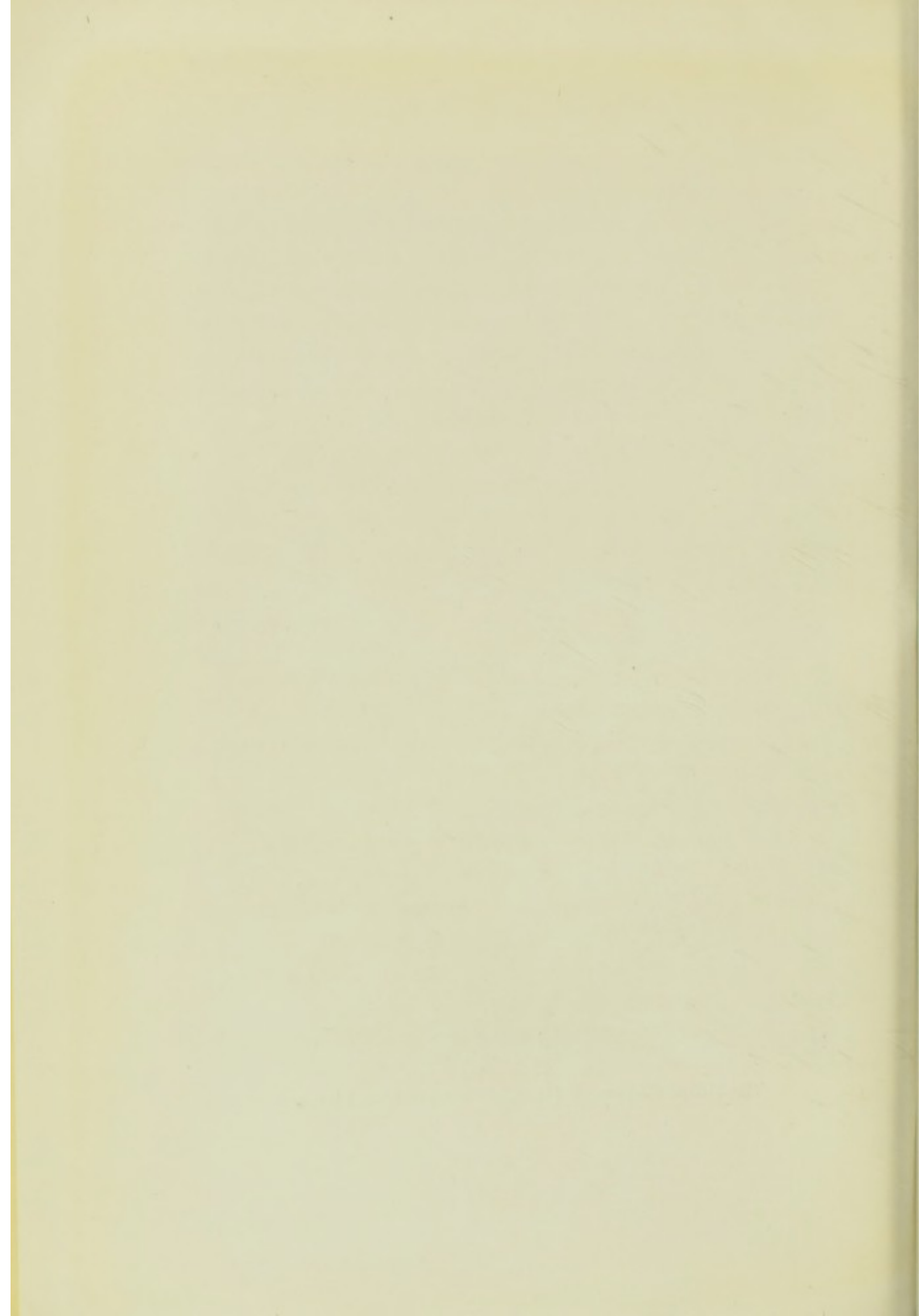
The whole plant is rough with hairs, cotton-like hairs being even found on the pale yellow corolla. Unlike the other Alpine Campanulas, this plant is a biennial—that is to say, it takes two years to mature. In the first year, when the seed germinates, only the root and a rosette of leaves close to the ground are formed. From this, in the second year, the stout, leafy flower-stem shoots up, producing in July a dense spike of flowers. Having set its seed, the plant dies. It is not at all an uncommon plant, though much less abundant than the three species of Bell-flower first mentioned. It grows in the pastures, with often a preference for somewhat shady places, near *Rosa alpina*, Linn., or other shrubs.

THE RAMPIONS.

The blue flowers of the Rampions, genus *Phyteuma* (natural order Campanulaceæ, the Bell-flower family), are conspicuous in the Alpine meadows and pasturages in the early summer. They are borne either in long cylindrical spikes or short rounded heads. There are several species, three of which are confined to High Alpine habitats. Of the two British species, the Round-headed Rampion (*Phyteuma orbiculare*, Linn.) (Plate XX., Fig. 2) is very frequent in the Alpine zone, but the other (*P. spicatum*, Linn.) does not occur except at lower elevations.

The flowers of the Rampion are in some respects very like, in others very unlike, those of their near allies, the Bell-flowers.

If we examine the young flower-buds, we shall find that the petals are all united into a closed tube (Text-fig. X., 1). At a later stage the petals begin to split apart at the base and the style pushes through the tip of the still united upper portions (Text-fig. X., 2 and 3). Finally, the petals separate altogether and
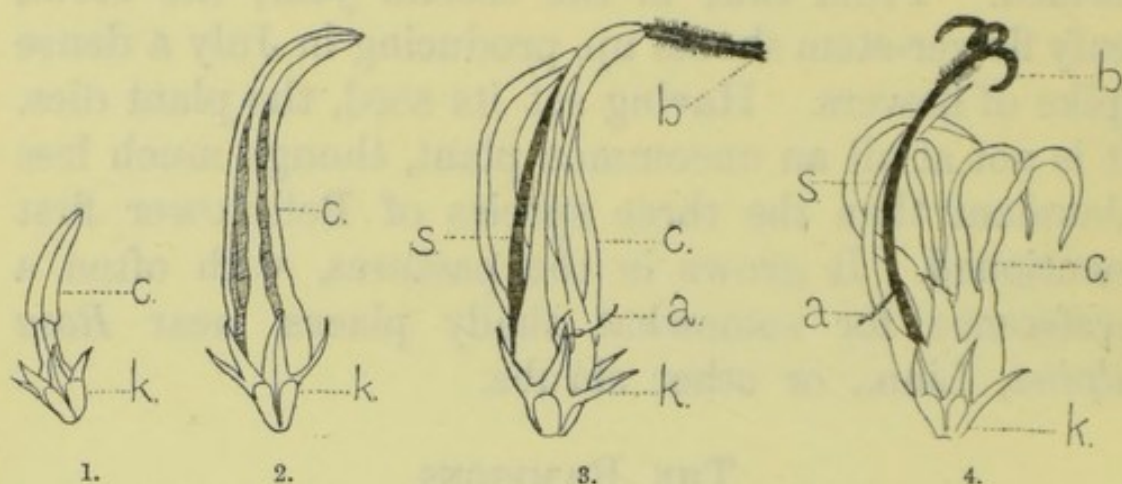

Fig. X.—The Flowers of the Round-headed Rampion (*Phyteuma orbiculare*, Linn.), in various stages. Magnified.

k=calyx; *c*=corolla; *a*=anther; *s*=style; *b*=stigma.

1. The united petals of a young flower, with the calyx below.
2. The petals separating in an older flower.
3. The petals further separated, and the style growing through the tip of the tube formed by the petals.
4. Mature flower with free petals, showing the style with stylar brush, and the three expanded stigmas.

curl apart, leaving the style fully exposed (Text-fig. X., 4). The same mechanism of the stylar brush exists here as in Campanula (p. 85). The Rampions, however, differ from the Bell-flowers in the mature petals being quite free from one another, though they are slightly united when young.

PLATE XX.

Fig. 1.—Leaves of the White Dryas (*Dryas octopetala*, Linn.).
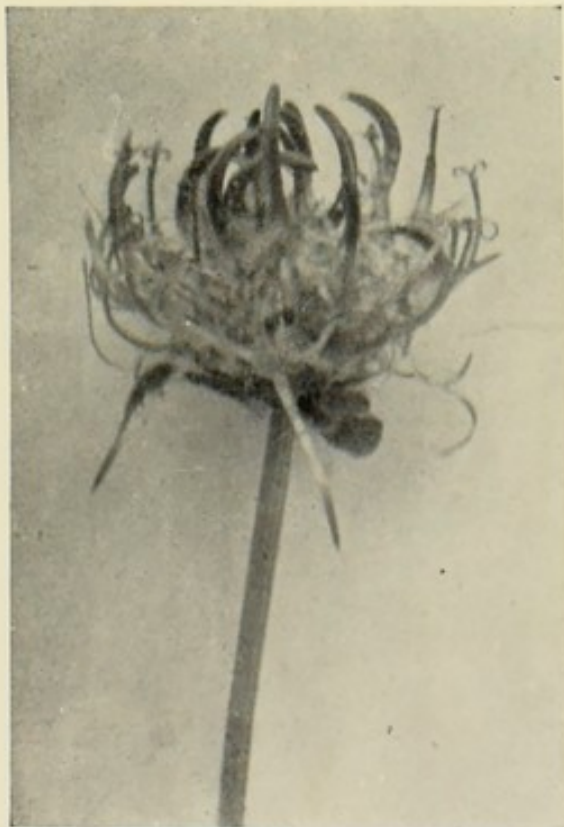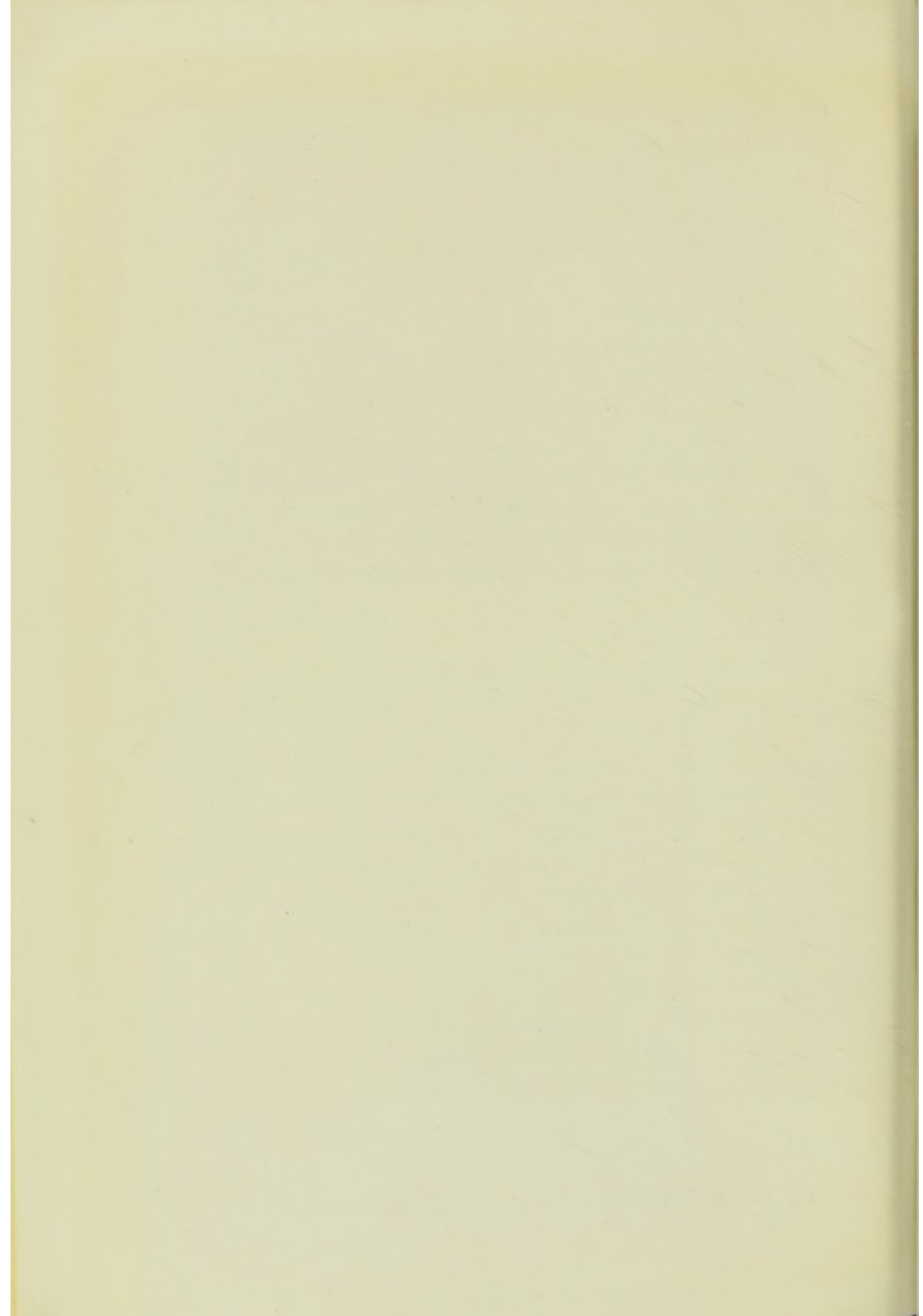

Fig. 2.—The Round-headed Rampion (*Phyteuma orbiculare*, Linn.).

CHAPTER IV

ROCK PLANTS OF THE PASTURES

IN the preceding pages we have noticed some of the most characteristic of Alpine genera represented in the upland pastures, though some of their species occur in the meadows, forests, or in other habitats. The flowers of the pastures are the crowning glory of the Alps, and we shall therefore devote the present and the following chapters to the consideration of other members of this most interesting assemblage of plants.

The pastures naturally vary in their physical features. Some are dry and stony, while others more closely resemble fertile meadows. Even in a typical fertile pasture, rocky boulders, or rock masses, each with its own little flora, are frequently conspicuous. The conditions under which plant life flourishes on the rocks and on the dry stony slopes, with their poor soils and small water supply, are naturally in marked contrast to those which pertain in the normal or typical pasture with its rich soil, often well watered by some neighbouring stream.

As a rule, the plants which grow on the rocky portions of an upland pasture are not those which abound in the normal pasture. We will devote the present chapter to the rock plants of the pastures, including with them those which grow under similar physical conditions on the dry, bare, stony slopes.

The study of the colonisation of bare ground or virgin soil by plant life, whether at home or in the Alps, is a most interesting occupation. Many will have noticed how in England some artificially made new ground suitable for plant life, such as a railway embankment, becomes gradually populated, the Coltsfoot being, as a rule, the first to seize upon the opportunity to establish itself. In the Alps, fresh areas of rock are constantly being exposed, either by the washing away of the soil and its vegetation by streams, especially in time of flood, or by avalanches in winter, or again by soil-slip, the ever-present tendency of the soil of the sides of the valley to slide downwards. In other cases, landslips on a large scale not infrequently lay bare the rock of a mountain side, which formerly was densely clothed with vegetation. How do plants establish themselves on such new ground? What are the first species to take advantage of the fresh opportunity?

We have already called attention to the struggle for existence, the competition for room, light, and air, among Alpine plants. It follows that any opportunities will naturally be quickly seized upon, where fresh

space is found to be available. But all plants are not capable of taking advantage of the fact that a new area of bare rock has recently become exposed in their neighbourhood. We know that if we transfer a plant of a damp meadow species to, or sow its seeds on, some bare and dry rocky ledge, the chances are very greatly against the survival of the species in its strange habitat. The plants which are most likely to survive on the new ground are those which grew formerly under conditions as nearly as possible similar to those which prevail in the area in which colonisation is being begun afresh. These are the rock plants of the pastures. They are the advance-guard of vegetation in its march from the normal pasture to the bare untenanted rocks, exposed from time to time by geological agencies.

The colonisation of new ground is effected in the great majority of cases by seeds which, in a very large proportion of Alpine plants, are distributed by the agency of the wind. Where outposts on some bare ledge have become established, the advance of vegetation may be furthered by some asexual method such as the formation of runners and offsets, which tend to distribute the species still further. But initially it is the wind-blown seed which is the coloniser in nine cases out of ten.

It is doubtful if a seed falling on absolutely bare rock will survive in any instance. Certainly it often happens that seeds perish in this way, for without some kind of soil, however primitive, the chances of

their survival are very small indeed. It need hardly be pointed out that in any case there is always a "high mortality" among seeds. A much larger number are always produced than can ever possibly survive, and the whole *rationale* of seed production is that, while many are certainly doomed to perish, there is a distinct chance that a few, perhaps only one, may survive, and so the species will continue in being.

We must, therefore, study the formation of a primitive soil, if we wish to understand all the stages in colonisation. Let us consider a large slab of rock recently laid bare. The surface of the slab will probably not be quite smooth. Smaller or larger irregularities in the surface will exist, and further, the rock, under the influence of what the geologist terms "weathering," will soon begin to crack in various directions, and at the same time the small irregularities of the surface will be accentuated.

It is around these irregularities and in the cracks that the primitive soil accumulates. It may be formed initially by those lowly plants known as Lichens (p. 291), especially the Crustaceous Lichens, forming the yellowish- or greenish-white crust on the surface of the rocks, so commonly seen in the Alps. These Lichens are really composed of two plants—one an Alga or pond-weed, and the other a Fungus, living together. After a time the body of the Lichen dies, but it continues to remain attached to the rock. The dead Lichens tend to hold any rain-water which falls on them for a time, and small wind-blown vege-

table fragments and dust collect round them, and so a primitive soil is built up. If the seed of a rock plant should have the good fortune to come to rest on such a spot, its chances are good. Some sort of soil at least exists, and that not entirely free from moisture.

Sometimes Mosses play the chief part in the formation of primitive soils, but these plants are rarely the first colonisers, though often the second, where some primitive soil already exists.

A very common soil of this nature in the Alps consists of little matted masses of pine-needles—that is, of the leaves of Pines, Spruces, or Larches. These are blown for considerable distances by the wind, and may come to rest in the cracks on the bare face of a rock, or cling to the little knobs or irregularities of the surface (Plate XLIV., Fig. 1). They form small masses interlocked together, which are wonderfully permanent, though not fixed to the rock face in any way. They retain a considerable portion of the rain-water that falls on them and collect humus and dust. Thus in the end a primitive soil results.

One of the greatest of the rock colonisers in the Alps is the genus *Sempervivum*, the House-leek, which plays a part somewhat similar to the Coltsfoot with us in Britain. The House-leeks are extremely interesting plants in many directions, as we hope to show.
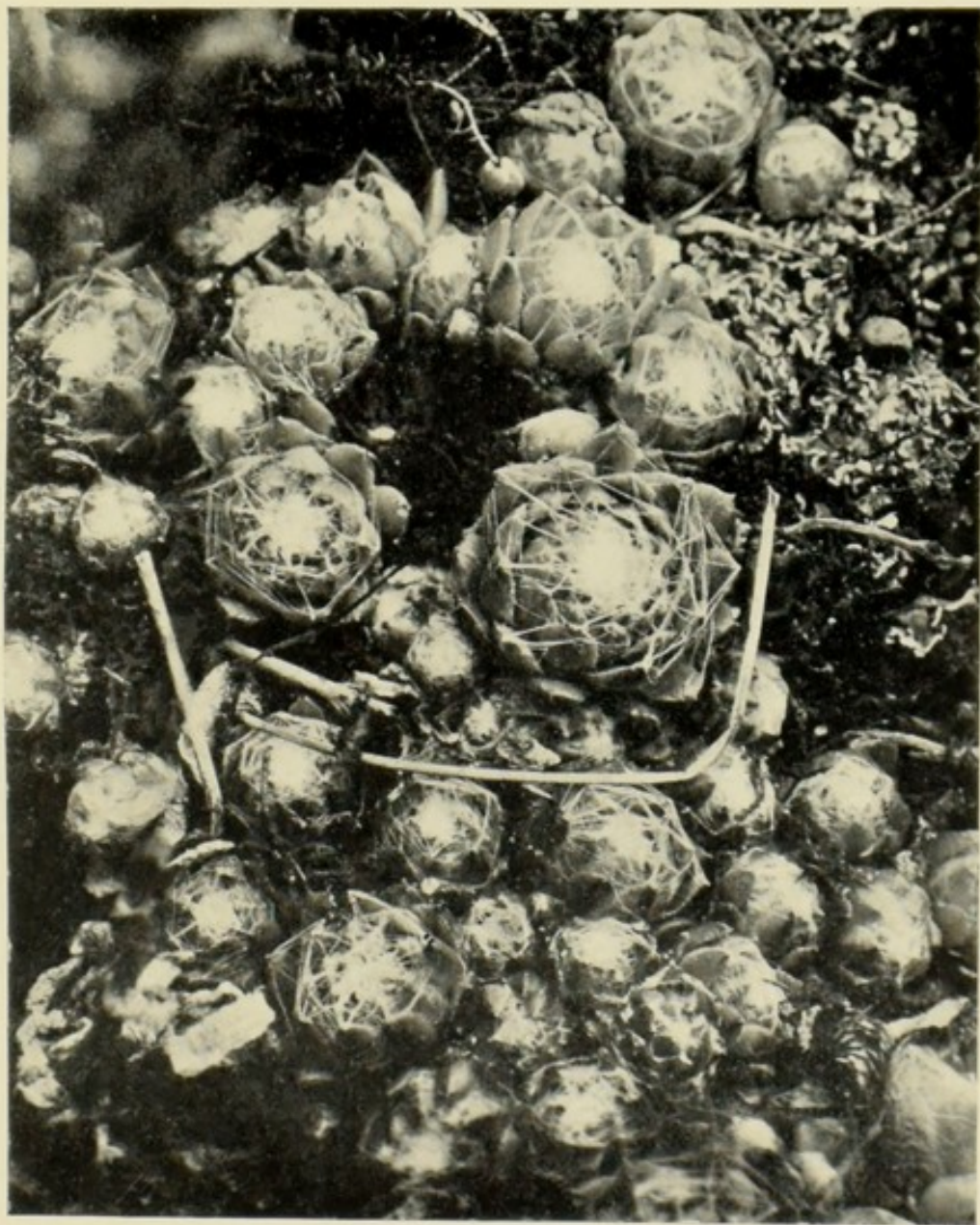
THE HOUSE-LEEKS.

The House-leeks, genus *Sempervivum* (natural order Crassulaceæ, the Stonecrop family), are among the most striking Alpine plants in dry rocky situations. The leaves are thick, fleshy, or succulent, and arranged in rosettes (Plate XXIV., Fig. 1) close to the ground. The flowering stems also bear similar leaves, but these are smaller and more scattered in their arrangement. The leaves of the rosette are held erect—that is to say, the apex of the leaf points directly upwards—and thus the sunlight only falls obliquely on their surfaces. This is another adaptation which tends to reduce the loss of water given off by the leaves. The leaves have also water-storage reservoirs in their tissues, and so are well adapted to the dry barren soils on which they live fully exposed to the summer sun.

In Britain, one species of House-leek (*Sempervivum tectorum*, Linn.) is common on cottage roofs and on old walls. This plant is also not infrequent in Switzerland. In the Alps there are also several species with large, handsome, rose-coloured or yellow flowers, which do not occur in Britain.

The Spider's-web House-leek (*Sempervivum arachnoideum*, Linn.) (Plate XVIII., Fig. 1) has peculiar rosettes in which the tips and edges of the leaves are all bound together by a white network of long hairs, the whole meshwork resembling a spider's web, hence the specific name (Plate XXI.). Where the plant grows in very shady places, the network

PLATE XXI.

The Rosettes of the Spider's Web House-leek (*Sempervivum arachnoideum*, Linn.).
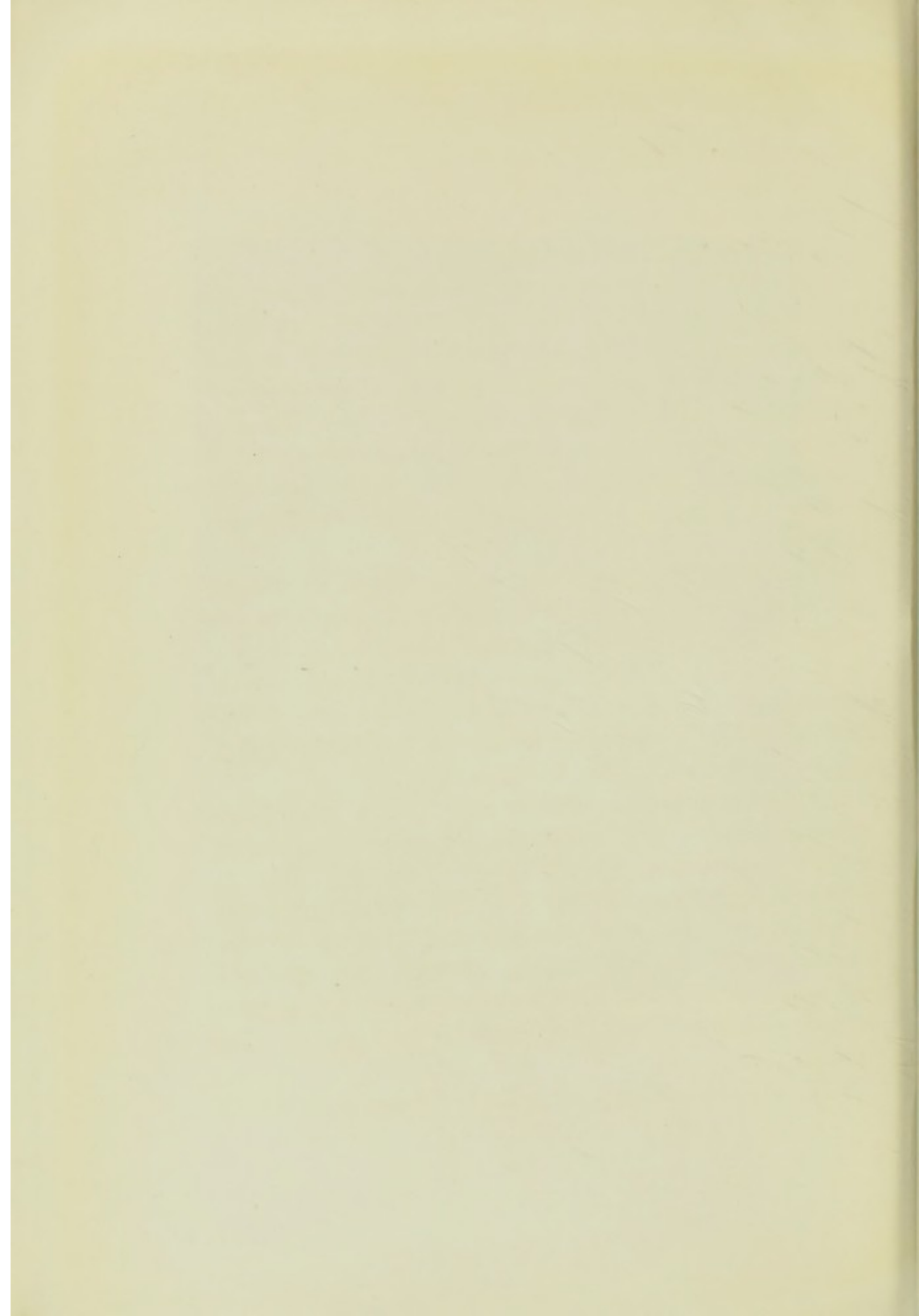
may be less pronounced, and the rosette appear to be green and not white. On the other hand, where fully exposed to the sun, the spider's web is usually very much in evidence.

The object of these matted hairs would appear to be to bind together the leaves of the rosette as compactly as possible, and thus ensure that each leaf is held erect, and that the risk of excessive loss of water by transpiration (p. 12) is reduced to a minimum. The fact above mentioned, that, in shady places, where there is less danger from evaporation, the web is much less in evidence or is only feebly developed, supports this view.

The hairs of the spider's web, as Fraulein Dintel of Vienna has shown, are modified glandular or secretory hairs. Glandular hairs are abundant on the leaves and flowering shoots of many Alpine species of this genus. Fraulein Dintel finds that it is the secretion of such hairs which forms the means whereby they are bound together into the web.

Another common House-leek to be found on Alpine rocks is the Mountain House-leek (*Sempervivum montanum*, Linn.) (Plate XXIV., Fig. 1, Plate XXII., and Plate XXIII.), which like the preceding species has rose-coloured flowers but no spider's web on the leaves, though they possess ordinary, small glandular hairs. This plant is perhaps the most abundant representative of the genus in the Alps.

We may take these two plants—the Spider's-web

and Mountain House-leeks—as typical of the genus in the Alps, and study them in regard to their adaptations to the particular conditions under which they there live. When the seed germinates on the primitive soil of some freshly exposed rock, a little rosette of leaves is first formed. The next step is the formation of a colony of such rosettes. This is done by means of what are termed runners and offsets, quite like those of our ordinary garden Strawberry Plants. From the parent plant, in the axil of one of the leaves of the rosette, a thin, prostrate stem is put out, which grows for some little distance along the surface of the rock. At or near its end, a second rosette of leaves is formed, which in turn produces other runners and offsets.

If we remove from the soil a colony of *Sempervivum* such as that of the Mountain House - leek figured on Plate XXIV., Fig. 1, we shall have no difficulty in making out the runners and their offsets. In most cases where these plants grow on flat-topped rocks with plenty of room all round, the runners are very short and new rosettes or buds are formed close to the parent, and so a very compact colony is produced. It is thus scarcely possible, unless the plant is removed from the soil, to make out the relationships of the colony. The runners connecting the rosettes will be found to persist for a long time, and tend to bind the individuals of the colony together as a whole.
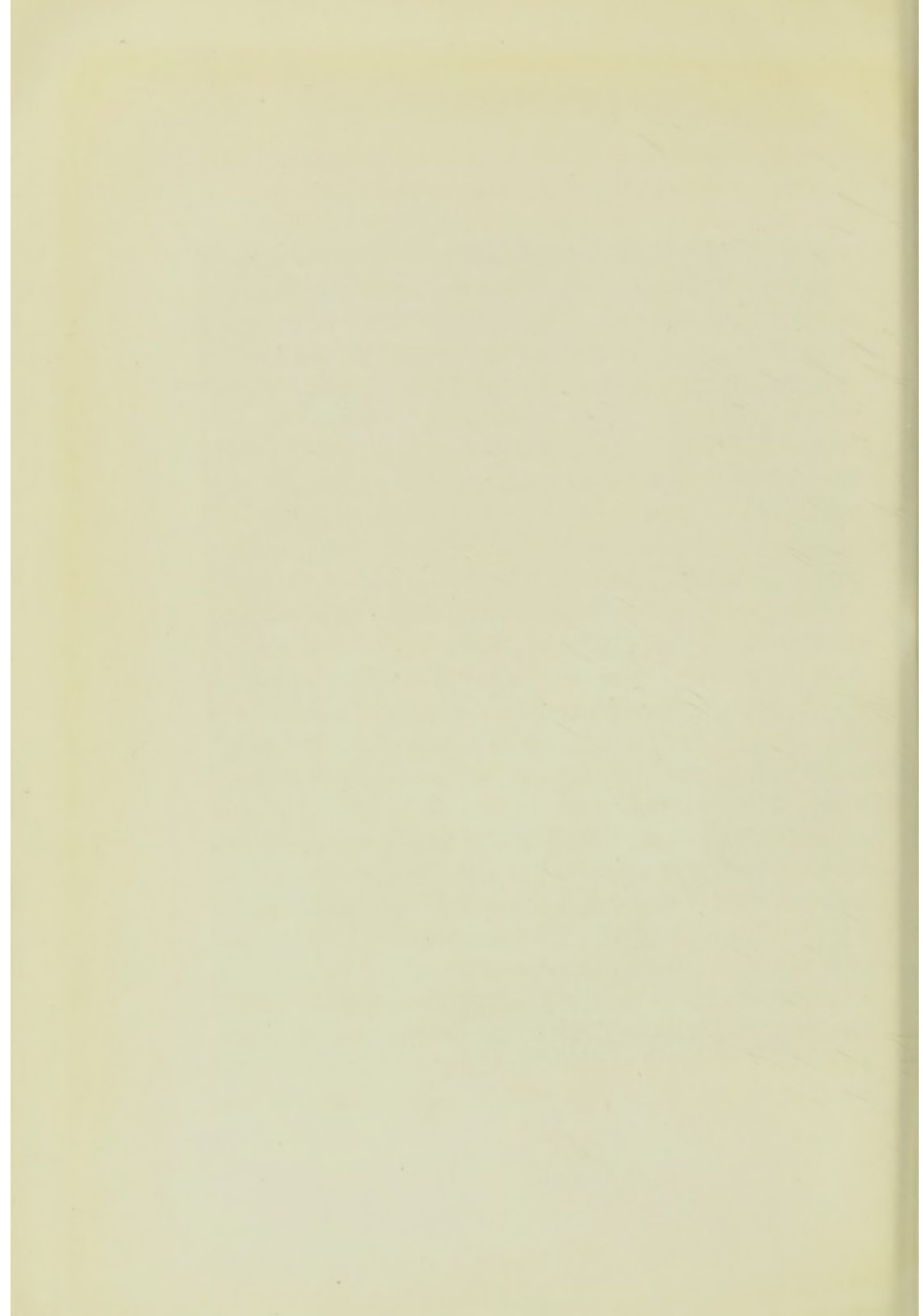
Compactness of growth, which is here well
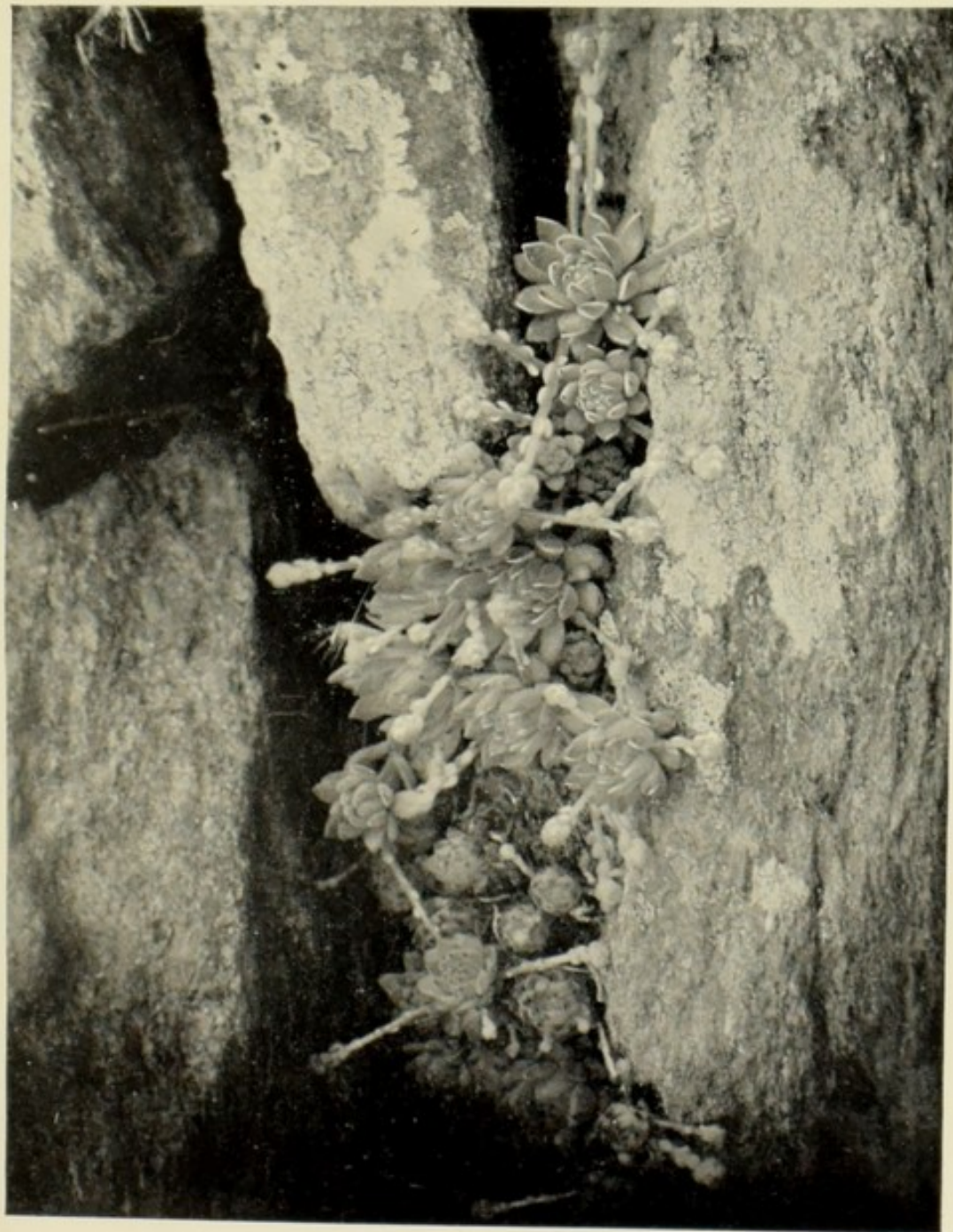
PLATE XXII.

The Migration of the Mountain House-leek (*Sempervivum montanum*, Linn.).

illustrated, is characteristic of many Alpines. The cushion plants, p. 179, and the carpet plants, are equally compact, though entirely different in habit. The compactness of the colony, cushion or carpet, tends to reduce to a minimum the risk of intrusion of other plants into the colony.

In the photographs of *Sempervivum arachnoideum* and *S. montanum*, on Plates XVIII., Fig. 1, and XXIV., Fig. 1, it is obvious that room for the extension of the colony can be found on its margins. The colony can advance and overwhelm the present occupants of the soil. Let us, however, examine cases where space is restricted, and see how the plant meets the difficulty.

The photographs on Plates XXII. and XXIII. show two colonies of the Mountain *Sempervivum* growing in the crevices of an old wall bounding a meadow near Saas Fee. For a time the plants have been quite at home, but now the necessity for further space to accommodate the growing colony has become pressing. We notice that the colony is no longer compact. We can now see the runners, which are very much longer than they are under normal circumstances. Each bears a few small leaves, and ends in a rosette-bud or offset. The runner arises in the axil of a leaf of the parent rosette.

We notice in the photograph on Plate XXII. the crowded nature of the rosettes, and, further, that the whole colony is tilted upwards on its side to face the light. For this reason, some of the

runners appear to be shooting straight up into the air. As a matter of fact, this is merely due to the circumstance that the rosettes are tilted through a high angle and the runners are always produced at right angles to the rosettes. Other runners are growing over the sides of the lichen-covered rocks, and on the right-hand side of the picture two runners are seen going round the corner, as it were, to another crevice to seek "fresh Woods, and Pastures new."

In the photograph on Plate XXIII., a colony is seen boldly letting itself down over the face of the rocks from ledge to ledge. The runners seen on the left-hand side are obviously creeping or marching down hill. On the right, the plant, by means of its enormously elongated runners, has, as it were, made a ladder of itself and is descending over the miniature precipice. The relation of the runner to the rosette can be clearly seen in this photograph.

In the two Alpine species described here, the runners are wonderfully persistent. Kerner has, however, described another species (*S. globiferum*, Linn. = *S. soboliferum*, Sims), which does not occur in Switzerland, in which the young rosettes soon become detached from the thread-like runners, and are blown by the wind from one rocky ledge to another, and eventually find refuge in some crevice, where a new colony is founded. This vegetative means of distribution has not, however, been observed in the case of either the Spider's-web or the Mountain House-leek.

PLATE XXIII.
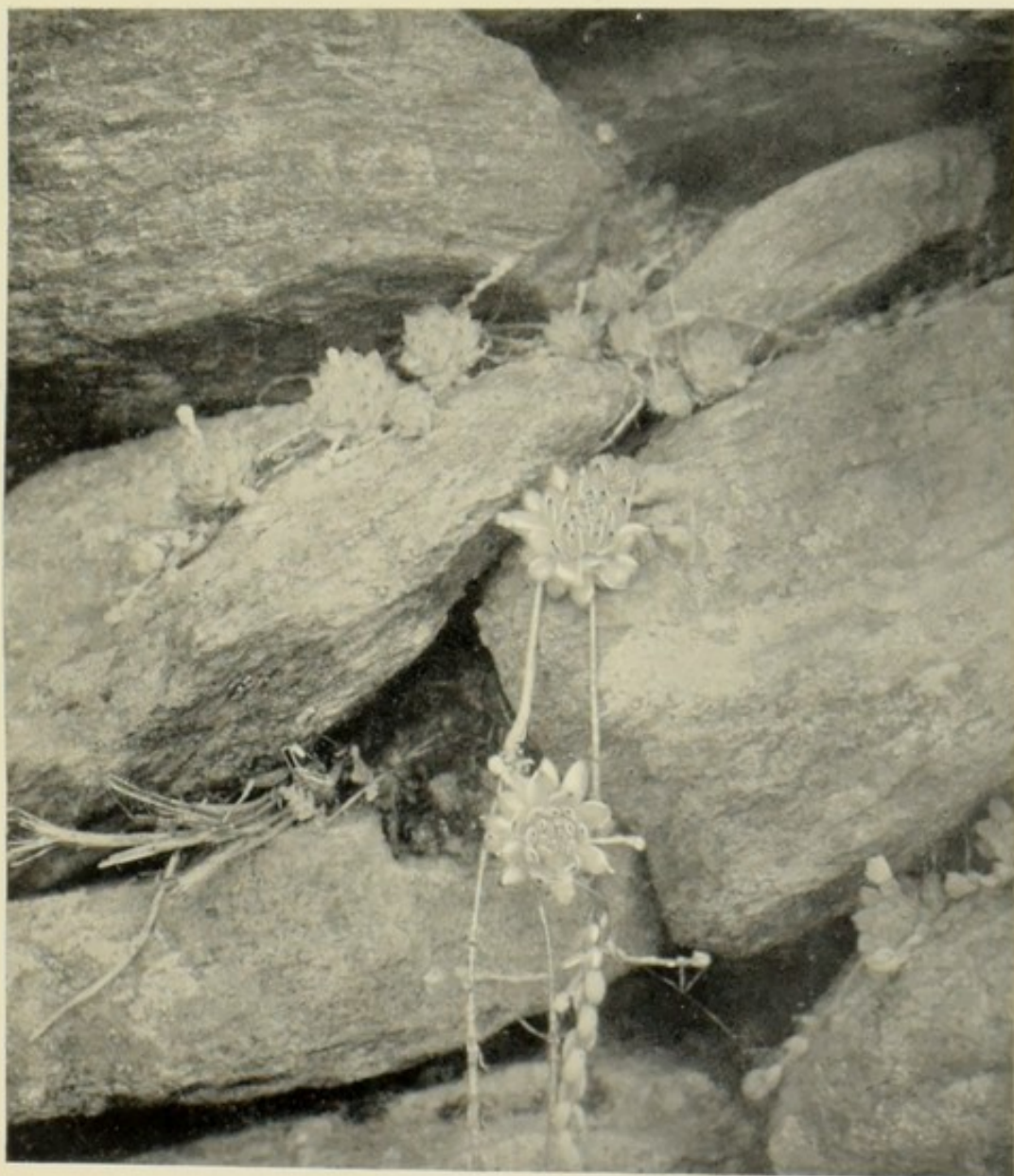
The Migration of the Mountain House-leek (*Sempervivum montanum*, Linn.).
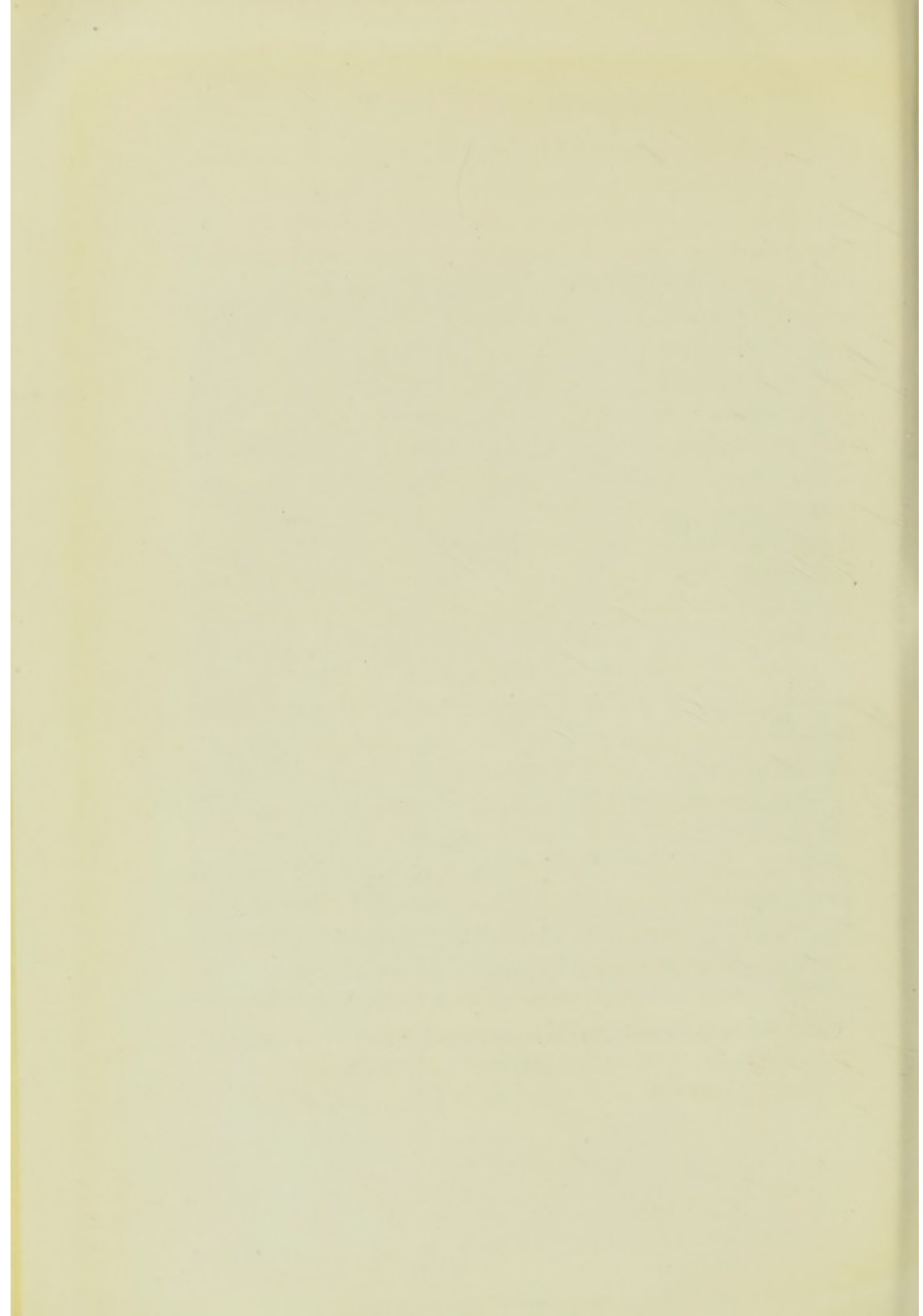
The name *Sempervivum,* meaning "ever-living," is not inappropriate for the House-leeks. It is true that the individual rosettes do not live beyond a few years at most, but their place is constantly being taken by new rosettes. The result is, the colony presents much the same appearance from year to year at each season. The old, dead rosettes persist for a long time beneath the new rosettes, and go to increase the humus and thus enrich the poor soil on which these plants manage to flourish. Even the withered flower-stalks of the previous year often remain attached to the rosettes. Many small wind-blown particles of vegetable matter and dust also collect round the colony, and thus the soil constantly receives fresh additions from without.

Other rock plants, which play an important part as colonisers of fresh ground, are the Stonecrops or Sedums, belonging to the same natural order as the House-leeks, and, like them, fleshy, succulent-leaved plants adapted to dry habitats, and some of the Saxifrages which we have already considered in Chapter III. In the Edelweiss, discussed in Chapter I., we have a typical rock-plant of a different habit, but equally adapted to similar dry situations, though not a frequent coloniser.

We may now turn to Alpine species which not only occur on rocky ledges, but are also frequent on dry stony and semi-bare patches in the pastures, on the bare moraines of glaciers, or on the debris of

torrents, habitats which all present similar difficulties to the plant as regards existence.

Among the first of these to be noticed as extremely abundant in such situations throughout the Alps, are the Wild Thymes (*Thymus serpyllum*, Linn., and *T. chamædrys*, Fries, natural order Labiateæ, the Mint family). These plants produce flowers of two sizes, the larger being hermaphrodite, and the smaller possessing only female organs. The difference between the large- and the small-flowered plants is noticeable even at some little distance.

There are two other British plants belonging to the Pea family (natural order Leguminosæ) which are often very much at home in the drier, stony portions of the pastures and on the moraines of glaciers.

THE BIRD'S-FOOT TREFOIL.

The Bird's-foot Trefoil (*Lotus corniculatus*, Linn.) is remarkable for its indifference to the nature of the soil, the degree of moisture, and situation. It will flourish under almost any conditions in the Alps, though it is most conspicuous on dry ground, where it meets with less competition from its fellow-Alpines. Its wide distribution over Europe and Central Asia, and even in Australia, is, no doubt, due to its adaptability to varied physical conditions.

It is extraordinary what a large area a single plant of this Trefoil manages to cover in the Alps. It is a perennial plant, held fast between the stones by a
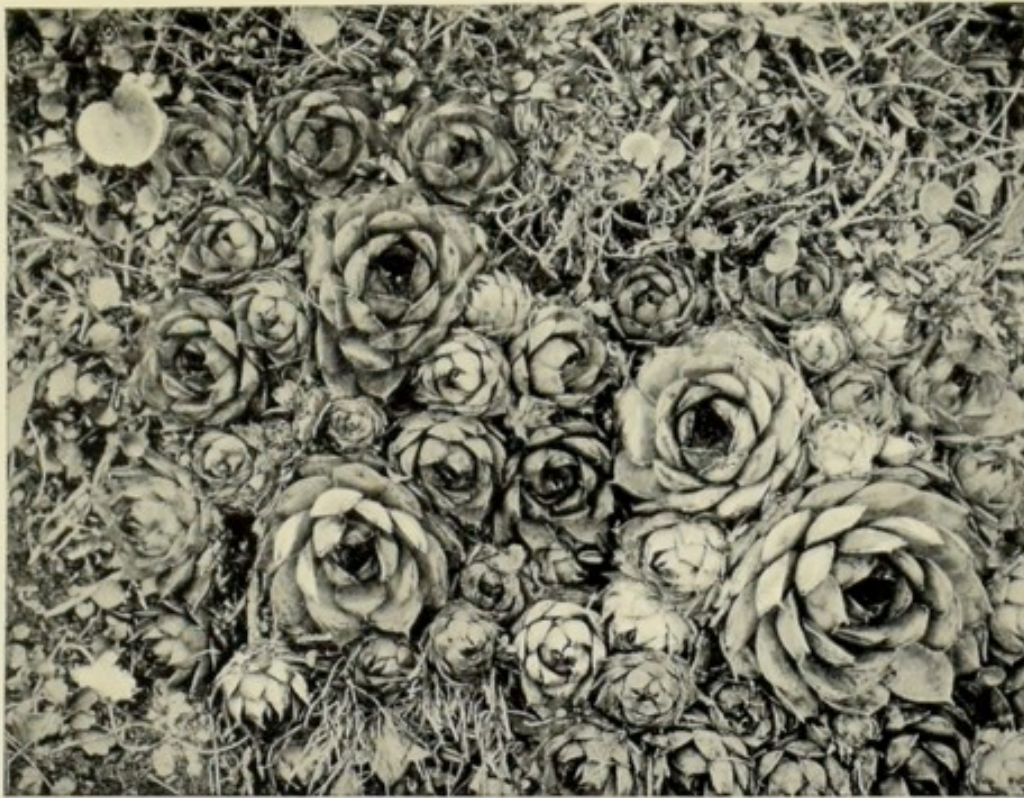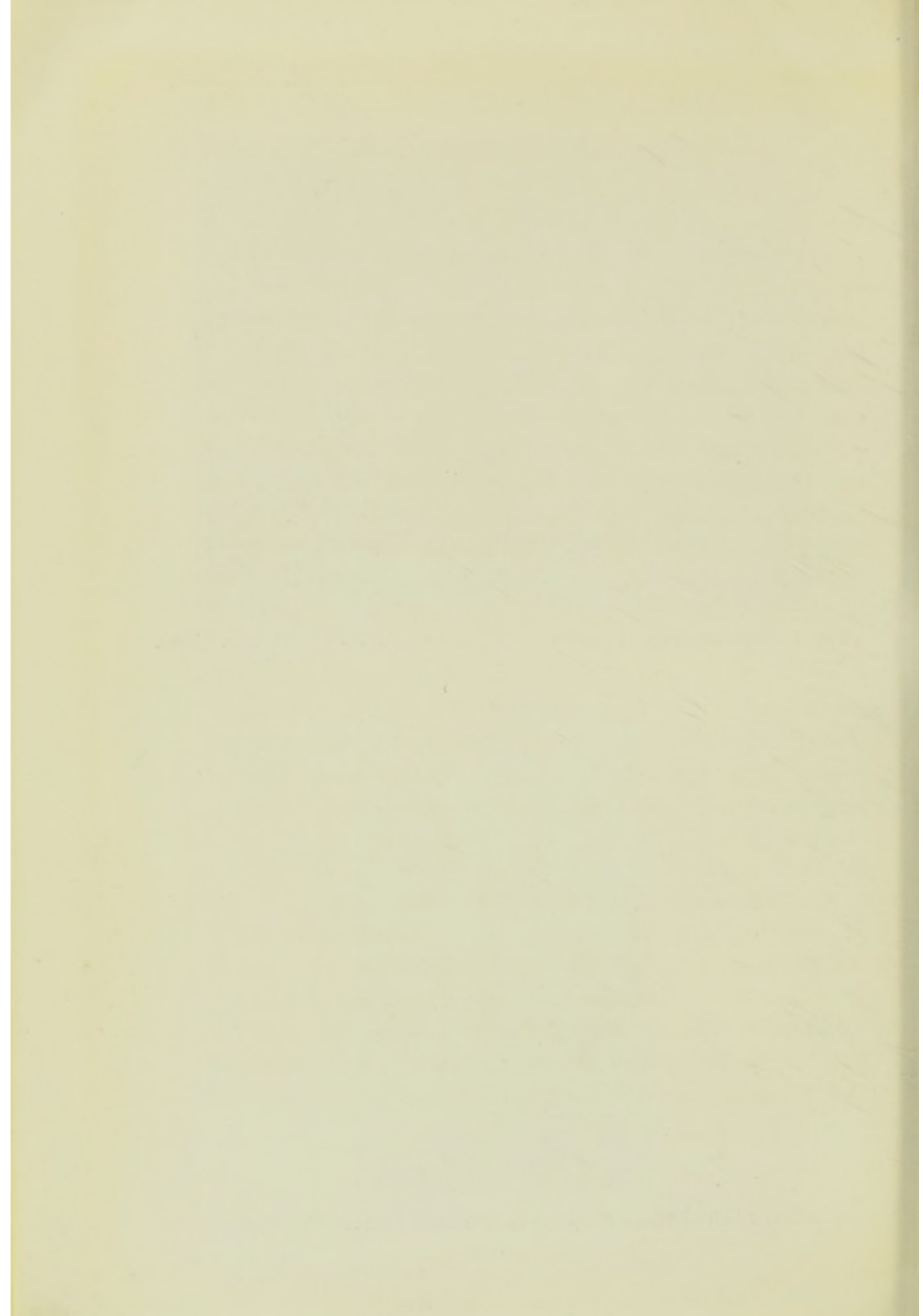
PLATE XXIV.

FIG. 1.—Rosettes of the Mountain House-leek (*Sempervivum montanum*, Linn.).

FIG. 2.—Rosette of a *Sempervivum* attacked by a Parasitic Fungus.

long, stout root-stock. Above ground the leaves radiate out in all directions from a very short stem. The flowers, clustered in little umbrella-like heads (umbels), are mounted on long stalks which extend even further than the leaves. The whole spreading habit adds greatly to the conspicuousness of the plant, and its advertisement to the insect world is thereby increased. As we shall see, when we come to describe the carpet plants of the Alps, such as *Dryas octopetala*, this spreading habit is characteristic of many Alpines, and the fact that many flowers are borne on the same plant is explained by the necessity for a large seed production, since the chances of the survival of an individual seed are smaller than in the plains, owing to the severer physical conditions which it has to combat.

The Bird's-foot Trefoil, as we should perhaps expect, when we consider its indifference to habitat, is a plant with many varieties. The flowers may vary in colour, even on the same plant; while the corolla is usually yellow, in some cases it may be reddish or even wholly red.

THE LADY'S-FINGERS.

The other British member of the Leguminosæ, the Lady's-fingers, or Kidney Vetch (*Anthyllis vulneraria*, Linn.), is almost as abundant as the Bird's-foot Trefoil, with which it is often associated. The flowers are also borne in umbels, though much larger than in the previous plant. They are easily recognised by

the hairy, inflated calyx formed by the united sepals. The leaves also end in large terminal leaflets, an inch or more in length. It is a biennial plant, existing for two years only.

In this species also, the flowers are very variable in colour. Usually yellow, they may be almost white, or again more or less red, or entirely so. They are frequently cross-fertilised by butterflies in the Alps, though in the plains, humble-bees are the chief and most useful visitors. Like the Bird's-foot Trefoil, it is one of the most important pioneers of vegetation on the bare stony patches of the pastures, on the moraines of glaciers, and the debris brought down by streams.

THE WHITE DRYAS.

The White Dryas (*Dryas octopetala*, Linn., natural order Rosaceæ, the Rose family) is one of the most beautiful of Alpine plants, flourishing in similar habitats to the preceding. Its large white or yellowish-white flowers form a welcome landmark on many a bare patch in the pastures.

The habit of the White Dryas (Plate XXV.) is very characteristic of that of many Alpines. It is what is called a *carpet plant*. Other examples of carpet plants will be found in the Trailing Azalea, the Alpine Juniper, and *Globularia cordifolia*.
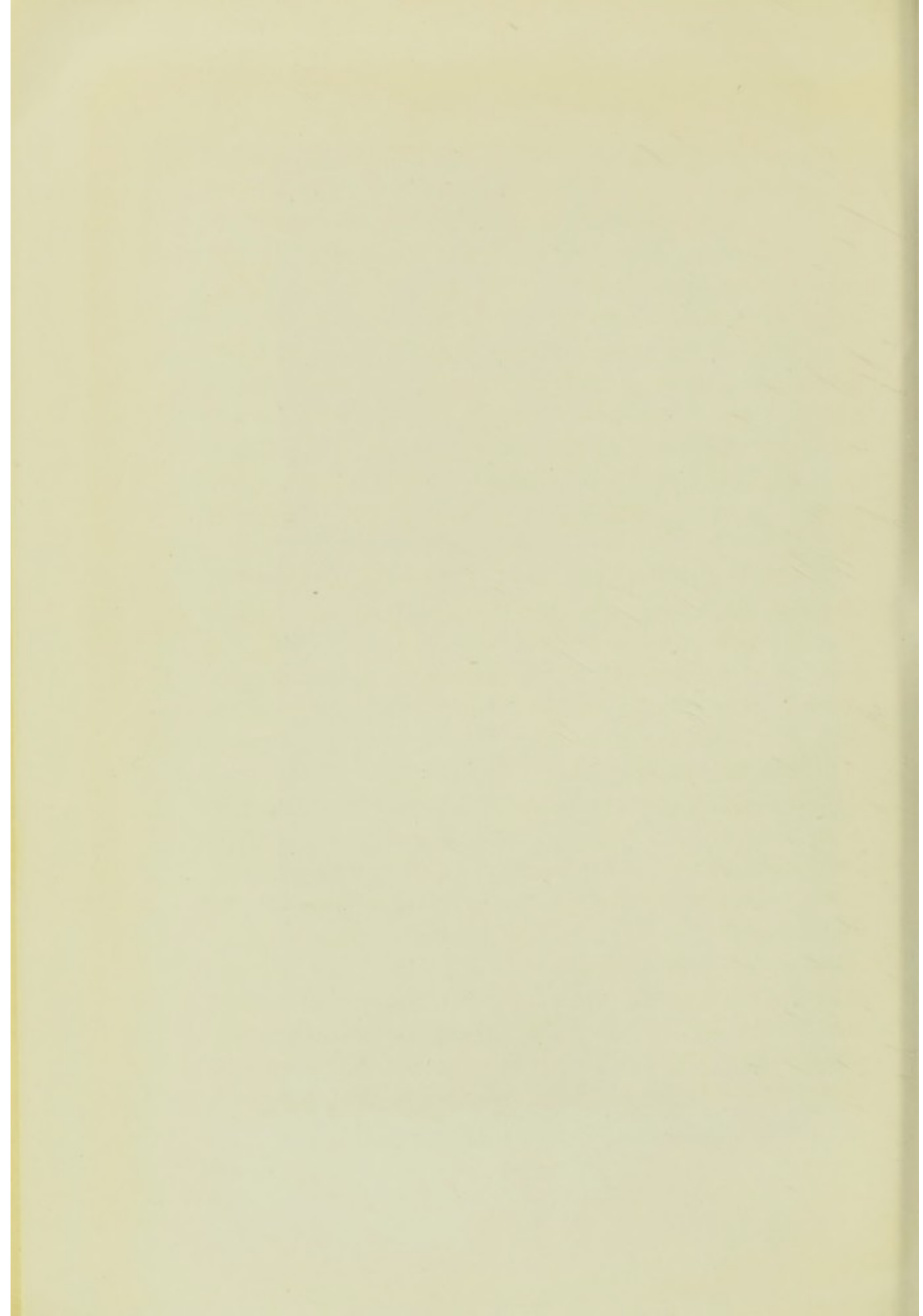
A carpet plant is really a very dwarf, recumbent shrub : one might almost say a miniature tree. The plant is woody and not herbaceous. The stem is very

PLATE XXV.
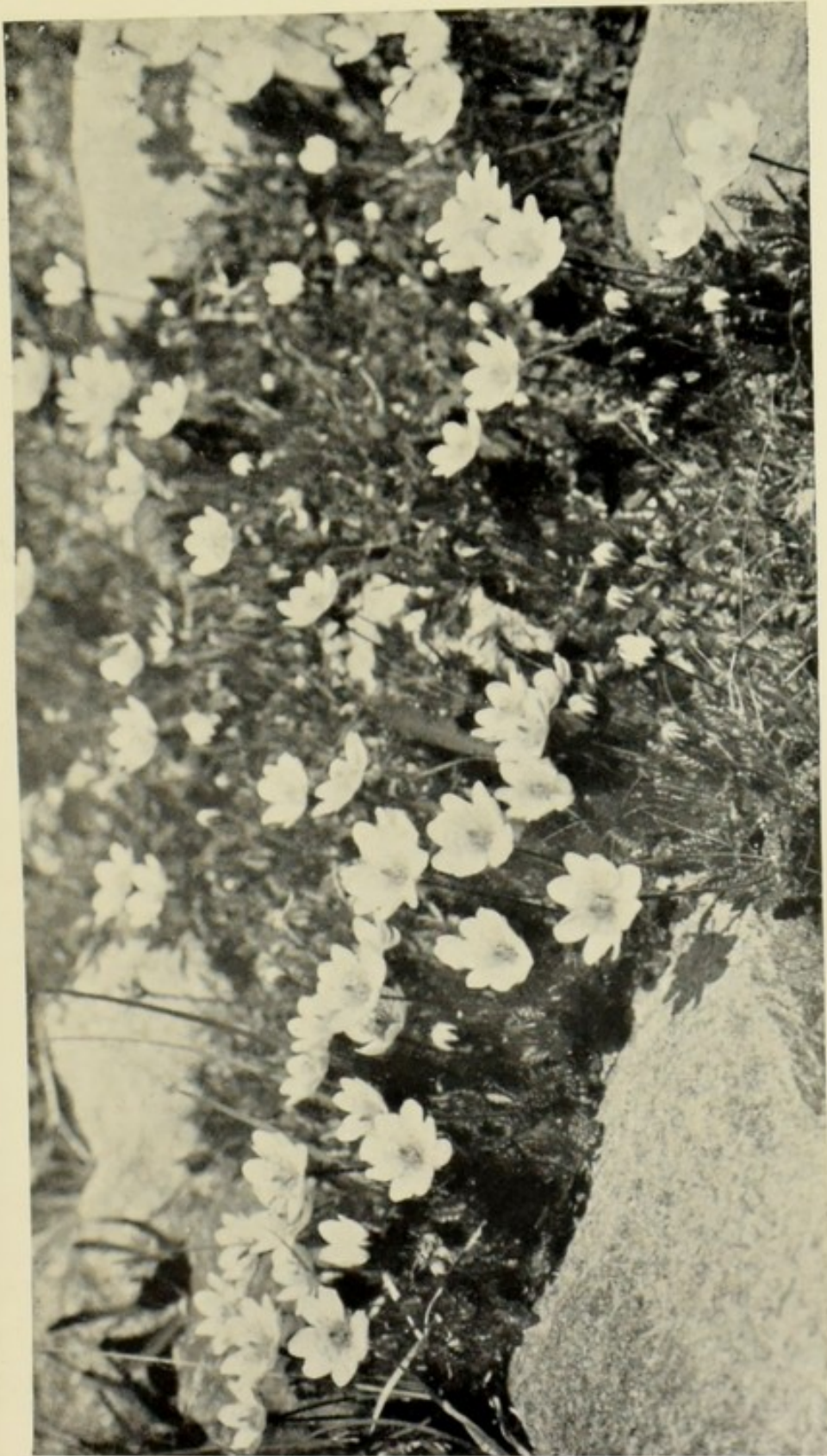
A Plant of the White Dryas (*Dryas octopetala*, Linn.).

[To face p. 106.

short and buried in the soil. Just above the ground a very large number of long prostrate branches spread over a considerable area, packed closely together. The branches bear numerous little tufts of leaves, and thus a green carpet of close texture, often occupying many square feet in extent, is woven over the soil.

The stems of many of these carpet plants reach a great age. In the case of *Dryas*, as many as a hundred years have been recorded on the evidence of the rings of growth of the woody tissues of the stem, as seen in transverse section. Thus these lowly plants are as permanent as many of the trees of a forest.

This type of habit has many advantages. It ensures space for the production of a very large number of flowers and consequently seeds. This we have seen to be a prime necessity for many Alpine plants. The close, compact nature of the carpet is very successful in preventing the intrusion of other plants on the same ground. Nothing can live beneath it. In the Alps the struggle for room leads to a daily war among plants. Not only does a carpet plant hold its ground successfully, but by the increase in the length of the branches it can increase its holding and oust out other plants which happen to be situated near the margin of the carpet. In winter-time also, when all the world is wrapped in snow, this particular habit is no doubt extremely well adapted to withstand the weight of the overlying snow, and thus to ensure the plant against injury.

The leaves, which, as we have seen, are borne in little tufts on the branches, are oblong in shape, deeply toothed, and mounted on long stalks. The upper surface is of a shining, deep green colour, and quite free from hairs. Below, the leaves are covered with a thick, felt-like coat of white, downy hairs, as is seen in the photograph on Plate XX., Fig. 1.

The leaves are evergreen and may persist for four or five years. In winter-time, when covered with snow, they are rolled on themselves, with the hairy, lower surface innermost. The young leaves are also covered over and protected by the downy lower surfaces of the older.

The hairs on the lower side of the leaf serve to protect the pores or stomata (see p. 10), which are confined to this surface. They both prevent too great evaporation of moisture from the leaf itself in dry weather, and, in wet, ensure that the lower surface, pressed close to the ground, does not become thoroughly soaked with rain-water, and thus that the gaseous interchange between the leaf and the atmosphere (p. 10) be not hindered.

The large and beautiful flowers, borne on stalks 2 to 3 inches in length, are remarkable for the fact that the sepals and petals vary from eight to ten, though the former is the more usual number. The fruits, which have long, feathery awns, enclosing a single seed at the base, resemble those of the Spring and Alpine Anemones (pp. 36 and 39) and the Mountain Avens (p. 128), the latter being a near relative of the

Dryas. They are adapted to travel long distances on a windy day.

There are only three living species of Dryas. Like many other Alpine plants, however, they are widely distributed, occurring not only in the mountains of Europe and Asia, but in the Arctic regions and in North America.

THE TRAILING AZALEA.

The Trailing Azalea (*Loiseleuria procumbens*, Desvaux, also known as *Azalea procumbens*, Linn., natural order Ericaceæ, the Heath family) is another typical carpet plant (p. 106) of the Alps. The numerous reddish-brown branches are imperfectly clothed with leaves. The leaves are small and oval in shape, set nearly at right angles to the branch and arranged usually in four rows. The flowers are usually borne in little groups near the ends of the branches, each arising in the axil of a leaf. They are small and rose coloured.

In comparison with many other Azaleas and Rhododendrons (two genera now usually regarded as identical), especially those characteristic of the Himalayas, which are now so common in cultivation, our Alpine Trailing Azalea, with its lowly habit and small leaves and flowers, presents a marked contrast. By some botanists it is still regarded as a typical Azalea, while others include it in a separate genus, *Loiseleuria*, on the ground that the flowers are perfectly regular in their construction. There is

only one species, which has, however, a wide distribution.

In Alpine Switzerland the Trailing Azalea is fairly common in all sorts of habitats. It may occur in woods which are not very dense (p. 248), on flat-topped hills resembling moorlands, and elsewhere, though it generally inhabits some slab of rock or some patch of dry stony ground. It occurs in the Highlands of Scotland, where it also forms a carpet on the flat dry hilltops. When grown in the Lowlands, it may abandon its prostrate, trailing habit and become erect.

The small leaves of this plant are worth examining. It will be found that they are rolled inwards at the edges. The stomata or pores are situated on the lower surface in two grooves near the edges, which are filled with hairs and further protected by the incurving of the leaf at the margins. Similar adaptations to guard against excessive loss of moisture from the leaf are found in the leaves of the Alpine Heath (*Erica carnea*), the Ling (*Calluna vulgaris*), and the Black Empetrum (*Empetrum nigrum*).

The Alpine Globularias.

In the Alpine Globularias, of which there are two species—the Round-leaved Globularia (*G. cordifolia*, Linn.) and the Bare-stemmed Globularia (*G. nudicaulis*, Linn., natural order Selagineæ, the Selago family)—we have a family of plants which does not

PLATE XXVI.
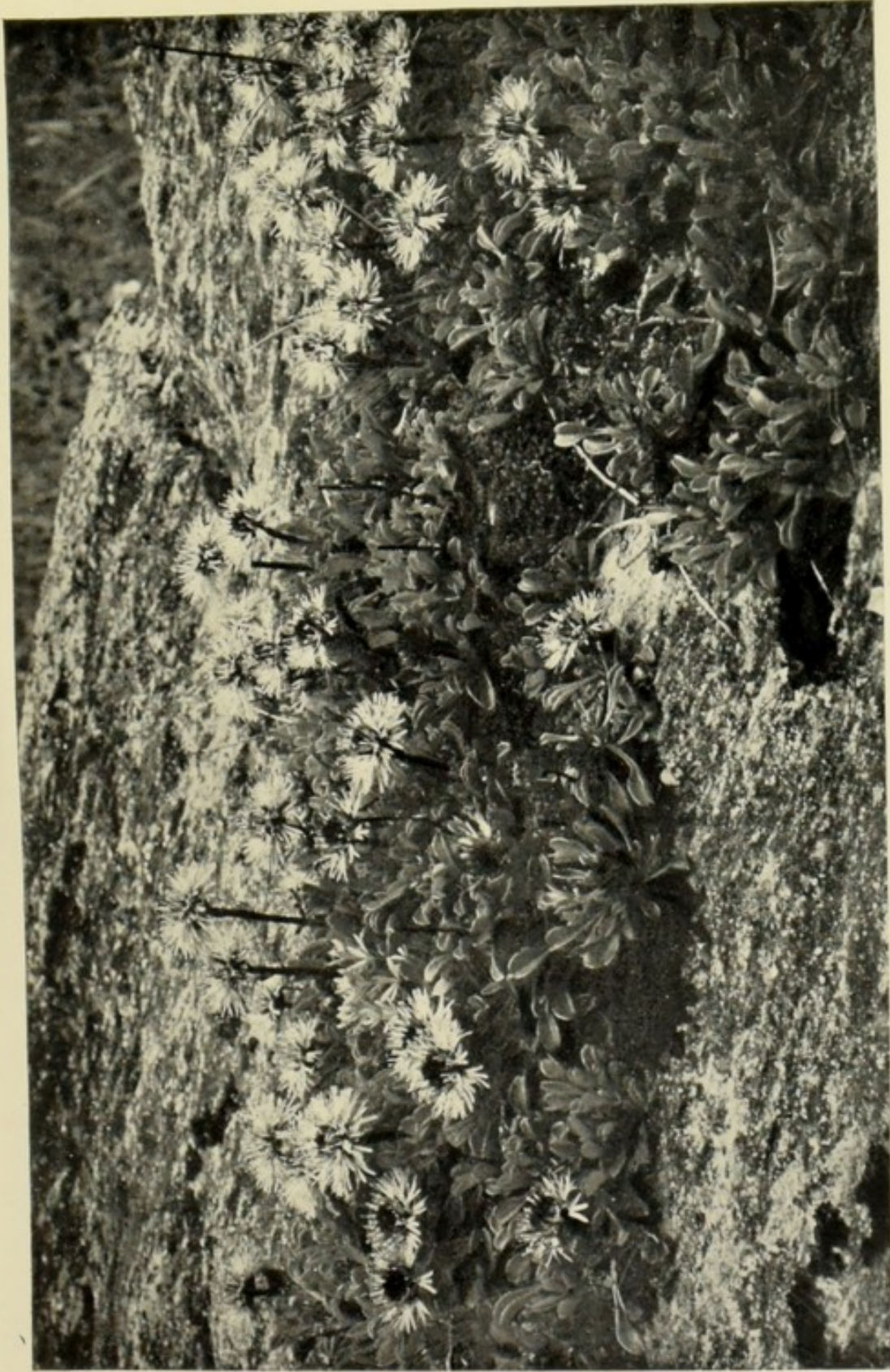
A Typical Alpine Carpet Plant (*Globularia nudicaulis*, Linn.).
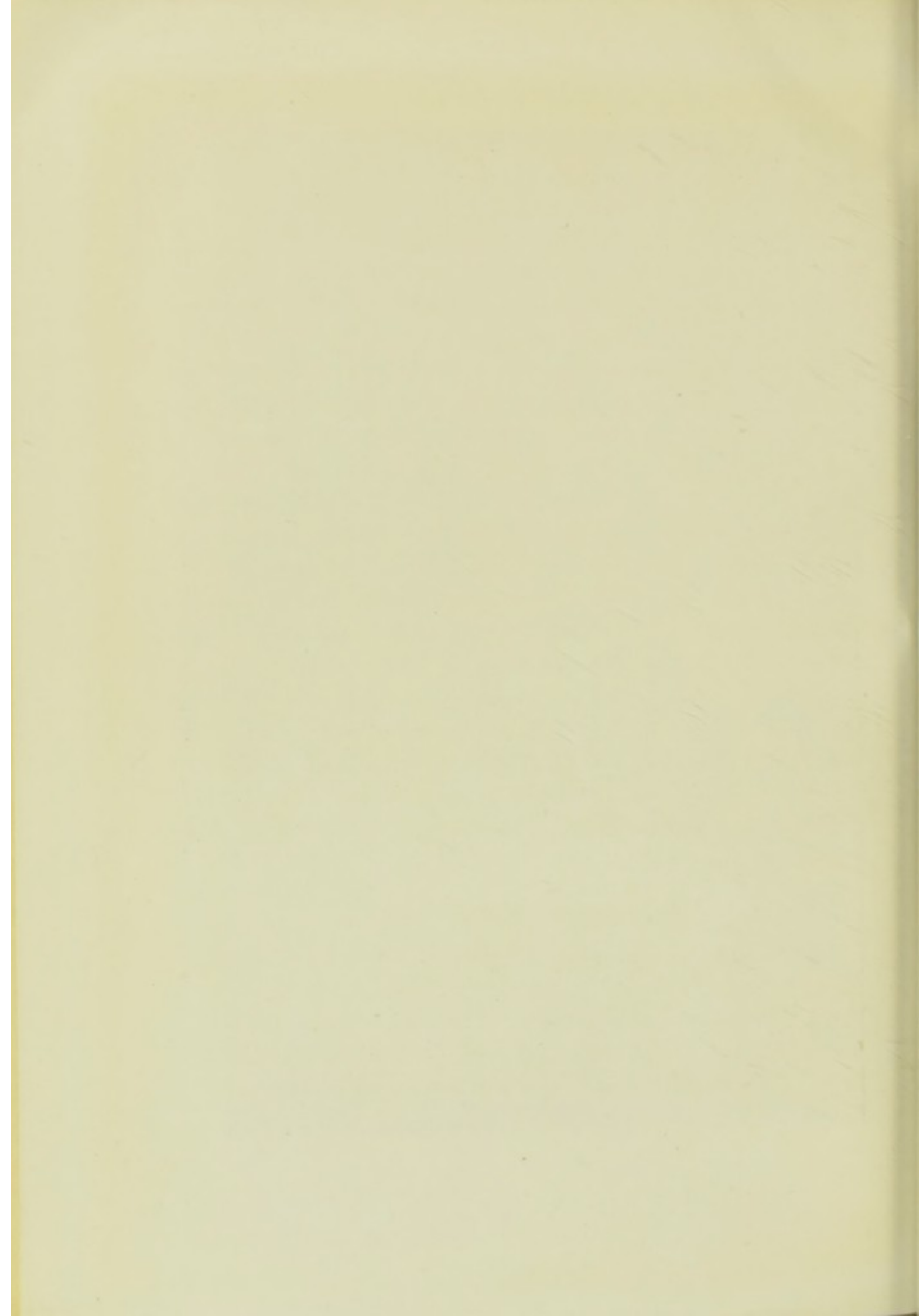
occur in Britain. In Alpine Switzerland they are an invasion from the Mediterranean subtropical flora.

The Alpine Globularias are typical carpet plants, in habit quite like those which we have just discussed. They are common on flat-topped rocks and in stony, dry places, and are easily recognised by their little dense heads of blue flowers borne erect on long stalks, which are leafless except for one or two very small bracts. The arrangement of the flowers in compact heads closely resembles that characteristic of the order Compositæ, the Daisy family, though here there is no involucre of bracts below the flower-head or capitulum. The flowers are two-lipped, and are for the most part fertilised by butterflies. In both species the leaves may occur in little rosettes on some portions of the trailing stems, while else-where they are scattered in their arrangement. In the Round-leaved Globularia (the leaves of which, by the way, are more spoon-shaped than round, despite the specific name) numerous runners are produced. These are not found in the case of the Bare-stemmed Globularia ; *cf.* also *Geum reptans* and *Geum alpinum*, p. 127.

The Alpine Buttercup.

The Buttercups, or Ranunculi (natural order Ranunculaceæ), are particularly numerous in the Alps. Some have yellow flowers, others white. They flourish under a great variety of circumstances, and are remarkable for being very little modified

externally in response to the physical conditions under which they grow.

The Alpine Buttercup (*Ranunculus alpestris*, Linn.) is often an abundant representative of the genus on rocks or on rocky ground, especially on calcareous soils at an elevation of about 6,000 feet. Its chief peculiarity is the dwarf habit, which, however, it shares with other Buttercups at high elevations. The whole plant is only from 2 to 4 inches in height. The leaves, which spring from a very short stem, are stalked, heart-shaped, and lobed. The nerves are very conspicuous on the upper surfaces, as in some other Alpines; cf. *Salix reticulata*, p. 188. The white flowers are solitary, and each is borne erect on a long stalk (Plate XXX., Fig. 1).

The whole plant is remarkable for being entirely free from hairs, unlike the majority of Alpines.

THE ALPINE PINKS.

In the month of July in the Alps, some of the spring flowers, especially on the drier stony slopes in the mountain pastures, are replaced by newcomers, among which are the Pinks. Three species are fairly common in the Alpine zone, while others occur at lower elevations, and one rare species is confined to the High Alps.

The Large - flowered Pink (*Dianthus superbus*, Linn., natural order Caryophyllaceæ, the Pink family), flourishing in meadows and on the edges of woods, is the handsomest of the Alpine species.

It is easily recognised by its pale pink corolla, deeply cut into a fringe of delicate segments.

The flowers have a scent resembling oil of cloves. The Wood Pink (*Dianthus sylvestris*, Wulf., also known as *D. inodorus*, Steud.), on the other hand, is scentless, and has solitary flowers. It is perhaps the commonest species all over Switzerland, especially in rocky places. In the Carthusian Pink (*Dianthus Carthusianorum*, Linn.), the dark red flowers are borne in clusters, and the leaves are blue-green. In our cultivated Sweet - William, which is a Pink, we find similar flower-clusters. In addition to the erect flowering shoots, we sometimes find at the base of this plant small, more or less prostrate shoots, each bearing only a single flower, which is female and does not possess stamens.

There is nothing very striking, biologically, to relate of the Alpine pinks. Their tufted habit and erect, grass-like leaves, peculiarities also shared by other Alpine plants, such as the Anthericums (natural order Liliaceæ), are adaptations fitting them to exist in situations fully exposed to the sun, and on soils which are comparatively dry.

THE ALPINE TOADFLAX.

The Alpine Toadflax (*Linaria alpina*, Mill, natural order Scrophulariaceæ, the Foxglove family) is a characteristic plant on the dry stony debris bordering on Alpine streams and in other localities physically similar. We are familiar in Britain with

two Toadflaxes, the handsome Yellow Toadflax (*Linaria vulgaris*, Mill) and the Ivy-leaved Toadflax (*L. cymbalaria*, Mill), the latter common on old walls. These do not occur within the limits of the Alpine zone. They are there replaced by the Alpine Toadflax, with its violet or deep ultramarine blue flowers, touched with yellow at the throat of the corolla. This plant is thus a further example of an Alpine replacement (see p. 266), and adds another to the large number of the blue-flowered plants of the Alps (p. 43).

In the Alpine zone this species is usually a perennial. Prof. Bonnier of Paris has experimented with this and other Alpine plants, in respect to its duration of life at different altitudes. The vast majority of Alpines are perennials, but certain annuals, such as the Snow Gentian (*Gentiana nivalis*, Linn.), p. 49, and *Saxifraga controversa*, Sternberg, p. 82, or biennials such as *Campanula thyrsoidea*, Linn., p. 90, also manage to flourish very well. Prof. Bonnier finds that many Lowland plants, which are annuals or biennials in the plains, may become perennials if transplanted to the Alpine zone. The Alpine Toad-flax, on the other hand, if removed to the Lowlands, is found to become an annual or biennial. The duration of the life of the individual plant is thus, at least to some extent, adapted to the physical conditions under which it lives. Owing to the shortness of the summer in the high Alps, there is not sufficient time to carry out the life's work in

one season, as in the plains, and consequently some different plan of operation has to be adopted, and this finds its expression in the perennial habit.

The flowers of the Alpine Toadflax, which, like many other members of the same order, only possess four perfect stamens, the fifth being suppressed, are remarkable for the spur formed by one of the petals, a rare occurrence in this family. The petals are also so shaped that the corolla is closed at the throat. The same feature is also seen in the Snap-Dragons (*Antirrhinum*). The pollen and the honey are thus hidden. This is a special adaptation, to ensure that only large and strong insects, such as certain bees, can force open the throat of the corolla. Further, such insects must possess a long tongue to reach the nectar secreted in the spur, and incidentally cross-fertilise the flower. This flower is thus specialised for certain insects alone.

There are many other Alpine plants flourishing in rocky situations, such as some of the Potentillas (natural order Rosaceæ) or the Rock Catchfly (*Silene rupestris*, Linn., natural order Caryophyllaceæ) (Plate XVI., Fig. 2), with its widely spreading branches, but most of them are not known to present any very striking points of biological interest.

CHAPTER V

INTERESTING PLANTS OF THE ALPINE PASTURES

In Chapters II. and III. we have reviewed some of the more characteristic plants of the Alpine pastures. There remain others, which, unlike those considered in the last chapter, are rare in dry rocky habitats, but inhabit the typical, grassy alpen or pastures. We will consider some of the more interesting of these in the present chapter.

The distribution of Alpine species in the Swiss Alps is very uneven. Some districts are rich in species more or less confined to them, so far as Switzerland itself is concerned. For instance, the valleys of Canton Valais, especially the Zermatt and Visp Thalen, or the high Alpine valleys of the Upper Engadine and Davos, with their tributaries, are remarkable in this respect, and form the finest collecting grounds for Alpine plants in Switzerland. Other districts, such as the Bernese Oberland, are relatively poor. In a later chapter we will discuss the theories put forward to account for this inequality of distribution. For the present, we will simply bear in mind that it exists.

At first sight it might appear that the nature of the soil may be a controlling element in determining the distribution of a species. Some plants appear to occur in Switzerland only where granite or schist forms the rock from which the soil is derived. Others seem to frequent only limestone soils. A third set of plants appear to be quite indifferent as to soil. We can thus distinguish three groups : the calcicoles, confined to limestone soils; the calcifuges, which occur only where lime is absent from the soil; and a third, those which are indifferent as to soil.

It is frequently asserted that the white-flowered *Anemone alpina* occurs on all sorts of soil, while the still commoner variety with yellow flowers, often called *Anemone sulphurea*, is only to be found on non-calcareous soils. Again, the rarer Hairy Alpenrose (*Rhododendron hirsutum*) is believed to be calcicole, whereas the commoner species, *Rhododendron ferrugineum*, is indifferent in its tastes. The Auricula (*Primula auricula*) is also stated to be calcicole. It is true that in many localities this is the case. The Auricula, for instance, flourishes exceedingly on the limestone rocks of the Engstlen Alp (Canton Berne). But from a botanical standpoint, in order to estimate the absolute effect of the constituents of a soil, as factors controlling the distribution of plants in the Alps, it is of importance to know whether each species is always restricted to one particular soil.

Professor Bonnier, whose work we have already

referred to more than once, has specially enquired into this problem.   For this purpose he studied the flora of three mountain regions, widely separated : the French Alps of Dauphiné, the Austrian Alps, and the Carpathians.   The distribution of the same plant was observed in each of these three districts, especially in relation to its soil.   He found that some species, such as the Glacial Buttercup (*Ranunculus glacialis*), p. 193, the Stemless Catchfly (*Silene acaulis*), and the Mountain House-leek (*Sempervivum montanum*), p. 99, were calcifuge in two regions, though not in the third.

Other plants, such as the Alpine Anemone (*Anemone alpina*), p. 37, the Alpine Buttercup (*Ranunculus alpestris*), p. 112, and the White Dryas (*Dryas octopetala*), p. 106, may be indifferent as to soil in one or even two districts, yet in a third they are distinctly calcicole.   The Edelweiss (*Leontopodium alpinum*), p. 15, proved to be calcifuge in Dauphiné, indifferent as to soil in Austria, and calcicole in the Carpathians.   Hardly any Alpine is confined to limestone soils in all three regions, and only three species are absolutely calcifuge.

It is thus obvious that while in one country such as Switzerland a plant may be almost entirely calcicole, it is quite likely that, in one of the other mountain ranges of Southern Europe, it will be found to be indifferent as to soil, and thus the influence of the soil alone on distribution is, at the most, local and not absolute.

At the same time, the nature of the soil has naturally a very profound influence on vegetation locally. A good example is seen in the case of "chalet plants," so called because they flourish in abundance close to the picturesque wooden cow-chalets of the pastures, and are but rarely found elsewhere. This is probably due to the fact that round the chalets the soil is relatively rich in humus in comparison with many other localities, the humus being derived from the manure which accumulates close to the chalets, and which is to some extent spread around them when exposed to rain.

Many of these chalet plants are common weeds. Our well-known Dandelion (*Taraxacum officinale*,[1] Weber, natural order Compositæ, the Daisy family), with its beautiful little parachute fruits, adapted for travelling long distances in the air, is very common in this position, though also widely distributed in other localities. Our two British Stinging Nettles, *Urtica urens*, Linn., the Small Nettle, and *Urtica dioica*, Linn., the Common Nettle, are also often abundant near chalets, though rare or absent else-where. The latter species flourishes exceedingly at 6,000 feet or more in the Alps, producing very tall, vigorous plants, 3 feet or more in height.

The Alpine Gagea (*Gagea Liotardi*, Schult., natural order Liliaceæ, the Lily family), allied to the Star-of-Bethlehem and our British Yellow Gagea,

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[1] So called because parts of the plant were formerly used as medicine ; *cf*. Officinal.

is another plant which is rare except in damp places near cow-chalets, as on the Engstlen Alp (Canton Berne).

The Alpine Dock (*Rumex alpinus*, Linn., natural order Polygonaceæ, the Dock family), with very large leaves borne in massive clumps, is frequently to be seen near chalets. It is largely cultivated by careful manuring, and is made use of as a fodder. The leaves are cut two or three times during the course of the summer and boiled down, the concoction being laid by for the use of the cattle in winter. The German-speaking Swiss call this dock "Blacken," and the patches of dock "Blackengärten." The same name is also sometimes found applied to certain pastures, such as the Blacken Alp on the Surenen Pass, where this plant is abundant.

The White Veratrum.

We will now discuss some further pasture plants of interest, beginning with the White Veratrum (*Veratrum album*, Linn., natural order Liliaceæ, the Lily family) (Frontispiece, and Plates XXVII. and XXVIII.), which is a stout herb very common in the pastures. The stem is tall and the leaves light green in colour, large and broad. The flowers are greenish-white, the perianth leaves being widely open, and the anthers globular in form. The specific name, "album," = white, if it refers to the flowers, is certainly a misnomer, for their colour is, as a rule, much nearer green than white.
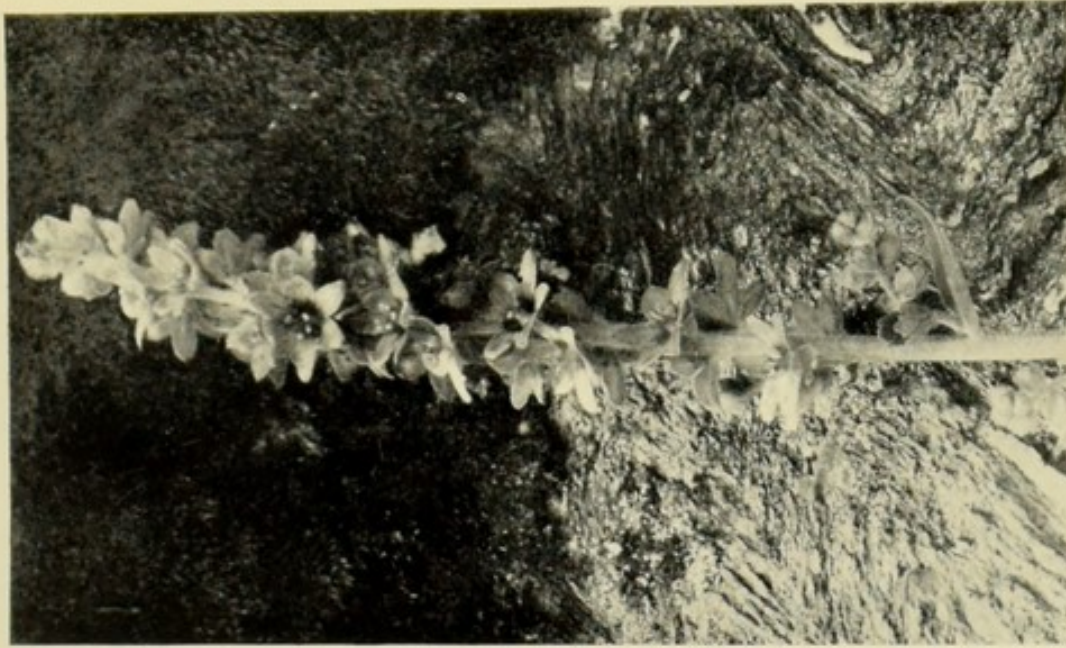
PLATE XXVII.

Fig. 2.—Inflorescence.

Fig. 1.—Leafy Shoots.

The White Veratrum (*Veratrum album*, Linn.).
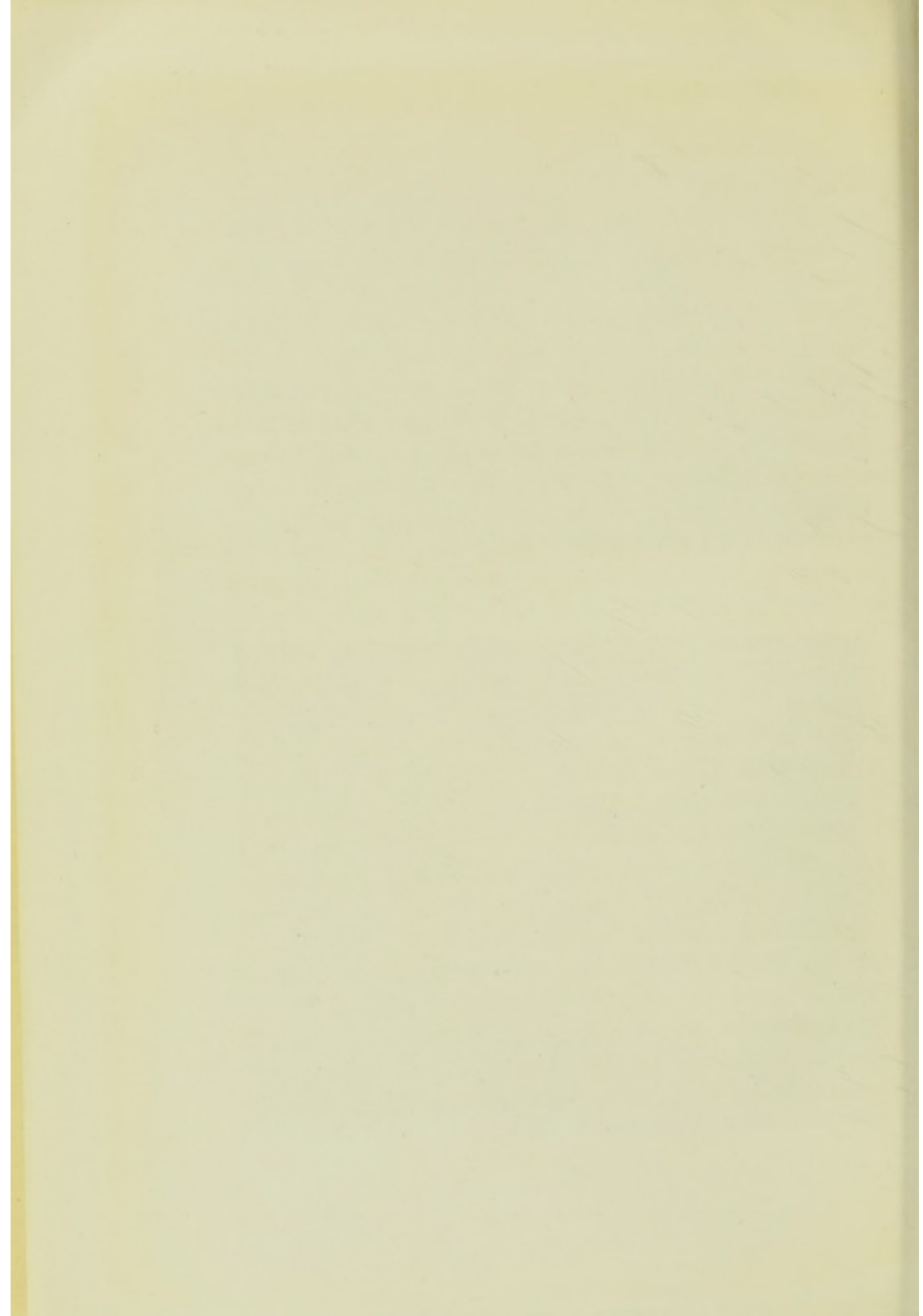
The leaves are interesting structures (Plate XXVII., Fig. 1). The upper surface is concave and the leaf is folded lengthways, so that a series of ridges separated by grooves are formed. It is believed that these ridges and grooves help to direct rain, falling on the leaf, to the soil immediately above the large underground stem. The water collects in the concave leaves and trickles down in the grooves to the base of each, and thus falls on the soil immediately below the insertion of the spirally arranged leaves on the stem. In this way a larger quantity of water is probably brought within the reach of the underground stem, than would be the case if the rain-water dripped from the tips or edges of the leaves. The fact is easily verified by the experiment of pouring some water from a neighbouring stream over the plant, and watching its course to the soil.

It is interesting to compare the young shoot of a Veratrum (Plate XXVIII., Fig. 1) as it appears forcing its way up above ground when the snow is melting, with the fully expanded, mature plant and its spreading leaves (Frontispiece, and Plate XXVII., Fig. 1). The young shoot somewhat resembles a compact form of cabbage. The leaves are all held erect and closely wrapped round one another, their tips being directed upwards, the whole forming a compact, conical bud of large size, with a few scale leaves at the base. If we cut one of these shoots in two lengthways, we shall find the

whole plant, as we recognise it later when fully expanded, present in miniature or almost tabloid form! The internodes of the stem and its branches— that is to say, the portions of the stems between the nodes where the leaves are borne— are very short and compressed. As the stem grows, the internodes lengthen rapidly.

The underground stem of Veratrum is a stout stock, which is worth digging up and examining. It contains a highly poisonous substance, the alkaloid known as *veratrin*. The underground stem is, or was, called by herbalists, the "white hellebore root," a misnomer, for the stock is botanically a stem or rhizome, and not a root.

If we examine the thick roots borne by this underground stem, we shall find they are wrinkled transversely (Plate XXVIII., Fig. 2). We have here a good case of what are called "contractile roots." Similar contractile roots occur in the case of many other Alpines, such as some of the large Gentians with yellow or red flowers, and they are also very common among bulbous and tuberous plants. By means of these roots, the rhizome, tuber, or bulb, as the case may be, is being pulled downwards continuously, and lowered, so to speak, into the soil, especially when the plant is young. The "Californian Lily," for instance, produces one great, thick, contractile root annually, which draws down the tuber into the soil, from two-fifths to three-fourths of an inch each year. In another case,

PLATE XXVIII.

Fig. 2.—Root-stock and Contractile Roots.

Fig. 1.—Young Shoots in Spring beginning to expand.

The White Veratrum (*Veratrum album*, Linn.).
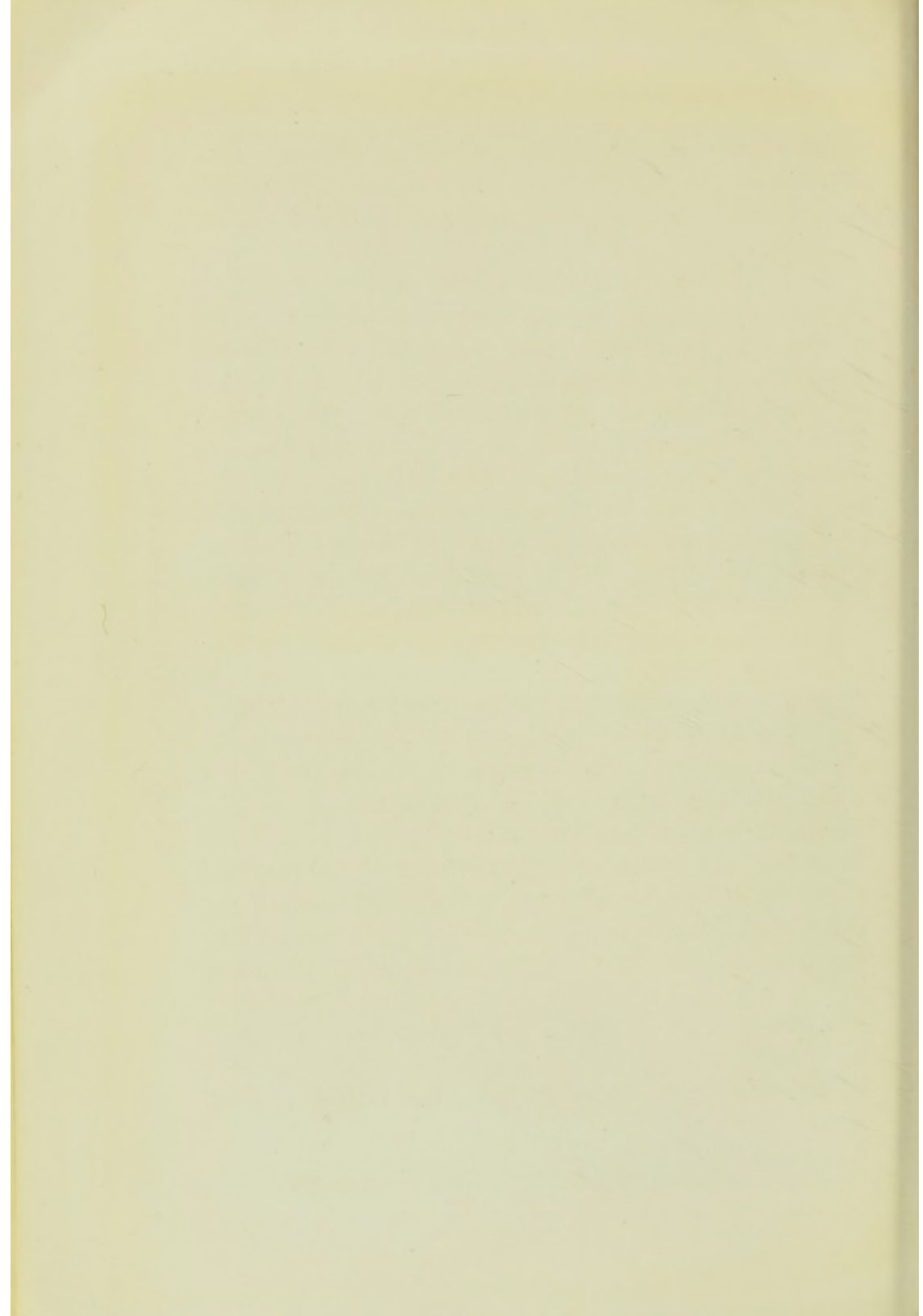
the seedlings of the British Cuckoo Pint (*Arum maculatum*, Linn.) have been observed to be dragged downwards a distance of 2 inches between May and October.

It is impossible to attempt to explain here the mechanism whereby the contraction is effected. To do so would involve a detailed account of the internal structure and functions of the root. It may, however, be said, that certain internal cells have the power of contracting, and when this tissue shrinks it shortens the external tissues, which no longer fit it, but are drawn into wrinkles, like a glove too long for the finger. It is naturally important that the underground stem, as it increases in size, should be buried deeper and deeper in the soil, to escape the frosts of winter, and it is by the contraction of these roots that this is effected.

The flowers of Veratrum are interesting from the fact that while those of the main flowering shoot usually contain both sexes (hermaphrodite), the flowers of the lateral branches are generally male only. In the plant figured on Plate XXVII., Fig. 2, it was found that thirty-two hermaphrodite flowers occurred on the main axis, against forty-nine male flowers on the lateral branches. We have already noticed in the case of the Alpine Anemone, p. 39, that male flowers are often more abundant than hermaphrodite. Occasionally in Veratrum, some of the upper flowers are entirely female, without any trace of stamens.

The flowers of Veratrum are often wholly green,

yet they are conspicuous objects, quite apart from the large, shining, green leaves. Conspicuousness to the insect world is a matter of the highest importance to the majority of Alpine plants, which depend on insect visits to ensure cross-fertilisation (p. 271). In the greater number of cases, as in Veratrum, it is the corolla or perianth which forms the conspicuous advertisement to the insect world on the part of the plant. The corolla of a Pansy or Violet (p. 161) is a good example. In some plants, however, the stamens play this part. The Meadow Rues (genus *Thalictrum*, natural order Ranunculaceæ), of which there are several species in the Alps, including the beautiful *Thalictrum aquilegifolium*, with its lilac-coloured stamens, and the Alpine Willows, p. 189 (genus *Salix*, natural order Salicaceæ), are examples of this class.

In other flowers, it is the calyx, and not the corolla, which serves as the attractive organ; as, for instance, in the Globe-flower (genus *Trollius*), p. 207, and the Monkshoods (genus *Aconitum*), p. 130, both belonging to the Ranunculaceæ. In other plants, it is the bracts or leaves of the inflorescence, as in *Bupleurum* and *Astrantia* (natural order Umbelliferæ), the Edelweiss, p. 19, and the Spurges (genus *Euphorbia*, natural order Euphorbiaceæ), which perform this function. These facts illustrate the variety of means by which nature attains a single end.

The Carline Thistle.

The Carline Thistle (*Carlina acaulis*, Linn., natural order Compositæ, the Daisy family) is quite unmistakable from its habit of flowering flat on the surface of the ground, in many an Alpine pasture and mountain-side (Plate XXIX., Fig. 2). A real stem is present, despite the specific name : only, it is very short, and buried as much as possible in the soil. This type of habit, known to botanists as the geophilous habit, is characteristic of Alpine plants as a whole. Usually the underground development of an Alpine plant greatly exceeds that above ground. Not only is the root system in many Alpines extremely well developed, but the underground stem, comparatively safe from the attacks of the winter's frost, is often a large structure modified to serve as a storehouse for reserve food laid by to enable the plant to begin work again in the spring at the earliest possible moment.

From the short underground stem of the stemless thistle a large number of spiny leaves radiate, all of them being closely pressed to the soil. In their centre a single, large, pale yellow thistle-head, 2 to 3 inches in diameter, occurs, which in its turn is closely pressed to the leaves. The flower-heads are ripe in August, and usually persist throughout the following winter. They are very interesting, from the fact that they act like weather - glasses. The flower-leaves (bracts) of the head, arch upwards and form

a penthouse over the flowers on the approach of wet weather, so as to protect the pollen (Plate XXIX., Fig. 2). On sunny days the bracts bend backwards on to the leaves, and leave the flowers fully exposed to the heavens.

When the flower-head is young and its diameter relatively small, the length of the bracts is also short. But as the flower grows and increases in size, so the bracts also lengthen. Thus the roof or penthouse grows in proportion with the dimensions of the whole flower-head, and protection is at all times efficient.

It has been found experimentally that it is not a change in the intensity of the light or of temperature, which stimulates this Thistle to erect its penthouse, but a variation in the amount of humidity or moisture in the air. For this reason these flower-heads are often used as weather-glasses or hygrometers.

The heads of the Carline Thistle are wonderfully conspicuous, especially when expanded, and this is largely due to the silvery white, glistening, inner surface of the strap-shaped bracts. The flowers of the head are much visited by humble-bees, which carry the pollen from one flower to the stigma of another. The stylar-brush mechanism, already described on p. 85, exists in this, as in all other members of the Compositæ.

PLATE XXIX.

FIG. 2.—The Carline Thistle (*Carlina acaulis*, Linn.), in Bad Weather.
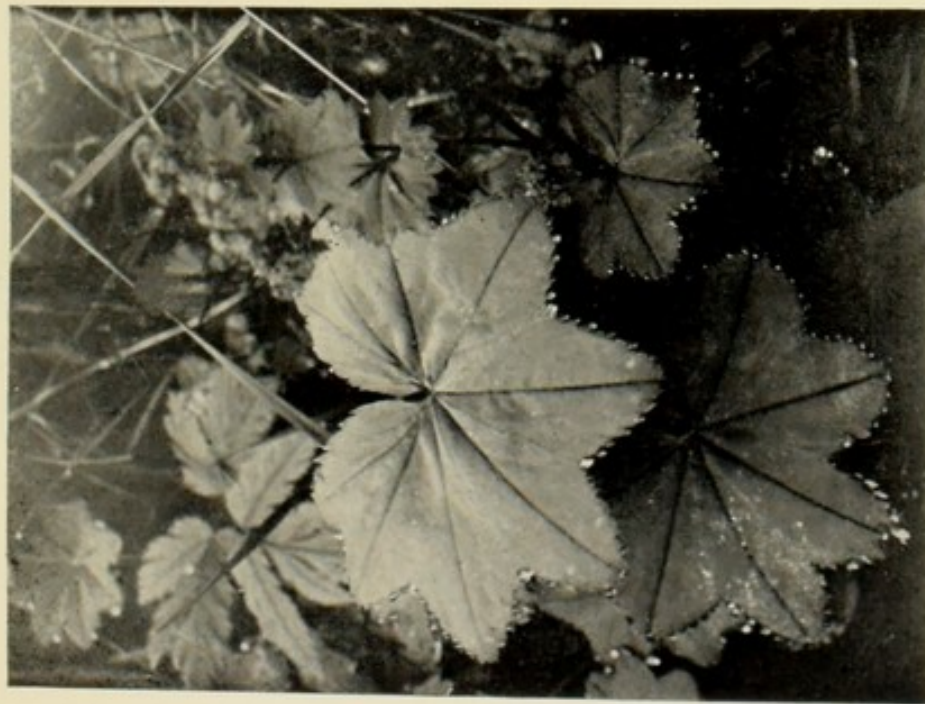
FIG. 1.—The Leaves of a Lady's-mantle (*Alchemilla*), with Drops of Water exuding from the Pores on the Margins.
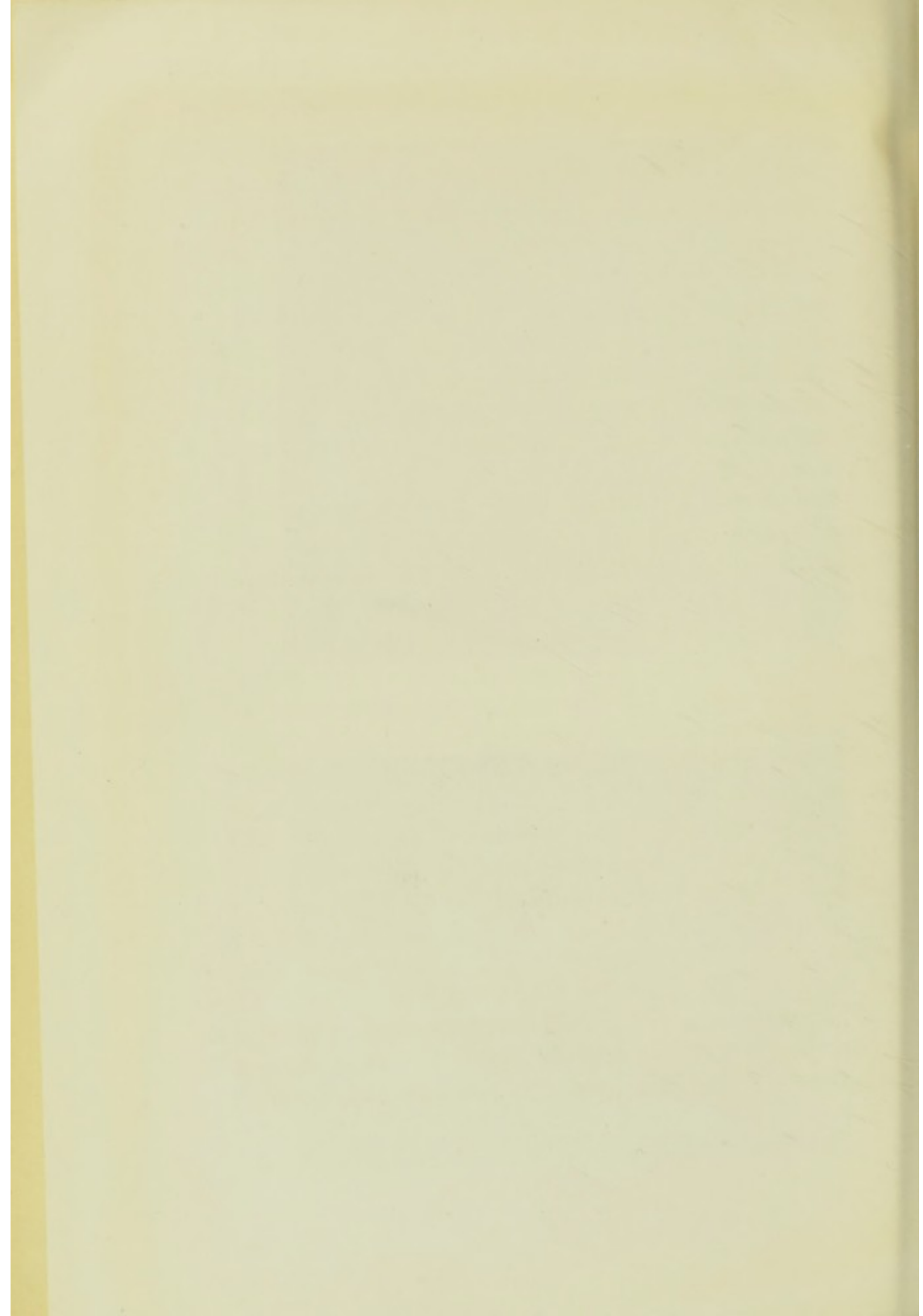
The Creeping and Mountain Avens.

The genus *Geum* (natural order Rosaceæ, the Rose family) is represented by four species in the Alps. Two of these are British plants chiefly confined to the Alpine meadows (p. 157). The other two, sometimes placed in a distinct genus, *Sieversia*, are the Creeping Avens (*Geum reptans*, Linn.) and the Mountain Avens (*Geum montanum*, Linn.), both common plants on the pastures, with a preference for dry soils.

The Avens are easily mistaken for Buttercups or even Anemones. In some respects the family to which they belong closely resembles the Buttercup family. It is distinguished by the fact that the sepals are united below into a cup, on which the petals and stamens are borne. If a flower is cut in half lengthways with a pocket knife, this can easily be seen. In the Buttercup family all the organs of the flower are quite free from one another, and attached separately to the receptacle.

The Creeping Avens produce little runners like those of the Strawberry or of the House-leeks (p. 100). These take root a few inches away from the parent stem, and at this point a bud is formed, which grows into a new plant. The Mountain Avens, on the other hand, does not form runners.

The leaves are compound, and all spring from a short stem just above the ground. Each has a large terminal leaflet, and the other leaflets become

smaller and smaller towards the base. In the case of the Creeping Avens the leaflets are pointed and have sharp teeth, while in the Mountain Avens both the leaflets and teeth are rounded.

The yellow flowers, which are large and handsome, are borne singly on long stalks, pinkish-brown in colour. The calyx is double, a peculiarity also shared by several other genera of Rosaceæ, including the Potentillas, a very abundant Alpine race, and the Strawberry. Six outer members of the calyx alternate with six longer inner sepals. The petals are usually six in number, while the stamens are very numerous. The pinkish-brown fruits have feathery plumes, like those of the White Dryas already mentioned (Plate XXX., Fig. 2).

The flowers of the Avens are often unisexual, and the same holds good also in the case of the White Dryas. Some will be found to be perfect—that is to say, they possess both stamens and carpels—while others contain stamens only. This tendency to derive unisexual male flowers, from perfect or hermaphrodite organs, is not infrequent among Alpine species of Rosaceæ and Ranunculaceæ. We have already noticed another instance, in the case of the Alpine Anemone (p. 39).

THE LONG-SPURRED VIOLET.

The Long-spurred Violet (*Viola calcarata*, Linn., natural order Violaceæ, the Violet family) is frequent in June and July on the slopes of the higher pastures

PLATE XXX.
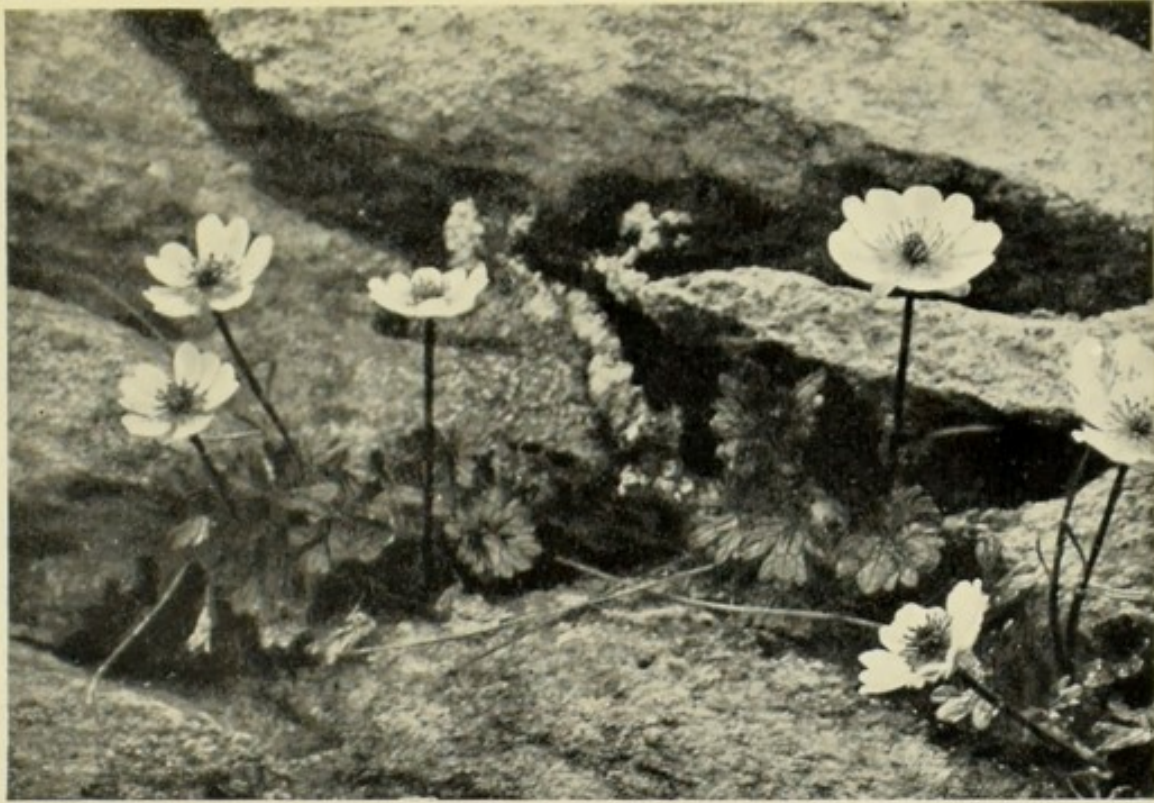
Fig. 1.—The Alpine Buttercup (*Ranunculus alpestris*, Linn.).
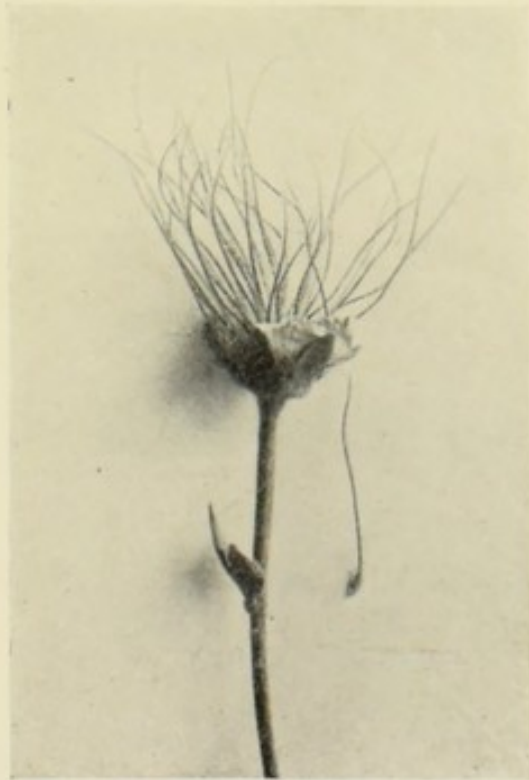
Fig. 2.—Fruits of the Mountain Avens (*Geum montanum*, Linn.).
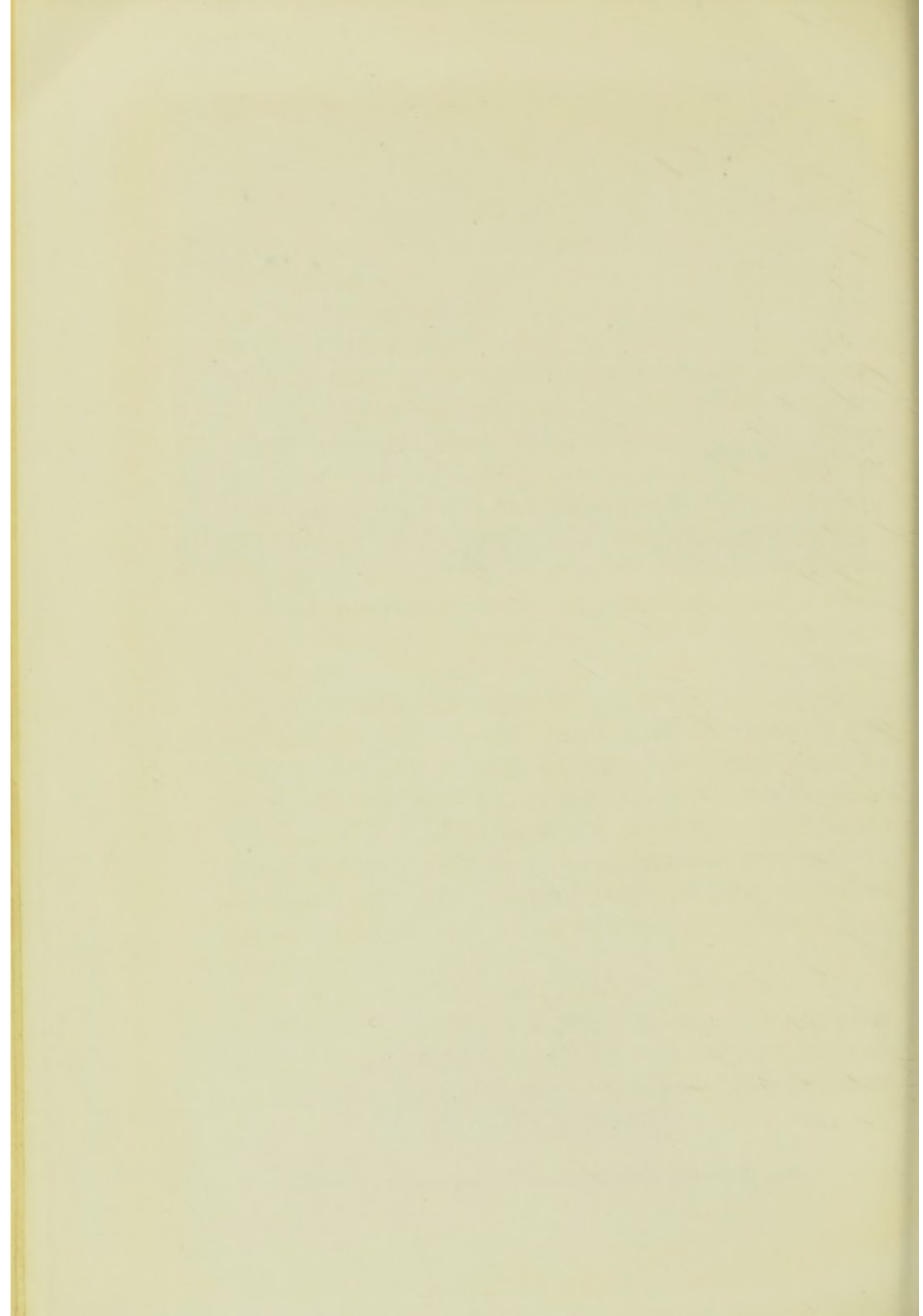
all over Switzerland, between 6,000 and 9,000 feet. It is often so abundant that it forms a regular carpet of flowers of a pale violet-blue colour on the mountain-side. The leaves are toothed. The flowers are exceptionally large for Violets, and possess a very long, slender spur, in which the honey is stored. Like many other Alpine plants, they are fertilised by butterflies, being specially adapted to this class of insects. The long spur is a device for placing the nectar out of the reach of any other insects except butterflies, which alone possess a sufficiently long and slender tongue or proboscis to penetrate into the spur. This spur is more than $\frac{3}{4}$ of an inch in length, and is very narrow, being only about $\frac{1}{16}$ of an inch across. Even if the proboscis of some other insect were long enough, the extreme narrowness of the spur would prevent it reaching the nectar.

The great naturalist, Hermann Mueller, to whom we owe our present knowledge of the fertilisation of Alpine flowers, observed that in the Alps, nine different butterflies visited no less than 194 flowers of this Violet in the space of $6\frac{3}{4}$ minutes.

The mechanism to ensure cross-fertilisation is otherwise practically identical with that to be described later in the case of the Field Pansy (p. 160).

In the High Alpine region, another but similar species, the Mont Cenis Violet (*Viola cenisia*, Linn.), occurs infrequently. The leaves differ in being quite uncut at their margins.

THE ALPINE MONKSHOODS.

The Alpine Monkshoods, genus *Aconitum* (natural order Ranunculaceæ, the Buttercup family), are several in number. We will notice two: a blue-flowered species, *Aconitum napellus*, Linn., and the yellow flowered, *Aconitum lycoctonum*, Linn. The flowers are interesting from their peculiar construction. There are five coloured sepals, one being much larger than the rest, and fashioned in the form of a helmet. The petals may be eight in number, but they are all very small, except a pair which are covered in by the helmet-like sepal. These are converted into long-stalked honey-glands, of a peculiar form, with a large nectary at the apex. The flowers are specialised for cross-fertilisation through the agency of humble-bees, other insects being unable to reach the nectaries protected by the helmet-like sepal. *Aconitum* is not known to occur in any region of the world from which humble-bees are absent. Curiously enough, these insects often rob the flowers of the honey by biting through the helmet, instead of seeking the nectar by the natural entrance to the flower. In such cases, of course, the plant loses the chance of being cross-pollinated. Sometimes every flower in the inflorescence is thus mutilated.

The tuberous roots, and also the leaves of the Monkshoods, contain a very poisonous alkaloid, known as aconitine. One-fiftieth part of a grain is said to be a fatal dose. The alkaloid obtained from

A. lycoctonum is less powerful than that from *A. napellus.*

THE ALPINE BUGLE.

The Alpine Bugle (*Ajuga pyramidalis*, Linn., natural order Labiateæ, the Mint family), is a striking plant, on account of its pagoda-like habit. It is often to be found growing in the shade of rocks. The build of this species is wonderfully regular and symmetrical, almost formal. Like all Labiates, the stem is square and the leaves are placed in opposite pairs. The pairs of leaves alternate very regularly, so that there are four longitudinal rows of leaves in all, one on each side of the square stem.

In the Alpine Bugle the leaves are larger and longer than in our British species, and decrease in size much more gradually toward the top of the plant, thus constructing the characteristic pagoda-like habit. They are often tinged with a bright-red colour.

The flowers are borne in complicated and compressed inflorescences in the axils of the leaves. They occur in abundance from the base of the plant to the very apex. Unlike the Swiss Lowland species and some of the British Bugles, the Alpine plant does not form runners. This fact is the more curious, for runners are characteristic of many Alpine plants such as the House-leeks, the Creeping Avens, and others.

The Alpine Clover.

In the Alpine pastures and meadows various species of Clover are conspicuous, some of which have beautiful yellowish - brown flower - heads. We will notice here one species, the Alpine Clover (*Trifolium alpinum*, Linn., natural order Leguminosæ, the Pea family), in which the rose-coloured flowers are very large and handsome. As compared with Clovers in general, the heads contain only comparatively few flowers, which are much larger than those of the other Swiss species. Here we see another good example of increase in the size of the individual flowers so characteristic of many Alpines. A few large flowers in a head compete successfully with heads containing many smaller flowers. The flowers have a very strong, sweet scent.

The fruits are also interesting, from the fact that the calyx remains attached to the one- or two-seeded pod after the corolla has fallen, and aids as a flying apparatus for the distribution of the fruit by the wind.

The Alpine Clover in Switzerland is a calcifuge—that is, it avoids calcareous soils. It has a great underground development of root and stem, as we shall find if we attempt to unearth a plant. It is a perennial, and may attain to a considerable age.

THE ARNICA.

Among the many Alpine Composites (natural order Compositæ), the flowers of the Arnica (*Arnica montana*, Linn.), of large size, and deep orange-yellow colour, are quite common and unmistakable. The roots and leaves of this plant contain a bitter resinous substance, arnica, together with a volatile oil which, in the form of a tincture, is made use of medicinally, chiefly in connection with sprains and bruises.

The leaves are borne close to the ground in a cross-shaped rosette, and from this springs a long flower-stalk, bearing one to three flowers and one or two pairs of opposite leaves. The flowers of the disc are good objects for the study, by means of a hand-lens, of the mechanism of the stylar brush (p. 85). When the flowering stage is over, the long ray florets all droop and hang vertically, and thus the heads assume a very characteristic appearance.

THE ALPINE ORCHIDS.

The Orchids of the Swiss Alpine regions are very numerous, and though the individual flowers are generally rather small, they are arranged in an extremely graceful manner, which entitles them to be reckoned among the beauty plants of the Alps. The most handsome of all the Swiss Orchids, with very large flowers in comparison to the rest, the Lady's Slipper (*Cypripedium calceolus*, Linn.), is not un-

common in shady places in the Subalpine zone, though rarely found in the higher region.

The Orchids are abundant in the Alps in three types of habitat : (1) very wet, marshy, or boggy places, especially where some rivulet is running sluggishly ; (2) steep banks in the pastures, which, on the other hand, appear at least superficially to be rather dry habitats ; (3) in the forests. Many of the Orchids flourishing in these situations are British plants, such as the Spotted Orchis (*Orchis maculata*, Linn.), the Frog Orchid (*Habenaria viridis*, R. Br.), and the Fragrant Habenaria (*H. conopsea*, Benth.). We will here notice two Swiss Orchids, the Black Nigritella (*Nigritella angustifolia*, Rich. = *N. nigra*, Reichb.) (Plate XXXI., Fig. 1), and its near relative the Lesser Butterfly Orchid (*Habenaria bifolia*, R. Br.) (Plate XXXI., Fig. 2). The latter is a frequent British plant, while the former does not occur with us.

THE BLACK NIGRITELLA.

The Black Nigritella is one of the best known of Swiss Alpines and is a universal favourite. The little conical heads (really dense spikes) of blackish-red flowers are quite unmistakable. They are often very abundant in the pastures in all sorts of situations, especially on steep banks.

It is worth while to dig up a plant of Nigritella and to examine it closely. If we unearth it carefully, we shall find, buried deep in the soil, a short stem,
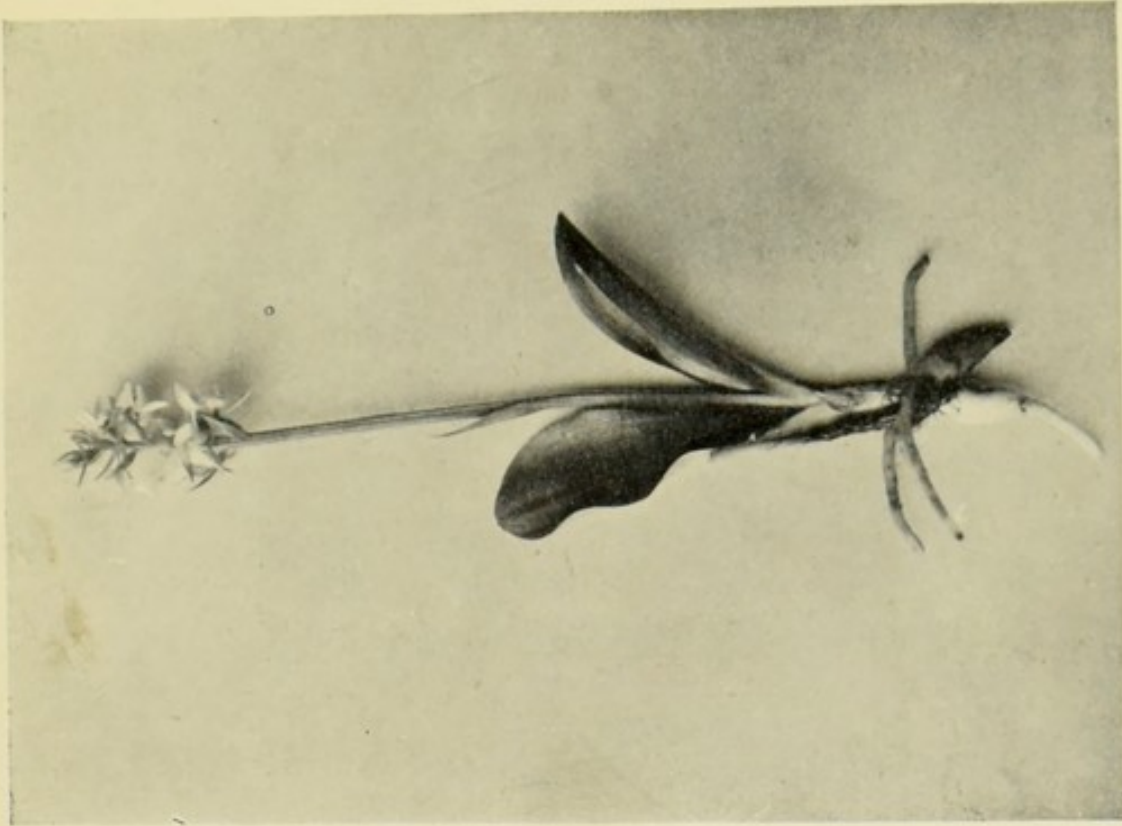
PLATE XXXI.

Fig. 2.—The Lesser Butterfly Orchid (*Habenaria bifolia*, R. Br.).

[*To face p.* 184.

Fig. 1.—The Black Nigritella (*Nigritella angustifolia*, Rich.).
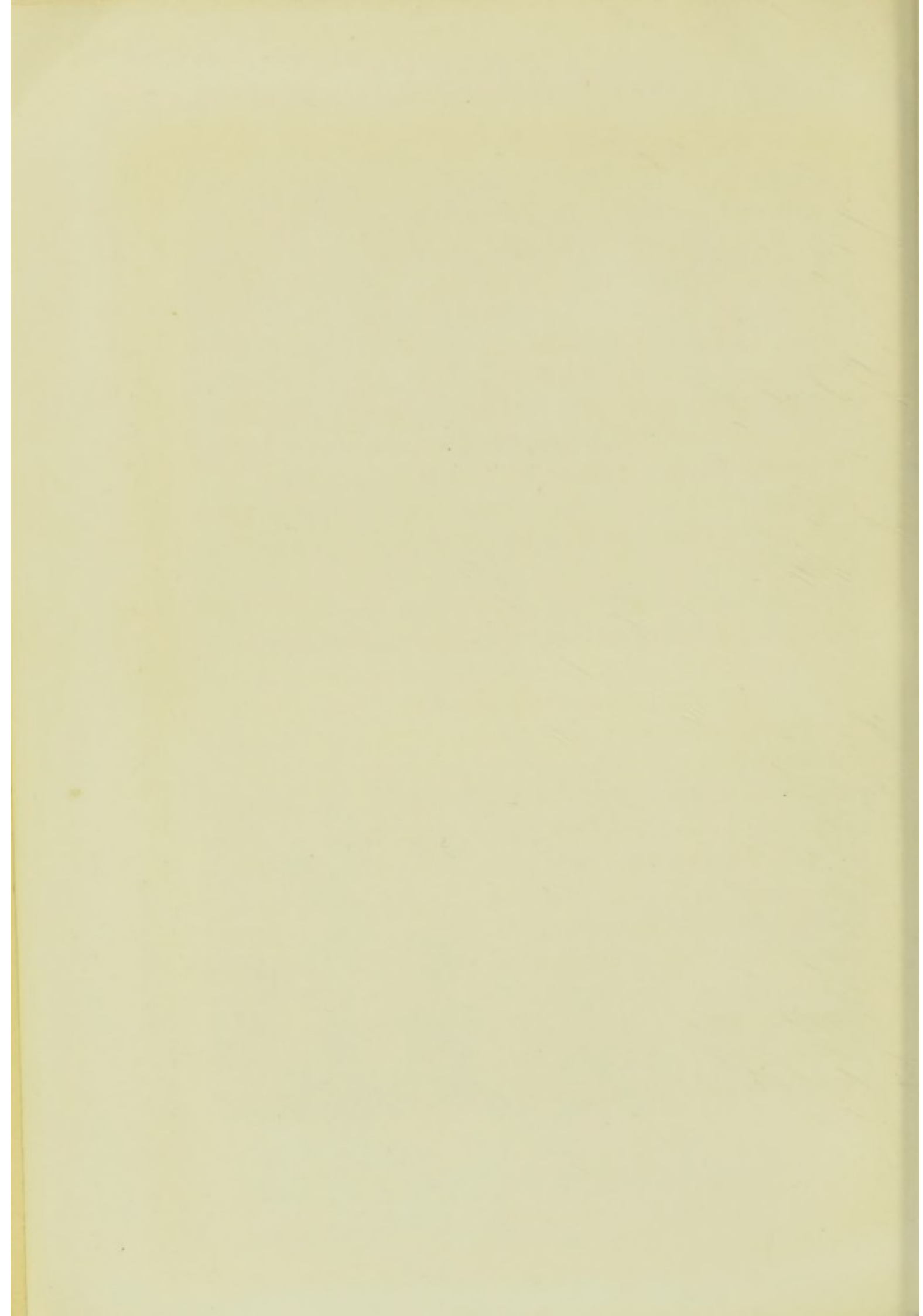
and then below, in addition to ordinary roots, a pair of tuberous roots, white and fleshy, which are of different ages (Plate XXXI., Fig. 1). Both are storehouses for reserve food material. The larger tuber contains the nourishment for the flowering stem, and was in existence last year. The smaller tuber dates from the present year, and in it will be stored reserves during the summer to further the growth of next year's shoot. The same state of affairs will be found in the case of the Lesser Butterfly Orchid. The leaves are rather thick and narrow. They wrap round one another at the base, and are enclosed in one or more scale leaves, of a brownish colour and thin papery texture. At the base the leaves are white and fleshy, no chlorophyll (see p. 10) being developed below ground because light is absent. The flower-stalk springs from among the leaves which invest it at the base.

We thus see that the Black Nigritella, like most Swiss Orchids, is a pronounced geophyte (see p. 125). Its storehouses of reserve food lie buried deep in the soil, away from the dangers of winter frosts.

The flowers, like those of many other Orchids, have a strong scent, in this case resembling that of vanilla. Vanilla itself is obtained from the fruits of a tropical climbing Orchid, known botanically as *Vanilla planifolia*, Andr. The structure of the flowers of the Orchids, as is well known, is specially adapted to insect visitors, and to cross-fertilisation by their agency. Those of the Black Nigritella are perhaps

rather small for examination, and we may therefore postpone a description of them until we come to discuss the similar structure of the Lesser Butterfly Orchid. We may merely note that in the Black Nigritella a very short spur is found.

The Lesser Butterfly Orchid.

The Lesser Butterfly Orchid (*Habenaria bifolia*, R. Br.), sometimes called *Platanthera bifolia*, Rich. (Plate XXXI., Fig. 2), is easily recognised by the two very large and broad leaves, and by the white flowers with long spurs, twice the length of the ovary. The general habit is otherwise not dissimilar to Nigritella, except that the leaves, other than the two broad ones arising from the base, are very few and reduced to scales, and the spike is cylindrical in form and much less dense.

In shape the flowers are supposed to possess some resemblance to a butterfly, just as other Orchid flowers are likened to bees, spiders, and flies. Curiously enough, the Lesser Butterfly Orchid is visited by some nocturnal insects, and especially by Hawk-moths (*Sphinx*). The clove-like scent of the flowers is strongest towards evening, and attracts night-flying insects. Only those with a sufficiently long and slender tongue or proboscis can reach the honey stored in the long spur.

Let us now examine one of the flowers to see how they are specialised for their insect visitors. The floral envelope in the Orchids is not differentiated into

calyx and corolla, but consists of a perianth of three
outer, and three inner, floral leaves. Of the former,
one is directed upwards, and two of the inner series
lie just inside it. The other perianth members are
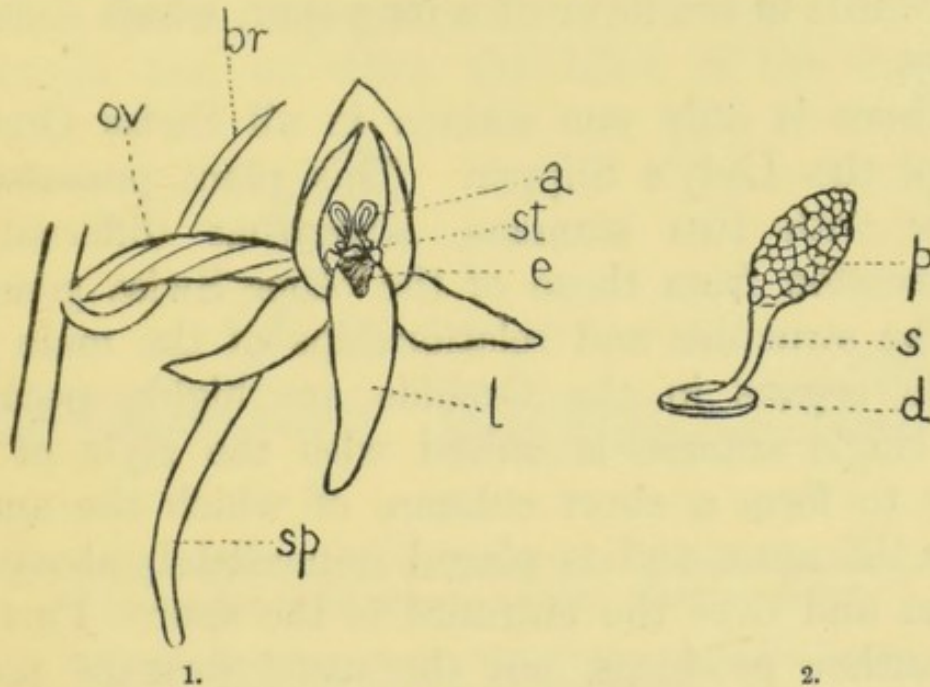
FIG. XI.

1. The Flower of the Lesser Butterfly Orchid (*Habenaria bifolia*, R. Br.).
Enlarged.

br, The bract, in the axil of which the flower arises ; *ov*, the twisted ovary ;
sp, the long spur of the labellum ; *l*, the labellum ; *e*, entrance to the
spur ; *st*, the stigma ; *a*, the anther.

2. A Pollinium. Much enlarged.

p, The pollinium proper ; *s*, the stalk ; *d*, the disc.

spreading. The lip (labellum)—that is, the third
member of the inner series—is directed forwards, and
forms a platform upon which the insect alights. In
many Orchids this lip is very different in form and
colour from the other perianth segments, and becomes
the most conspicuous portion of the whole flower.

In the present instance, however, the structure of the flower is relatively simple. The labellum only differs in being rather longer than the other segments, and is often green at the tip. The base is produced backwards in the form of a long spur, which contains honey.

There is only one stamen in all Swiss Orchids except the Lady's Slipper. This plant possesses a flower with two stamens, somewhat different in construction from those of the other Swiss genera.

The structure and relationships of the male and female organs in the Orchids are highly peculiar. The single stamen is united with the style of the ovary to form a short column, of which the anther forms the apex, and is placed immediately above the stigma and over the entrance to the spur. Further, the anther produces, not the usual dust of pollen grains, but two club-shaped bodies mounted on short stalks, and each attached below by a viscid adhesive disc. The upper portion of the club, or *pollinium* as it is called, consists of small compact masses of pollen grains, united together by elastic threads. When ripe, these club-shaped pollinia can easily be detached by loosening the adhesive discs with a needle or a pin, or even a sharp pencil point, and studied under a lens. If they are carefully watched, it will be found that they move. At first they are erect, but shortly they bend on themselves by the stalk, in a forward direction.

These features are all adaptations to cross-fertili-

sation by means of insects.   An insect seeking the entrance to the spur is quite likely to detach one or both of the club-shaped pollinia, which adhere to its head by the viscid discs.   Before the insect seeks another flower, these structures, at first erect, bend forwards, and so when the head of the insect is

1.   2.
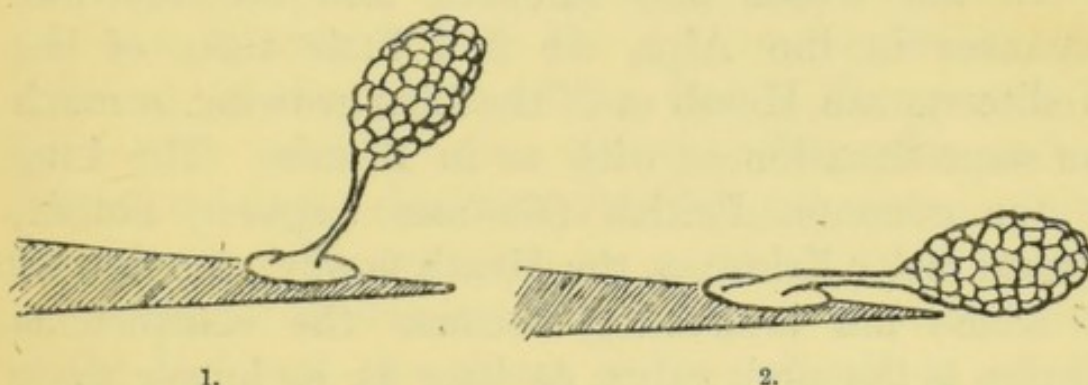
FIG. XII.—The Pollinium of an Orchid as removed from the flower, adhering by the disc to the end of a needle.   Much magnified.

1. The position immediately after removal from the flower.
2. The position assumed shortly afterwards.

inserted into the spur of the next flower, the pollinia come into contact with the stigma, to which they adhere.   Thus cross-fertilisation is effected.

In the Lesser Butterfly Orchid the structure of the anther and stylar column is relatively simple.   The club-shaped pollinia are naked, and not covered in as in many other Orchids.   They are therefore easily seen.

Another feature common to most Orchids is that the ovary is twisted, and thus the whole flower is turned through a semicircle (180°), so that the labellum, which is really the upper lip, comes to be

the lower. In the Black Nigritella, however, the ovary is exceptional in that it is not twisted, so that the labellum is in its proper position above the entrance to the flower.

THE MEDITERRANEAN HEATH AND THE LING.

In the woods and thickets, and on moor-like expanses in the Alps, we find little tufts of the Mediterranean Heath or of the Ling growing in much the same situation as with us in Britain. The Ling is our common British (*Calluna vulgaris*, Salisb., natural order Ericaceæ, the Heath family), the flowers of which are interesting because the conspicuous portion is the pink calyx, as long as, or longer than, the corolla, which it almost entirely conceals. On the other hand, only one of our five British heaths is found either in Lowland or Alpine Switzerland. This, the Mediterranean Heath (*Erica carnea*, Linn.), is, in fact, the only Swiss species of the genus. It does not occur in Great Britain, but only in Ireland. It is really an immigrant from the Mediterranean flora, and as such its presence in Alpine Switzerland can be readily understood. How it got into southern Ireland and yet not into England, is a more puzzling problem.

In this species the leaves are arranged in whorls of four, and the vase-shaped corolla is bright pink or crimson in colour. In the Alps the flowers are believed to be chiefly fertilised by butterflies, though some observers state that bees perform this office.

Both the Ling and the Mediterranean Heath usually grow in places more or less fully exposed to the sun. Their leaves, instead of being flat, are rolled at the edges, so that the lower surface lines a groove. By partially closing one's hand, and imagining that the palm and the lower surface of the fingers correspond to the lower surface of the leaf, one can roughly imitate the groove formed by the inrolling of the edges of the leaf. The groove is filled with minute hairs, springing from the underside of the leaf, which interlock together and choke the groove. The stomata or pores, through which water-vapour passes, are found only on the underside of the leaf, and the object of the adaptation of the hair-filled groove is to prevent an excessive loss of water by evaporation from the leaf through the pores—a matter of importance to a plant growing fully exposed to the sun, and with often a limited water-supply available in the soil for its roots.

CHAPTER VI

PLANTS OF THE ALPINE MEADOWS

THE meadows, which clothe the floors of many of the Alpine valleys over 5,000 feet in altitude, and extend for some little distance up their sides, are rich in Alpine flowers. The wonderful massing and play of colour in the meadows in spring, before they are reaped for the first time, constitutes one of the chief glories of the Alps. It is a sight which is missed by the great majority of those who visit Alpine Switzerland. By the beginning of July the meadows have, as a rule, been cut, and a second crop is growing vigorously, which will again be reaped in August. In many Alpine valleys, yet a third crop of hay is gathered in at the end of September or in early October. But after the first yield, the meadows never exhibit the same wealth of blossom as in spring. To see them in their full glory, a pilgrimage in the latter part of June is necessary.

The Alpine meadows, unlike the alpen or pastures, which we have seen to be owned by the village communes, are, as a rule, the private property of the

peasants. They are of immense importance, for the successive crops of hay which they yield during the summer furnish the greater portion of the fodder for the cattle during the long winter months, and it is on the cattle, or rather the cows, that the Swiss peasant relies for subsistence almost exclusively. For this reason the meadows are always very carefully tended. A liberal coating of manure is applied to them usually twice a year, and, where necessary, irrigation channels are made to supply them with the maximum of moisture. All these processes, including the cutting with the scythe, have their bearing on the botany of the meadow, as we shall see.

From a botanical point of view, these Alpine meadows are interesting in many ways. But it must always be borne in mind, especially when comparing the flowers of the pastures with those of the meadows, that the former are natural gardens, whereas the meadows are highly artificial. The periodic cutting with the scythe, and coating of manure regularly applied, help to induce a strong, dense growth of vegetation, consisting not so much of members of the Grass family as of various other Alpine plants. Consequently, some species which cannot grow without plenty of space, light, and air, are crowded out, and exist only in the pastures. The constant manuring of the soil, which adds to the amount of humus or decayed vegetable material naturally present in the soil, while favourable to the growth of some species, is unsuited to others, for plants differ much in

their requirements in this respect. Then, again, periodic mutilation by the scythe has a profound influence on the habit of the plants, and this, again, is a factor which eliminates certain plants from the meadows. Again, as we shall see, the typical Alpine meadows are damp associations, requiring a soil and surroundings which are the reverse of dry. Hence many plants, which have adapted themselves to the drier pastures, are absent from the meadows, for many typical Alpine meadows are little removed from marshes, so far as the water contents of the soil are concerned.

The exact time at which the meadows are first cut varies from year to year. Sometimes when the winter's snow has melted early, and the spring season has been forward, the middle of June will see the harvesters at work. In other years, a late spring implies that the meadows will not be cut until the first or even the second week in July. The nature of the crop also varies somewhat from year to year. At one time it will be comparatively short, and well under 3 feet in height, but of a thick, very compact growth. In another year, the growth is thinner and the height considerably greater.

To understand the conditions under which meadow plants flourish, it may be well to consider the whole year's cycle of a meadow.

In winter-time, for several months, on an average from the middle of December to the middle of April, the meadows are continuously covered with several

feet of snow. Both before and after this period, intermittent snowfalls occur, which by a lowering of the temperature act as temporary checks to growth during the most vigorous period of this phase of plant life.

By the end of March or the beginning of April, the snow begins to melt on the higher pastures, and the first spring flowers appear. The meadows, however, are not uncovered for some weeks later. When the snow at last disappears, scarcely a green blade is to be seen. This is a peculiarly disagreeable season, when but few have been tempted to study Alpine vegetation, and the meadows, like the pastures, have an ugly, deep yellowish-brown hue, rather reminding one of a patch of common or grass land which has recently been on fire.

The contrast between such a meadow in the middle of April, and the same meadow in the middle of June, with its wealth of colour and its harvest 3 feet high, is one of the most remarkable to be found in nature. Few comparisons, to my mind, give one a better idea of the huge outlay of energy which is being expended on growth, or of the rapidity of that process in the Alps.

It cannot be too clearly borne in mind that when the covering of winter snow disappears, the flowering period begins, and a great race against time is in progress. Rather, in the case of many of the plants concerned, the "full speed ahead" signal, as we shall see, has been given before the snow has entirely melted.

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Everywhere there is a rush to get into flower. For this object everything has been long prepared. The plant seems to be aware that the season is short and will last but a few months at the best, and that during this period temporary checks to growth will frequently occur in the shape of sudden lowerings of the temperature and transient snowfalls.

During the short summer period, the plant has to perform its duty to the next generation—the reproduction of offspring. The actual flowering period is but one stage in this process. Time is required to set and ripen the seed, to distribute it, and to allow it a fair opportunity of taking a firm hold in its new surroundings before the mantle of snow cuts it off from the outside world. All these processes are often comparatively lengthy. Hence the race against time.

But other work equally important has to be performed during this brief season. Most Alpine plants are perennials, and during the short summer months such a plant has varied duties to itself to perform. When it reaches the light, it has not only to manufacture its food-supply by the agency of its leaves, and thus maintain its own existence and make good the costly outlay of energy on reproduction, but it has, as often as not, to store up during the summer those reserves which are to carry it through the long, dark winter months. Thus, the brief summer season is, indeed, a busy time. In a temperate climate such as that of Britain, the period available for these processes is quite long in com-

parison with that of an Alpine or Arctic region : hence the necessity for haste in the Alps. It is due to this fact that the majority of Alpine plants "rush into flower" at the earliest moment.

But there is one class of plants for which the race is even more severe. In the High Alpine region the snow does not disappear until much later—perhaps the end of July. The conditions of May and June in the valleys resemble those of July and August in the High Alpine regions above 7,000 feet, and, by the end of August, snow may ring down the curtain once again. Thus for such plants the period of energy is much shorter, and the struggle against time still keener, while the work to be accomplished remains much the same.

But to return to the Alpine meadows, just laid bare by the melting snow, and of an ugly brownish hue : the peasant now seizes the earliest opportunity for a rich dressing of manure, often applied in semi-liquid form from a primitive tank-like wooden box on wheels. Within a few weeks the effect is magical. A dense growth springs into existence, and increases rapidly until, often before the end of June, the scythe is at work.

The hay is made in the usual way as with us in England, except that in many districts it is heaped up to dry in the form of miniature stacks on cross-shaped wooden frames placed, at this season, in the meadows. At other times these frames may be often seen ranged in rows outside, or on the walls of the chalets. When

dry, the hay is carried up the slopes in truly enormous bundles by a staggering Switzer, or by one of his female relations, to the hay chalets, which are frequently perched up in the air on the points of pillars of stone. Similar foundations are often used for our hayricks in England. These pillars raise the hay chalets above the level of the winter's snows, and so secure the crop against damp.

Now we reach the second stage. The moment the plant is mutilated by the scythe, it starts growth again, helped by the influence of a fresh dressing of manure. The new growth, however, is not so vigorous as the first. The earlier crop represents a growth prepared for during the late autumn, and to some extent during the winter, but especially in the months of early spring. Now, however, both the period is shorter, and damage by the scythe has to be made good. The strong young winter buds have gone, and the new ones, less matured, are further weakened by the fact that the leaves of the plant which supply the energy for growth have also fallen before the reaper.

The scythe, however, does not cut down the plant quite close to the ground. The stem which remains has first to heal its wounds, which it does by the growth of a pad of corky tissues over the injured part. Next, new leaves are developed afresh, and lateral buds, already existing in a dormant state in the axil of leaves right at the base of the stem, which have escaped the scythe, now grow out into branches.

The chief result of mutilation by the scythe is the development of a branched system from the stem, which originally may have been quite unbranched. The whole character of the plant is more straggling and less compact, owing to the prevalence of the branched habit, and the flowers are smaller and less conspicuous. Thus the second crop of hay differs remarkably from the first, and the Alpine meadows, when ready for the scythe for the second time, never present the same appearance as they did in spring. When a third crop is harvested, the contrast is even greater. Such is briefly a year's history of an Alpine meadow.

The meadow plants form an interesting association (see p. 32), well worthy of study, and of comparison with the flora of the neighbouring alpen or pastures. An English meadow in June is fair to look upon, but an Alpine meadow is still finer. This fact is due to several causes. Although our British fields are rich with Buttercups and Daisies, as well as other flowers, yet the Grasses, with their comparatively inconspicuous flowers, form by far the greater proportion of the plant inhabitants of the meadow. In the Alps, on the other hand, Flowering Plants of the Dicotyledonous class with conspicuous flowers are quite as numerous individually as the Grasses, and sometimes even outnumber them.

The greater beauty of an Alpine meadow is also due to the more intense coloration of the flowers, and to the extremely robust or " well-grown " habit

of the plants themselves. These plants frequently grow in clumps, which produce a wealth of bloom, forming conspicuous masses of colour when the whole meadow is viewed in the aggregate. We frequently notice large colonies of *Lychnis*, or *Silene*, of Bell-flowers and Rampions, of *Polygonum*, of *Geranium*, or *Polemonium*, each adding its note of colour, and contributing to the harmony of the meadow.

Another peculiarity of the Alpine meadows is that, in the majority of cases, they are comparatively damp or even wet places. Many of the plants of the Alps, with the most conspicuous flowers, thrive best in damp soils. The valley meadows of the Engadine or the Zermatt region are, for the most part, typical damp meadows. Those near Saas Grund, on the other hand, on drier soils are carefully irrigated, in order that they may receive the maximum amount of moisture available. On the Rieder Alp, above Mörel, in the Rhone valley, we find typical water meadows in which a large number of marsh plants, such as *Trollius europœus*, the Globe Flower, flourish.

One reason why the soil of an Alpine meadow is much damper than that of a typical English meadow, is the fact that it is well watered by the swiftly flowing streams and their tributaries, which are invariably to be seen traversing the fertile valleys in the Alps. Another and equally important factor is the nature of the soil, which frequently consists entirely of peat, one of the most powerful water - retainers among soils. The peat itself is formed by the slow

but constant accumulation of vegetable debris through a period extending over many centuries.

In the photograph on Plate XXXII., Fig. 2, a section or cutting of a typical valley-meadow is seen. The soil is composed entirely of peat, which is here more than 4 feet thick. In the lower portion, the white bleached masses, which are seen projecting, are the roots of trees, probably of Pines, which once covered the area now forming the meadow, like those seen at some little distance to the right of the photograph. It will be noticed that the actual soil on which the meadow plants are seen growing is very thin. It should be also pointed out that the hay of this particular meadow had been cut some weeks before the photograph was taken, so in this case the crop is small.

If we were to make an analysis of an Alpine meadow, we should perhaps be surprised to find how many of its inhabitants are British plants. Several of our British Buttercups, such as the Bulbous Buttercup (*Ranunculus bulbosus*, Linn.), the Field Buttercup (*R. acris*, Linn.), are abundant. The Bistort (*Polygonum bistorta*, Linn.), the Ox-eye Daisy (*Chrysanthemum leucanthemum*, Linn.), are characteristic. The Hare-bell (*Campanula rotundifolia*, Linn.), and the common Field Pansy (*Viola tricolor*, Linn.), are frequent. The Water Avens (*Geum rivale*, Linn.), and Jacob's Ladder (*Polemonium cœruleum*, Linn.), are often common. Some of our British Geraniums, Campions, especially *Silene cucubalus*, Wibel., and Catchflies, such as *Lychnis*

dioica, Linn., add greatly to the colour-mass of many an Alpine meadow. In late autumn the Meadow Saffron (*Colchicum autumnale*, Linn.) reigns supreme.

On the other hand, many of the conspicuous elements of the meadow flora are not found in Britain. Of the characteristic Swiss plants discussed in Chapters II. and III., only the Campanulas and Rampions are frequent in the meadows. Scheuchzer's Campanula (*Campanula Scheuchzeri*, Vill.), and *C. rhomboidalis*, Linn., with various species of Rampion, increase the percentage of blue-flowered meadow plants. To them are added many other non-British plants, too numerous to mention here, for it is not our purpose to construct a full list of the meadow plants of Alpine Switzerland. The above-mentioned species may serve to indicate some of the commoner inhabitants to be met with in most Alpine meadows.

At the same time, if we compare the floras of two Alpine meadows some little distance apart, we shall often find that they are dissimilar, or rather that the plants which are specially abundant in one meadow are less frequent in another. The meadows thus vary noticeably among themselves as regards their most abundant constituents, this, in fact, being one of their chief characteristics.

We will now study some of the commoner meadow plants, beginning with the Spring Crocus.

THE SPRING CROCUS.

The Spring Crocus (*Crocus vernus*, All., natural order Iridaceæ, the Iris family) is nearly always the first flower to appear in the meadows on the melting of the winter's snow (Plate XXXI., Fig. 1).

It is what botanists call a pronounced *geophyte*—
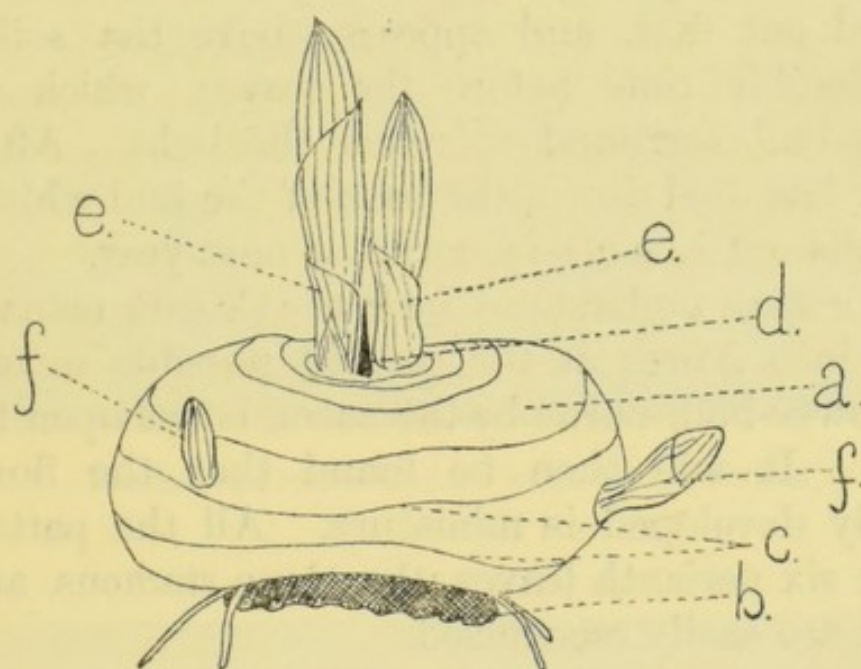
FIG. XIII.—The Underground Stem or Corm of the Spring Crocus (*Crocus vernus*, All.), in Spring.

The scale-leaves have been removed.

a, Corm developed from the base of last year's flowering shoot; *b*, corm of previous year; *c*, scars of scale-leaves; *d*, remains of last year's flowering shoot; *e*, buds which will flower this year; *f*, smaller buds which may flower next year.

that is to say, the plant spends a large proportion of its life underground. The stem has a peculiar structure, which is often spoken of by the horticultural fraternity as a bulb, but which is more accurately described as a corm (Fig. XIII.). It is a

thick, solid body which serves mainly as a store-house for reserve food materials. Externally it is sheathed in a few light brown scale-leaves of thin papery texture. Numerous roots spring from the base of the corm. From this underground stem, buds grow out, one or more of which are flower-buds. The central portion of each bud, the flower, is pushed out first, and appears above the soil some considerable time before the leaves, which in the young bud surround it, reach the light. After the flower has died down, the base of the bud which bore it swells out into a new corm for next year.

We shall understand how the Crocus manages to come into flower at the earliest possible moment, if the flower-bud, borne by the corm, is cut open length-ways. It will then be found that the flower is already developed in miniature. All the parts, such as the six perianth leaves, the three stamens, and the ovary, are easily recognised.

Thus we see that long before the snow of the meadow begins to melt, the flower is ready. On the coming of spring, all the plant has to do is to lengthen the flower-axis below the flower, and thus push up the flower to the light through the leaves, which for the time being remain dormant.

The Crocus, like some other Alpine spring flowers, frequently does not wait for the snow to entirely disappear. We shall often notice, where some patch of winter's snow still lingers in a meadow, the state of affairs seen in Plate XXXII., Fig. 1. Here the

PLATE XXXII.
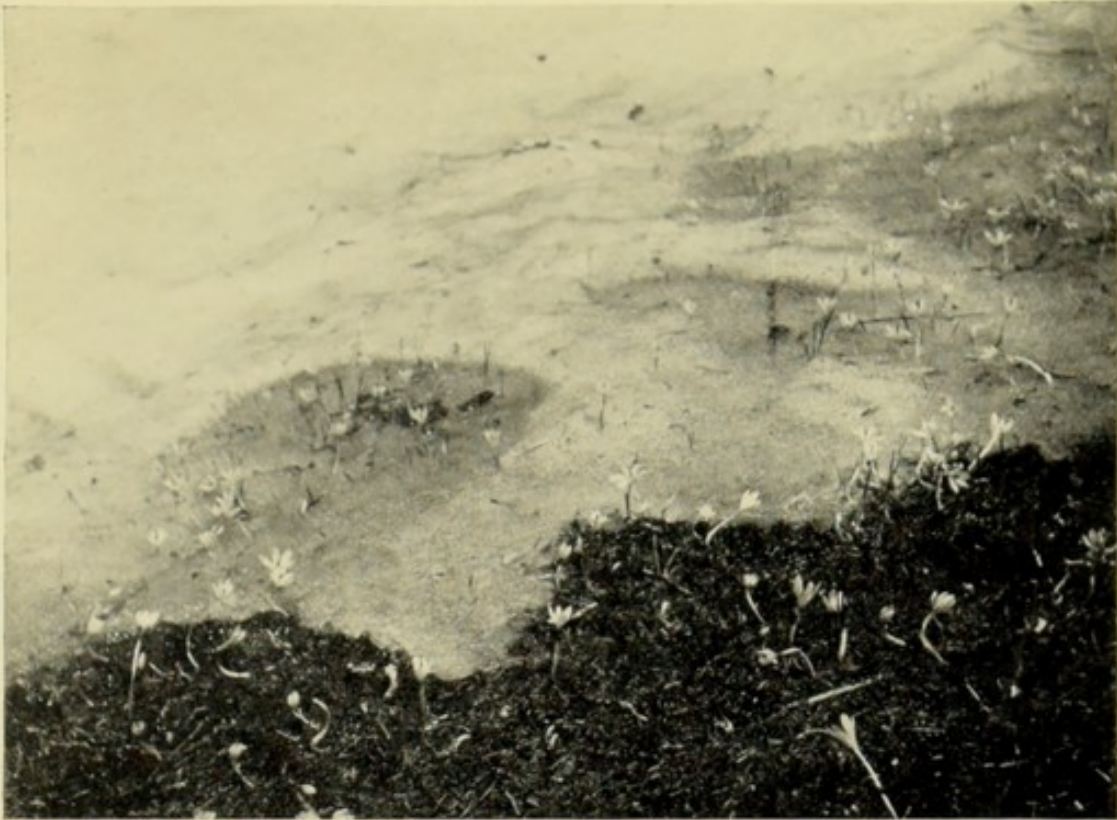
FIG. 1.—The Spring Crocus (*Crocus vernus*, All.) Flowering in the Snow.
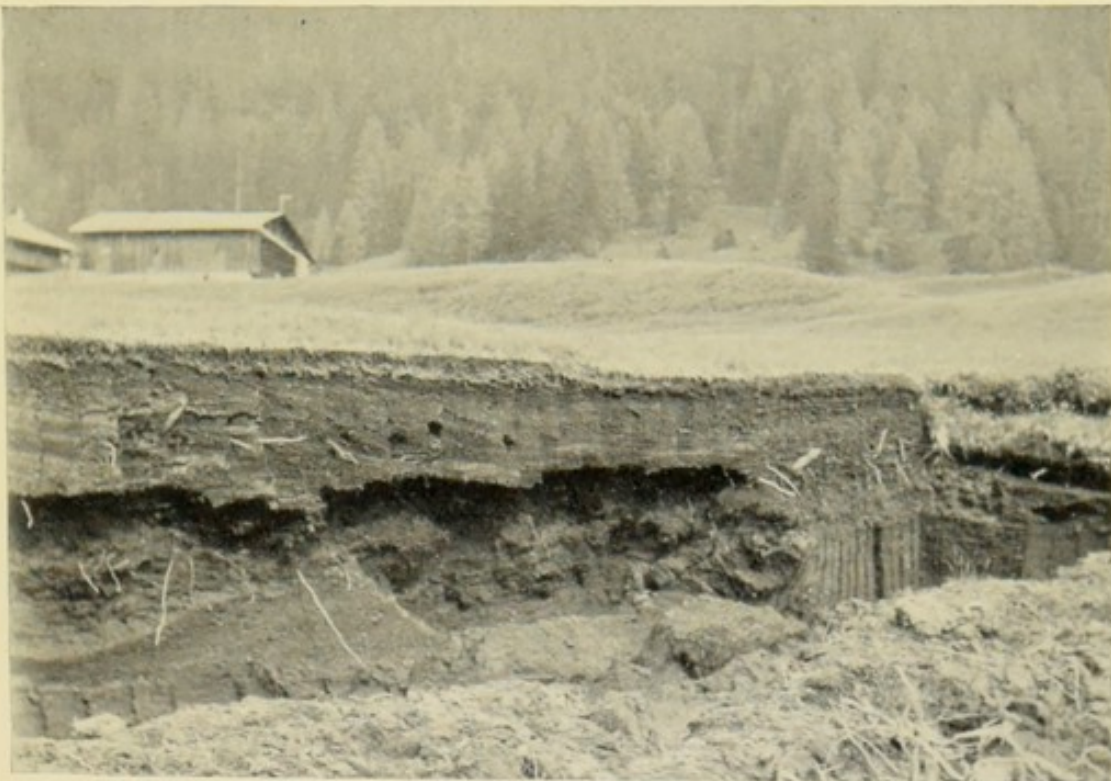
FIG. 2.—Section of an Alpine Meadow, showing the Peat Soil.
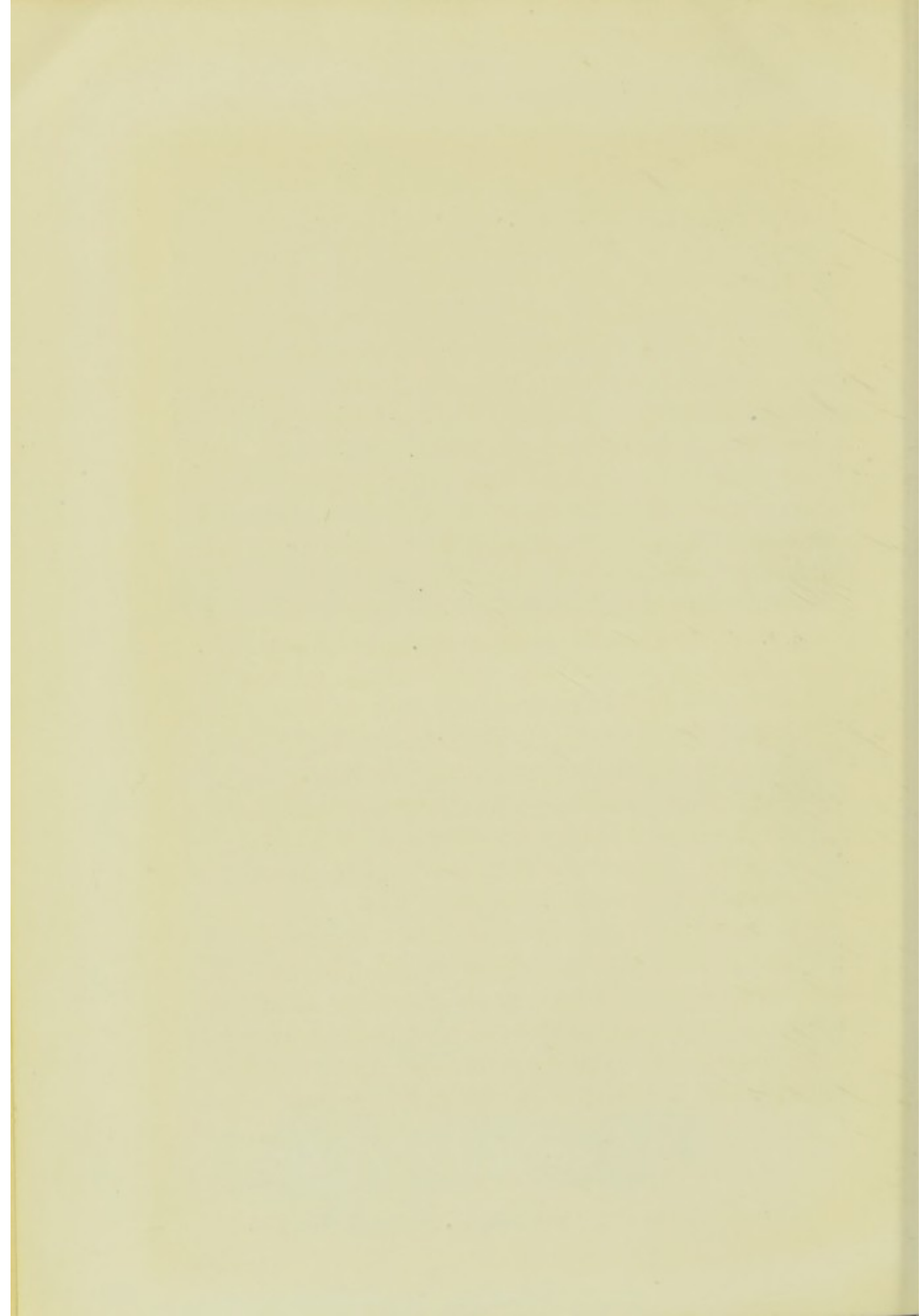
flowers have forced their way up through the snow, and flowering is in full swing. We have already discussed (p. 62) another instance of this curious haste to arrive at the flowering stage, when dealing with the Soldanellas of the pastures.

Once the process of flowering is over and done with, much work has still to be performed if the results of fertilisation are to be carried through to a successful ending. The next thing the plant does is to send up the leaves. If we enquire why the leaves appear after the flowers and not before, the answer is quite simple. The work of flowering demands a continuous supply of energy, just as an engine requires energy obtained from coal to enable it to perform work. In the case of the Crocus, sufficient energy for the flowering stage is stored up in the corm or underground stem, in the shape of reserve food materials. Hence new food materials, furnished by the green leaves, are not for the moment required. But once the flowers are over and withered, fresh food-supplies are required, both to ripen the seed and to store up new reserves in the new corms of the coming year. These supplies are manufactured by the leaves when once they reach the light.

Another peculiarity of the Crocus, which is of interest, is the varied coloration of the flowers. Some are nearly white, others are almost wholly purple, others, again, yellowish or pinkish. In some flowers, again, all three colours are combined. The significance of these fluctuations in colour is not

yet fully understood. No doubt the plants are thereby rendered extremely conspicuous to butterflies, by which they are often fertilised, though it is possible that self-fertilisation is the rule. In the case of the Autumn Saffron, which we shall shortly discuss, the colour has become "fixed" or constant, and this would appear at first sight just as effective as an insect advertisement. However, it does not appear that the manner of fertilisation of the Saffron flowers is known with certainty at present.

The Viviparous Polygonum.

The Viviparous Polygonum (*Polygonum viviparum*, Linn., natural order Polygonaceæ, the Dock family), is a very frequent plant in the Alpine meadows. Everyone is familiar with the beautiful pink spikes of flowers of its near relative the Bistort, *Polygonum bistorta*, Linn., which is a much more conspicuous plant, often contributing largely to the colour scheme of the meadows. The Viviparous Polygonum (Plate XXXV., Fig. 2) is easily recognised by the slender flower-spike, partly composed of small white or flesh-coloured flowers in the higher portion, and numerous little red "bulbils" below.

These "bulbils" are not flowers, though they occupy the position of flowers. They are really little buds—minute leafy shoots—which become detached from the spike and fall to the ground. They root themselves to the soil, and grow into new plants. Thus, should the Viviparous Bistort fail to produce

any seed owing to the flowers of the spike having missed fertilisation, the perpetuity of the plant is at any rate secured by means of these asexually produced "bulbils."

The ancient term "viviparous," sometimes still applied to this means of propagation, and still surviving in the specific name, is extremely misleading. When it was first used, the whole nature of these bulbils was misunderstood. The bulbils are in no way connected with any sexual organs, though in position they replace them. They are purely vegetative, and the term viviparous should be confined to certain animals, where it has a definite meaning and significance.

Several other Alpine plants, such as the Grass, *Poa alpina*, Linn., and a Saxifrage, *Saxifraga cernua*, Linn., also produce bulbils. This means of reproduction is sometimes met with in Lowland plants, though not so frequently as in Alpine and Arctic species, which is probably due to the fact that it is a saving of time for a plant to reproduce itself by bulbils rather than by seeds. The Viviparous Polygonum is itself an Alpine plant in Britain.

THE WATER AVENS.

The frequent occurrence of the Water Avens (*Geum rivale*, Linn., natural order Rosaceæ, the Rose family), in the meadows of the Davos and other Alpine valleys, affords a sure indication of the dampness of the soil of the typical Alpine meadow. With us in

Britain, this plant flourishes chiefly in marshes and wet ditches.

The drooping flowers, with dusky red petals, are interesting from several points of view. Like the Potentillas, this plant possesses a double calyx. The outer five sepals, known botanically as the *epicalyx*,
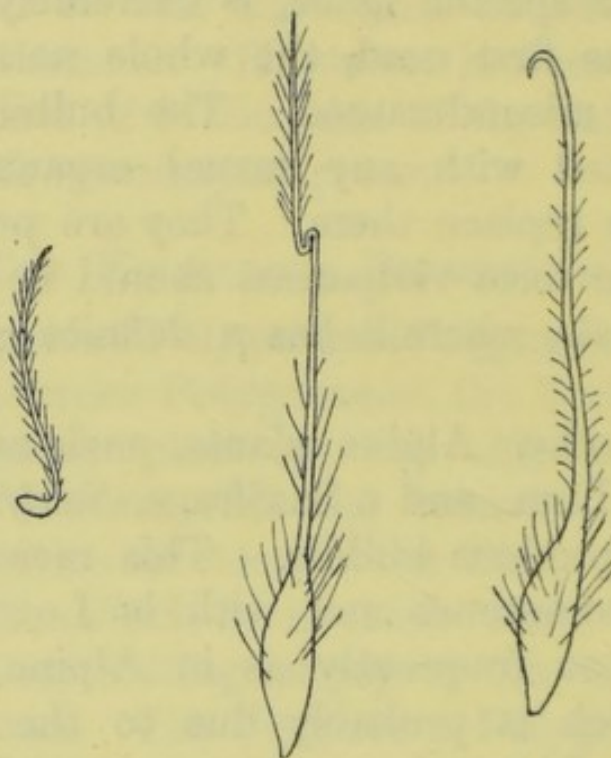
FIG. XIV.—Stages in the development of the Fruit of the Water Avens (*Geum rivale*, Linn.).

are small, and alternate in position with the five larger inner sepals.

The fruit of the Water Avens (Text-fig. XIV.) furnishes material for an interesting study. It is especially adapted for distribution by animal agency. Each of the carpels grows out into a long awn as the fruits mature. A well-marked hook is developed

at the end of the awn, and this catches in the fur or coat of any animal passing, and thus the seed at the base of the awn is carried to a distance from the parent plant. It eventually becomes detached, and starts life on its own account.

By comparing different stages in the formation of the mature fruit, it will be found that the hook is not formed at the actual tip of the awn. As the awn matures, it develops a twist or kink at a little distance from the end. At a later stage, the end of the awn above the kink is thrown off altogether, and a sharp point now terminates the fruit above the kink. The apparatus is now mature. The pointed end, in conjunction with the kink below it, acts quite like a fish hook, and tends to stick into any rough substance with which it is brought in contact. The stages in the formation of the mature awn are shown in Text-fig. XIV.

THE FIELD PANSY.

One of the first British plants which will be recognised in an Alpine meadow is the Field Pansy or Heart's-ease (*Viola tricolor*, Linn., natural order Violaceæ, the Violet family). Though a humble plant, it is interesting in several respects. The variation in the colours of different flowers, and variety of colour often observed in a single flower, ranging from purple and yellow to white, is a feature in which this species contrasts very markedly with the two other Violets common in the Alpine zone, which we shall describe

in other chapters.   The flowers of the Long-spurred Violet (*Viola calcarata*, Linn.) (p. 128), are a uniform pale blue; those of the Two-flowered Violet (*V. biflora*, Linn.) (p. 253) are yellow.

The flowers of all the Violets are specially modified or adapted to their insect visitors, and we may
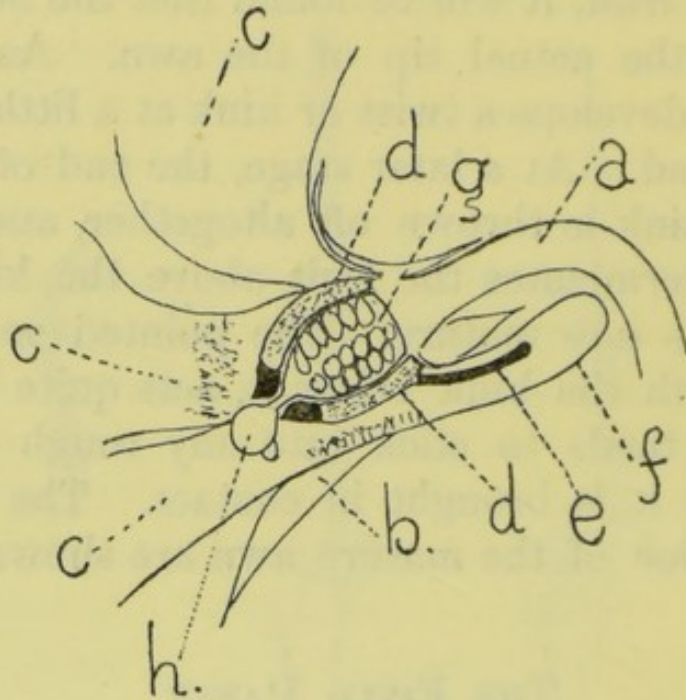
FIG. XV.—Section of a Flower of the Field Pansy (*Viola tricolor*, Linn.).

a, The flower-stalk ; *b*, sepal ; *c*, petal ; *d*, stamen ; *e*, nectary ;
f, spur of petal ; *g*, ovary ; *h*, stigma.

perhaps choose this opportunity of describing the flower of this common species in detail, in order to compare those of the Long-spurred and Two-flowered Violets.   A section through a flower is shown in Text-fig. XV.   All the organs there seen can easily be observed by dissecting a flower with a needle under a hand-lens.

Of the five petals, one is larger than the rest, and serves as a landing-stage for the bees and butterflies visiting the flower in search of the nectar, which is hidden away in the spur or backward tubular prolongation of the large petal. The bright colours of the petals, as a whole, serve to attract these insects, and the numerous streaks or lines of colour, all leading to the centre of the flower, serve as "honey guides," directing the insect to the narrow opening at the mouth of the flower, through which the knob-like stigma projects. If we dissect away the petals, we shall expose the five anthers, which are mounted on very short stalks, and closely applied to the ovary. The anthers open inwards towards the pistil, and above each anther a membranous appendage is found. From the bases of two of the stamens, two glistening, white, spur-like nectaries, secreting honey, hang freely in the spur of the large petal. They will be easily seen if the spur is carefully slit open. In the centre of the flower, the ovary is produced upwards into a club-shaped hairy stigma, on one side of which is a small pit or groove, below which a little triangular flap or valve can be seen. The stigmatic surface is situated in this groove.

Now let us imagine that a bee or butterfly has just alighted on the large petal. As it thrusts its tongue or proboscis into the opening of the flower to get at the honey in the spur, any pollen, derived from a previously visited flower, adhering to its head comes into contact with the stigmatic surface, which lies in

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the groove immediately above the entrance to the flower. Thus the plant visited is cross-fertilised. As the insect pushes its proboscis between the ring of stamens and the style, its head becomes dusted with pollen, exuded from the inner side of the anthers, and this pollen is carried away to another plant. All risk of transferring the pollen of one flower to the stigma of the same flower, as the insect withdraws its head, is prevented by the little triangular flap above mentioned, which is automatically forced upwards by the insect's head and thus shields the stigma.

In addition to the larger and more showy flowers of the Field Pansy, adapted to cross-pollination, other much smaller and less conspicuous flowers may be found to occur, which are self-pollinated. In other species of Violet, such as the Sweet Violet (*Viola odorata*, Linn.), which is not Alpine, some of the flowers are not only self-pollinated, but never open, and after fertilisation, bury themselves (*i.e.*, the whole flower) in the soil.

The fruits of the Field Pansy are also very interesting. The ovary bears many small seeds in a single chamber. When ripe, the fruit becomes erect, though formerly pendulent, and in dry weather the ovary splits into three valves, each of which has usually three rows of seeds. The valves dry up and contract, and thus the seeds are pressed firmly against one another, and are shot out one by one, often to a considerable distance. A space of 3 feet has been recorded. We can imitate this mechanism for seed

distribution by holding in the hand a group of several balls. If pressure is put on the outer members of the group, one of the inner balls is squeezed out.

Text-fig. XVI. illustrates the way in which the seeds are ejected. The seeds of each row are shot out in regular order. The upper valve has still its three rows of seeds; the valve below to the left has lost one row, while that on the right has lost two rows. When all the seeds are distributed, the valves of the capsule close on themselves.

THE CAMPION.

A very common plant in the Alpine meadows is the Campion (*Silene cucubalus*, Wibel = *Silene inflata*, Sm., natural order Caryophyllaceæ, the Pink family). This plant forms massive clumps, which are quite unmistakable.

FIG. XVI.—Ripe Fruit of the Field Pansy (*Viola tricolor*, Linn.), shooting out its seeds. Enlarged.

The top valve has not yet lost any seeds; the left valve has lost one row; the right valve, two rows.

The smooth, glossy, hairless stems bear numerous white flowers, with a very inflated or swollen calyx, the veins of which are very prominent. Some of the flowers contain both male and female organs, others only stamens, and others, again, only an ovary, the last being distinctly smaller flowers.

The inflated calyx certainly adds greatly to the conspicuousness of the flowers. The object of this adaptation is, however, still a debated question. The theory is that the swollen calyx serves to prevent the flower being "robbed" of its honey. The plant is visited by humble-bees and butterflies. These insects will often try to rob a flower of its honey by biting through the base of the calyx and corolla, instead of entering the flower in the legitimate manner. It is obvious that in such cases the insect can be of no service to the plant in the way of cross-pollination. It is imagined that the inflated calyx in some way protects the plant by making robbery of the honey impossible, or at least more difficult. If this is so, it can only be by deceiving the insect, for the tongue or proboscis of a humble-bee or butterfly is sufficiently long to penetrate both calyx and corolla and the empty space between these organs. It may be that the insect, having bitten through the calyx, is deceived by imagining that the space between the calyx and corolla, where there is no honey, is really the space surrounding the ovary where honey should be found. Finding no honey there, it assumes that some other insect visitor has been beforehand, and thus desists from further efforts. In view of the considerable intelligence possessed by such insects, it is doubtful, however, if so transparent a device would prove successful; hence this theory is not above suspicion.

THE RED LYCHNIS.

The Red Lychnis (*Lychnis dioica*, Linn.), belonging to the same family as the Campion, and likewise a common British plant, is another meadow species of some interest. It is a very near relative of the White Lychnis (*L. vespertina*, Siboth.), of which it is very probably only a variety with red flowers adapted to pollination in the day-time, whereas in the White Lychnis the flowers are closed by day and open only at night, when they are visited by moths. White is a more conspicuous colour than red at night-time, though not by daylight. The Red Lychnis is fertilised by bees. Both these plants have unisexual flowers, the male and female flowers being borne on different plants. Bisexual flowers are also sometimes found.

THE MEADOW SAFFRONS.

If we visit the Alps in September, we shall find that the meadows in autumn present a very similar appearance to that noticed in early spring. They are thick with a Crocus-like plant, often called the Meadow Crocus, with pink or lilac flowers. This is really the Meadow Saffron, and in most cases it is the common British Saffron (*Colchicum autumnale*, Linn., natural order Liliaceæ, the Lily family). There is another species sometimes found in cantons Tessin and the Valais, the Alpine Saffron (*Colchicum alpinum*,

D. C.), a rare plant, but very similar to the commoner species.

The Meadow Saffron, though somewhat similar in habit to the Spring Crocus, is no relative of that plant, but belongs to a distinct family. It is easily distinguished by the six stamens, whereas the Crocus has only three. But, like the Crocus, the Meadow Saffron is a pronounced geophyte (p. 125), the whole plant being buried deep in the soil, perhaps a foot or more below the surface, at which depths frosts fail to penetrate. Only at certain seasons of the year does any portion of the plant appear above ground.

If we take the trouble to unearth a plant by digging out a large sod of turf a foot or more deep—no easy task, and a delicate operation needing some care, if it is to be performed without injury to the plant—we shall find a little underground stem. The structure of this stem or corm is different from that of the Crocus, and is illustrated in Text-fig. XVII.

In autumn, when the flowers dot the meadows, there are no leaves to be seen above ground. The leaves, which are narrow, though broader than those of a Crocus, do not appear until the following spring, when, in the absence of flowers, they are easily overlooked. All that we see above ground in the autumn, are the upper parts of extraordinarily long flowers. They rise perhaps 4 inches above the soil, and extend below ground for another 9 to 12 inches, and are thus of a total length of a foot or more.

Two flowers nearly always arise from each under-

ground stem.   A few brownish scale-leaves, below
the flowers, serve to protect them when they are
pushed up through the soil.   The perianth of six
united floral-leaves has the form of a very long,
funnel-like tube, reaching down to the corm.   The six
stamens spring from the tube at various levels, but
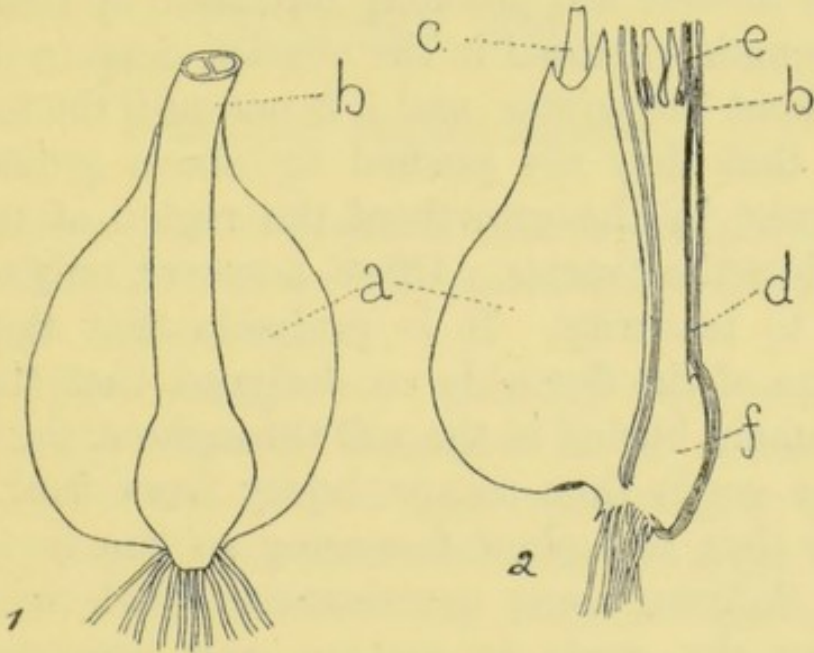
Fig. XVII.—The Corm or Underground Stem of *Colchicum*, the
Meadow Saffron.

1. Corm seen from the front.   2. Longitudinal section through corm.

a, corm ; *b*, sheathing leaf ; *c*, flowering axis of last year ; *d*, foliage leaf ;
e, leaf on flower-stalk ; *f*, next year's corm.

the ovary is right at the base of the tube, a foot deep
in the soil.   Three very slender, thread-like styles
extend from the ovary, nearly the whole length of the
tube of the perianth.

In describing the flowers of Primula (p. 68), we
drew attention to the occurrence of two forms of
flowers, one with a long style and low stamens, the

other with a short style and high stamens. It is asserted that the Meadow Saffron possesses three forms of flowers, in which the styles are long, short, and intermediate in length respectively, and is thus similar to the well-known case of *Lythrum* described by Darwin.

The flowers are probably fertilised by bees. The seeds remain enclosed in the ovaries, deep in the soil, throughout the winter, and it is not until the following spring that they are pushed up above ground with the leaves, by the growth of the region of the stem just below the ovaries. Often, however, only one fruit comes to maturity. It is probable that the whole structure of the flower is so designed that the fruits shall remain buried in the soil throughout the winter, and the seeds thus escape injury from frost. It is obvious that, to a plant flowering so late in the year as the Saffron, some contrivance, which will allow time for the seeds to mature, and preserve them unharmed from winter frosts, must exist.

The seeds of the Meadow Saffron contain a powerful, poisonous alkaloid, known as colchicin, which is sometimes made use of medicinally.

CHAPTER VII

THE HIGH ALPINE PLANTS

WE now pass to a discussion of the peculiarities of the highest plant assemblage in the Alps, the species of the High Alpine region.

It is often thought or assumed that, above a certain height vaguely imagined to be somewhere between 10,000 and 13,000 feet, vegetation, or at any rate Flowering Plants, cannot exist in the Alps. This idea is entirely fallacious. It is true that in the higher mountain regions, vegetation is much more scanty than at elevations of 5,000 or 6,000 feet; but wherever the physical conditions are in the least degree favourable, there plants will be found, whatever the altitude may be.

The physical conditions that an Alpine growing at a height above 10,000 feet in the Alps has to combat are no doubt extremely severe. The first necessity for its existence is absence of snow or ice for a sufficiently long period from some sheltered spot. Given a flowering season of adequate length, many of the High Alpine species will be able to overcome most of the other

difficulties. On the other hand, the extreme short-
ness of the flowering season at high altitudes is
probably the factor which, more than any other, limits
the upward distribution of Alpines. Time for
flowering alone is not sufficient. A certain length
of time afterwards must also be available to set
and distribute the seed, to enable the offspring to
take a firm hold in its new home, and to allow the
parent to manufacture reserves against the coming
winter.

The so-called snow-line, or imaginary line above
which the snow continues to lie all through the
summer, varies in elevation according to the aspect,
situation, and other physical conditions of any parti-
cular locality. In general, it lies between 8,500 and
10,500 feet, but is sometimes lower or even higher.
Though above this elevation the coating of snow is
permanent, it is by no means continuous. Rocks
fully exposed to the sun, steep slopes, and precipitous
crags quickly lose their snowy covering, for a time
at least, in summer, though the periods during
which they are free from snow may be only short and
intermittent.

But bare rock alone will rarely furnish a liveli-
hood sufficient to permit the seed of a High Alpine
to establish itself. Some sort of primitive soil, such
as those which we have already discussed (p. 96),
must in most cases be present. In the High Alpine
region the thalli of Crustaceous Lichens appear to
contribute in a large degree to the building up of

primitive soils, and around them wind - blown dust and debris of all sorts accumulate.

Once a seed becomes established on a primitive soil on some rocky ledge, free from snow perhaps for less than two months in the height of summer, it has to face certain other difficulties. The gap between the extremes of temperature to which it will be exposed is enormous. The temperature in the sun at midday may rise to nearly 20° C. (= 68° F.), and sink several degrees below zero C. at night - time. In winter-time it may fall to − 25° C. or more. Further, the difference between sun and shade temperature in the daytime is much greater than at lower elevations, so that whenever the sun is hidden by a passing cloud, a sudden and considerable drop in temperature takes place.

Another difficulty often to be faced is the lack of an adequate water-supply for the roots. This is not due, as is sometimes supposed, to the coldness of the soil, for it has been shown that, in summer at any rate, the soil is several degrees warmer than the atmosphere in the shade, and that the soil is generally at a higher relative temperature in the Alps than in the lowlands. But at high altitudes rain rarely falls, and such water as penetrates to the roots is derived from melting snow. Since the supply is precarious, many High Alpine plants possess hairy coats or other adaptations, designed, as much as possible, to reduce transpiration or loss of water by evaporation.

Other drawbacks to life in high altitudes are the

excessive intensity of the light, the relatively stronger ultra-violet rays, the increased rarity of the atmosphere, the greater force of the wind, and the scarcity of insect visitors. Yet, strange to say, plants will overcome all these difficulties successfully, if only a favourable chance offers.

If the highest of the Swiss peaks were free from snow and ice for only six weeks or two months in summer, there is every reason to believe that they would accommodate a large and varied population of Alpine plants. The rich flora of the Gorner Grat (10,290 feet), near Zermatt, an exceptionally favourable situation for plant life in the High Alps, enables us to form some idea of the vegetation we should meet with at even greater elevations, if the conditions were similar.

The highest mountain in the Alpine Chain, Mont Blanc, is 15,782 feet high. It is partly in France (Savoy), and partly in Italy. Monte Rosa is partly in Switzerland and partly in Italy, and reaches 15,217 feet. The highest mountain entirely in Switzerland is the Dom, between the valleys of Zermatt and Saas; it is 14,942 feet high.

The greatest height at which a flowering plant has been found in Switzerland is about 14,107 feet (4,275 metres), which proves the assertion previously discussed: that there is no real upward limit to vegetation in the Alps.

In other parts of the world, vegetation far exceeds this altitude. On the north side of the Himalayas,

Flowering Plants occur as high as 18,000 feet, while in the Bolivian Andes, species have been found growing at 18,700 feet, if not higher.

The late John Ball, a great authority on Alpine plants, relates how, when botanising on the Aletsch Glacier (Bernese Oberland), the largest snowfield in Europe, he found no less than forty plants in flower, including the Common Thyme and the still commoner Dandelion, on a slope of fine debris, clear of snow, at an elevation of about 10,700 feet. This is by no means an exceptional instance.

De Saussure, one of the earliest naturalists to devote serious attention to nature in the Alps, and the famous leader of the first party to reach the summit of Mont Blanc, related how, in 1796, he found *Silene acaulis* growing on that mountain at an elevation of 11,450 feet, and *Androsace glacialis*, near the Col de Geant, at about the same height. The celebrated Swiss botanist, Dr Christ, states that at least thirteen Flowering Plants have been found on the Théodule Pass, 10,900 feet, between Zermatt and Breuil. Here the mean temperature for the year is known to be − 5·59° C., the minimum − 21·4° C., and the maximum + 15·1° C.

The well-known "Jardin" of the Mer de Glace, above Chamonix, is perhaps the most reputed of the higher localities for Alpine flowers in the Alps. The flora of this favoured spot, on a moraine of the glacier, having an area of about 7 acres, and forming, as it were, an island in a sea of ice, has been repeatedly

recorded. Nearly a hundred Flowering Plants, as well as a large number of Mosses and Lichens, have been found. Yet the height of the "Jardin" is only 9,140 feet, which is low in comparison with the other localities mentioned above. It is nowadays possible to reach by train to even greater heights, where the high Alpine flora may be studied!

We may now enquire what is the highest recorded species for Switzerland. According to Prof. Schroeter, *Ranunculus glacialis*, the Glacial Buttercup, has this honour. This plant has been found at 14,107 feet (4,275 metres) on the Finsteraarhorn, the giant of the Bernese Oberland. Seven other species are known to occur at or above 13,200 feet (4,000 metres)—namely, *Achillea atrata*, *Saxifraga aspera*, var. *bryoides*, *S. moschata*, on the Finsteraarhorn; *Androsace glacialis*, on the Lauteraarhorngipfel; and *Saxifraga muscoides*, *S. biflora*, and *Gentiana brachyphylla*, at 13,860 feet on the "shoulder" of the Matterhorn.

If we study the distribution of plants within the Alpine zone—that is, at elevations above 5,000 feet in altitude—we shall find that between eighty and ninety species of Flowering Plants are only found in the higher regions, and do not occur in the lower portion of this zone. At elevations of above 8,000 or 8,500 feet, we shall notice that the flora is composed of species such as the Bavarian Gentian, which are also abundant in the lower Alpine region, and in addition a number of other plants occur, many of

which are of rare or local occurrence, and are only exceptionally met with at lower elevations.

Heer found that between 8,580 and 9,135 feet, 336 species occur in Switzerland as a whole, 294 in Canton Grisons, 206 in Canton Valais, and 150 in Canton Berne.   As we ascend, the numbers gradually decrease; at an elevation of about 10,200 feet, the figures were 120, 32, 118, and 17 respectively; at 11,260 feet the number of species sank to 13, 4, 18, and 6, while above 12,870 feet only 6 species occur in the whole of Switzerland, none in the Grisons, 2 in the Valais, and 5 in Canton Berne.   Thus the Valais is much richer in High Alpine species, and the Bernese Oberland much poorer, than any other district in Switzerland.

These figures give only an approximate result, for estimates of the number of species in any district differ according as the author regards certain plants as distinct species or only as varieties—a question which is always one of great difficulty, and quite impossible to settle, for variation is characteristic of plants as of animals.   But whether we regard Heer's figures as rather too high or too low is immaterial.   The important point is, that of 336 species occurring at about 8,600 feet, a large number consist of plants common in the lower Alpine region, while others are what we will term High Alpines, and are almost unknown in the lower zone.

Schroeter has made an analysis of the flora known to occur at, and above, 10,725 feet (= 3,250

metres). Of the 73 species or varieties instanced, 40 are Alpine, 30 are High Alpine (Nivial), one, *Thymus serpyllum*, is a Lowland plant, and two, *Gentiana verna* and *Phyteuma corniculatum*, are Subalpine and widely distributed. These figures give a good idea of the proportion of Alpine to High Alpine species at this great elevation.

We can thus subdivide the Alpine zone into a lower and a higher region, the latter characterised by the presence of certain species, the High Alpines. At the same time, the transition from the lower Alpine to the higher Alpine region is perfectly gradual, just as is the transition from the Subalpine to the Alpine zone.

The High Alpine species are perhaps the most interesting of all Swiss plants. They are often spoken of as constituting the Nivial or Glacial flora of Switzerland. They present certain peculiarities of habit which at first sight may appear to be unique. As a matter of fact, it will be found, if the lower and higher Alpine floras are closely compared, that most of these peculiarities are shared by plants growing in the lower Alpine region, described in the preceding chapters, though in a less pronounced degree.

It is customary to speak of the "Alpine habit" as characteristic of plants growing at great elevations in the Alps. By this is usually implied nothing more than their dwarf stature. Perhaps the most striking feature of Alpine vegetation as a whole is, that the

plants are distinctly shorter, and much more compact in build than in the Lowlands. There is a marked absence in Alpine plants of those features which gardeners term "leggy" or "weedy." The stems are relatively shorter, and in many cases are buried below the surface of the soil. The axes of the flowering shoots are also less extended. Yet the average Alpine plant can hardly be called a dwarf, if by that term we imply a plant which only rises from 1 to 4 inches (2 to 10 cm.) above the level of the soil.

Among the lower Alpine species, such plants as the Alpenroses, the Yellow- and Red-flowered Gentians, the White Veratrum, the Monkshoods, and the Martagon Lily are very far from being dwarfs. On the other hand, the majority of the lower Alpines are short in stature, though not true dwarfs. The rosette and carpet plants may be regarded as the best examples of the dwarf plants, but these types of habit are far from being universal.

When we turn to the High Alpine flora, we find a decidedly larger number of dwarf plants. The stature of these species is on the average distinctly shorter than in the lower region. Yet all High Alpine plants are not dwarfs, for *Adenostyles leucophylla*, Reich., is often 3 feet high, *Doronicum (Aronicum) scorpioides*, Lam., is from 6 inches to 2 feet in height, and *Empetrum nigrum*, Linn., is a shrub varying from 6 to 18 inches in height. On the other hand, the majority of High Alpine species, as contrasted with their near relatives flourishing in

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the lower Alpine region, are distinctly smaller plants and shorter in stature, even if they cannot all be termed true dwarfs.

The term "Alpine habit," if applied in any other sense than size, has no botanical significance. There are several types of Alpine habit or build, which, with one exception, are found both in the lower and the higher Alpine regions. Thus, apart from the cushion plants, which are only represented by one or two species in the lower Alpine zone, the "architectural" peculiarities of High Alpines only differ from those of the lower Alpines in degree, not in kind.

We will now discuss the different types of habit met with in the High Alpine region: the cushion plants, the carpet plants, the rosette plants, and the normal but dwarf habits.

We have seen that among the Alpines of Switzerland many of the species are British plants. When we turn to the High Alpine plants, it is interesting to find that several, though a much smaller proportion, are also British. The Alpine Cerast (*Cerastium alpinum*, Linn.), the Crowberry (*Empetrum nigrum*, Linn.), the Mountain Lloydia (*Lloydia serotina*, Sweet), the Scotch Asphodel (*Tofieldia palustris*, Huds.), and the Reticulate and Dwarf Willows, are, for example, almost confined in Switzerland to the High Alpine region. Several other plants, common both in the lower and higher Alpine regions, such as the Moss Campion (*Silene acaulis*, Linn.) and the Purple Saxifrage (*S. oppositifolia*, Linn.), are also British.

The Cushion Plants.

The cushion species present a type of plant architecture or habit essentially characteristic of the High Alpine region.   In the flora of the lower Alpine region, only two cushion plants, the Moss Campion and the Purple Saxifrage, are met with, and these, as we have seen, are also abundant in the higher Alps.

The cushion plants (Plates XXXIII. and XXXIV.) are constructed on a definite plan. There is a simple, unbranched stem buried deep in the soil.   Just above the surface of the soil, the stem gives off a very large number of leafy shoots or branches, radiating out, as it were, from the centre of an hemisphere.   The main branches give rise to secondary branches, also clothed with leaves, which all grow out to about the same length, and the whole of the shoots are crowded together into the smallest possible space (Plate XXXIV.), thus giving rise to a compact, cushion-shaped structure.   The exact form or shape of the cushion varies in different species, as illustrated on Plates XXXIV. and XXXV.   The cushions often grow to a very large size.   The largest cushion of the Moss Campion we have measured was near the Hotel Weissmies (9,180 feet) above Saas Grund.   It was nearly circular, and the diameter was 3 feet 4 inches, and the height about 4 inches.

Cushion plants, it may be of interest to add, are also found in many other parts of the world besides

the high Alps, where one or more of the physical conditions are similar. They are found in the Arctic and Antarctic regions, in deserts such as the Sahara, and in the Steppe region of Russia.

THE COMMON MOSS CAMPION.

The moss-like cushions of the Common Moss Campion (*Silene acaulis*, Linn., natural order Caryophyllaceæ, the Pink family) are one of the most familiar sights in Alpine Switzerland. They are dark green in colour and flat topped. The leaves, which arise in opposite pairs, are short, narrow, and awl-shaped. Each cushion produces an enormous number of rose-coloured or pink flowers, each borne singly on a very short flower-stalk, arising from the axil of a leaf.

There are three kinds of cushions : those bearing flowers with both stamens and carpels, which are rare ; those with male only, and those with female flowers, in which stamens are absent. The last are smaller than the others.

This British plant is not only common at 5,000 feet in the Alps, but extends upwards to nearly 12,000 feet.

THE SESSILE-FLOWERED MOSS CAMPION.

The Sessile-flowered Moss Campion (*Silene exscapa*, All.) (Plate XXXIII., Fig. 1) is a very near relative of the species just discussed, and may be only a variety of it. It differs in having only a very short flower-stalk, which is winged, and in certain

PLATE XXXIII.
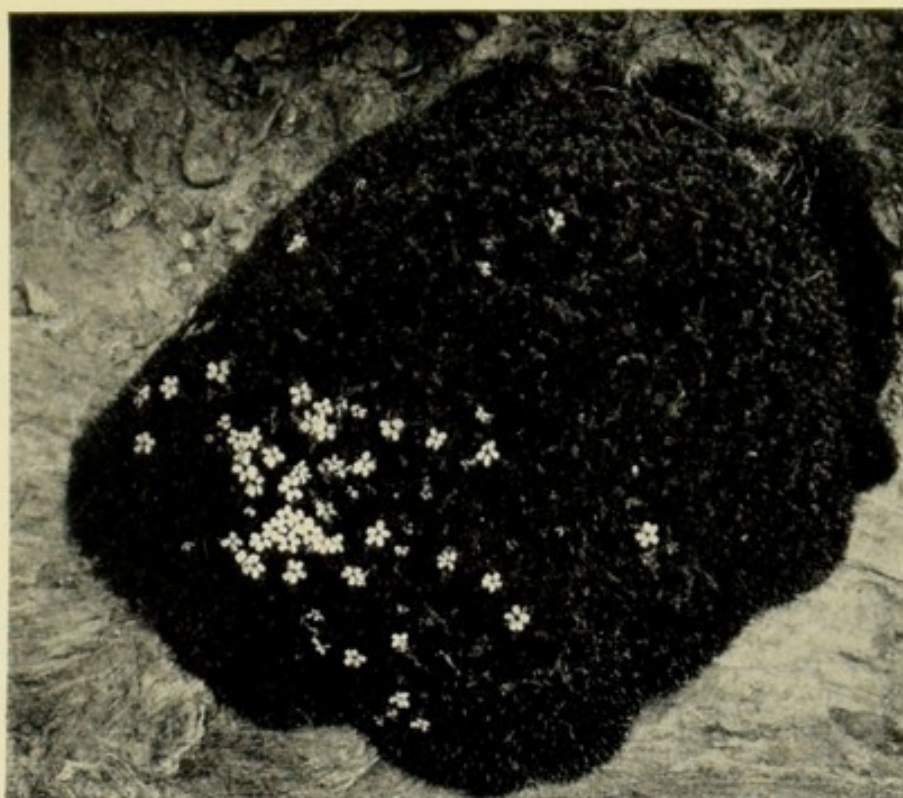
FIG. 1.—The Sessile-flowered Moss Campion (*Silene exscapa*, All.).
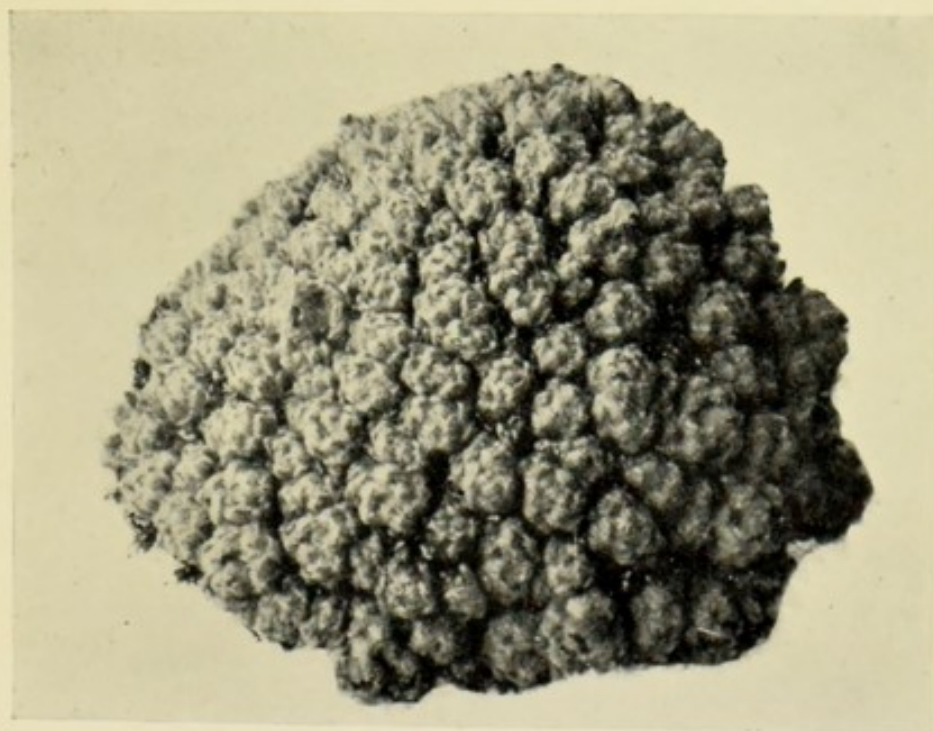
FIG. 2.—The Swiss Androsace (*Androsace helvetica*, Gaud.).

Typical High Alpine Cushion Plants.
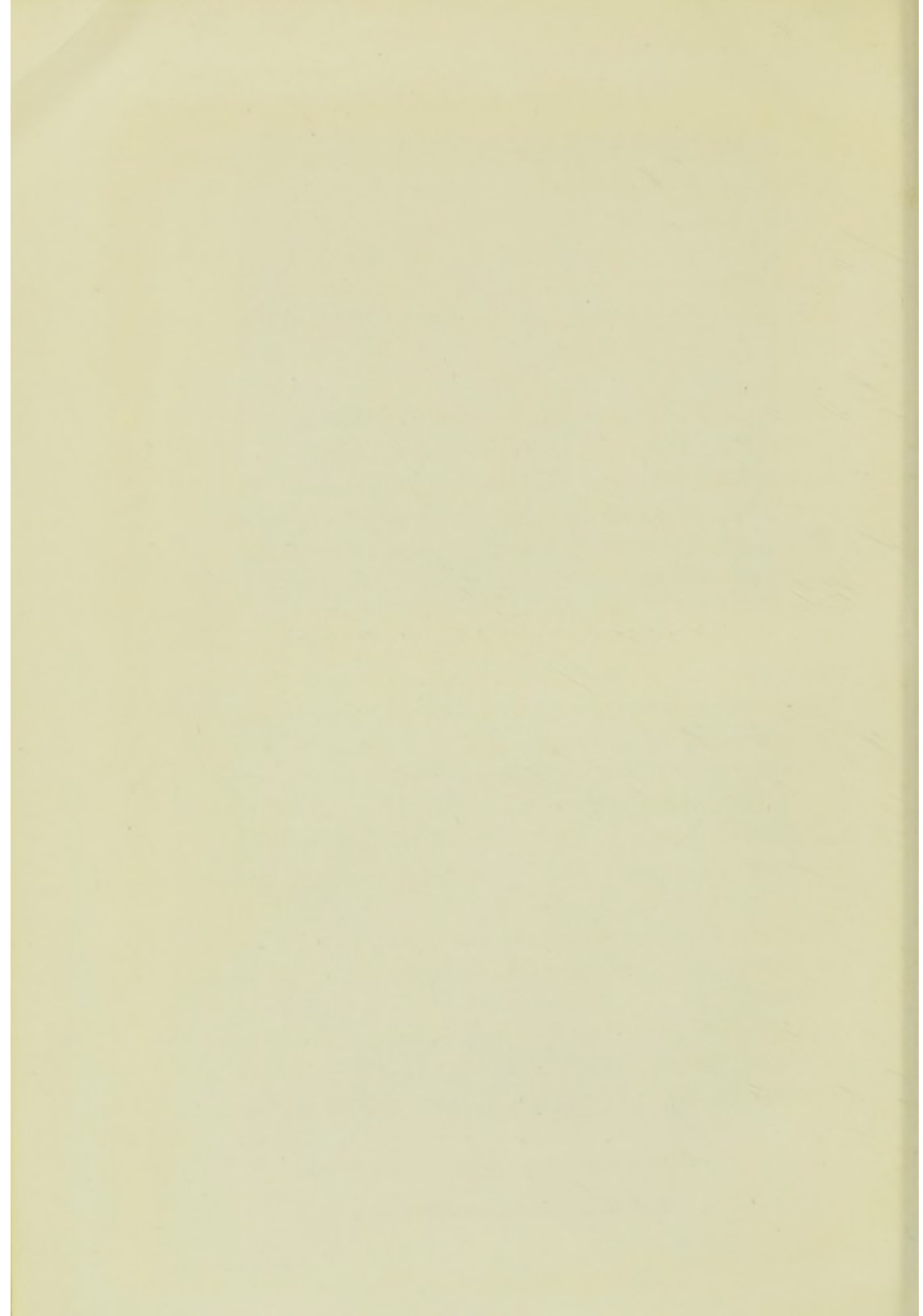
peculiarities of the calyx and fruits. Its cushions are commonly mistaken for those of *Silene acaulis*, but they are more densely tufted, more spherical in shape, and the leaves shorter. The flowers are also smaller and paler. It is generally believed to be confined in Switzerland to the High Alpine region. It is not a British plant.

THE HIGH ALPINE ANDROSACES.

The Androsaces of the lower Alpine region described in Chapter III. are typical rosette plants. Yet all the High Alpine species possess the cushion habit. The Swiss Androsace (*Androsace helvetica*, Gaud., natural order Primulaceæ, the Primrose family) (Plate XXXIV., Fig. 1) is a typical example. This plant builds cushions, resembling an hemisphere in shape, and sometimes 6 inches high. These are formed by a large number of crowded branches, each branch clothed with very small, blunt, over-lapping leaves, which form compact, cylindrical, bud-like growths at the ends of the branches. The leaves are covered with simple hairs. The flowers are borne on very short stalks, the corollas being white with a yellow centre. This plant is not uncommon in the fissures of calcareous rocks at great elevations. The cushions are said to reach a considerable age, 50 to 60 years being reported in one case.

The much rarer Imbricated Androsace (*Androsace imbricata*, Lam.) builds cushions similar to those of the Swiss Androsace. They are, however, easily

distinguished by the dense, grey felt of star-shaped hairs which covers the blunt lance-shaped leaves. The flowers are rose coloured or white, with a red "eye" at the throat of the corolla.

In the next three species, the cushions are fashioned on a somewhat different plan. They are hemispherical in shape, but much less compact. The leaves at the end of the branches, instead of forming dense bud-like growths, are arranged in fairly open rosettes. The older leaves below the rosettes tend to die off, so that the cushion is only leafy towards the surface of the sphere. Thus we have here a combination of the cushion and rosette habits.

The Glacial Androsace (*Androsace glacialis*, Hopp.) (Plate XXXIV., Fig. 1) is a typical example, and possesses rose-coloured corollas. A rare species, found only in Canton Tessin, Charpentier's Androsace (*Androsace charpentieri*, Heer.), is very similar, but the flowers are mounted on longer stalks, and differ also in a number of other details. The Downy Androsace (*Androsace pubescens*, D. C.) has cushions quite like those of the last two species, but white flowers with a yellow "eye." It occurs chiefly in the Valais.

Vital's Androsace (*Androsace vitaliana*, Lap., = *Aretia vitaliana*, Murr.[1]) (Plate XXXVIII., Fig. 1)

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[1] Also known as *Gregoria vitaliana*, Duby. According to Index Kewensis, this plant should be called *Douglasia vitaliana*, B. and H.f. I have, however, here included it in the genus *Androsace*, to which, even if it should be referred to a separate genus, it is very nearly related.

PLATE XXXIV.

Fig. 2.—Cushion of the Dwarf Alsine (*Alsine sedoides*, Froel.).

Fig. 1.—Cushion of the Glacial Androsace (*Androsace glacialis*, Hopp.).

High Alpine Cushion Plants.
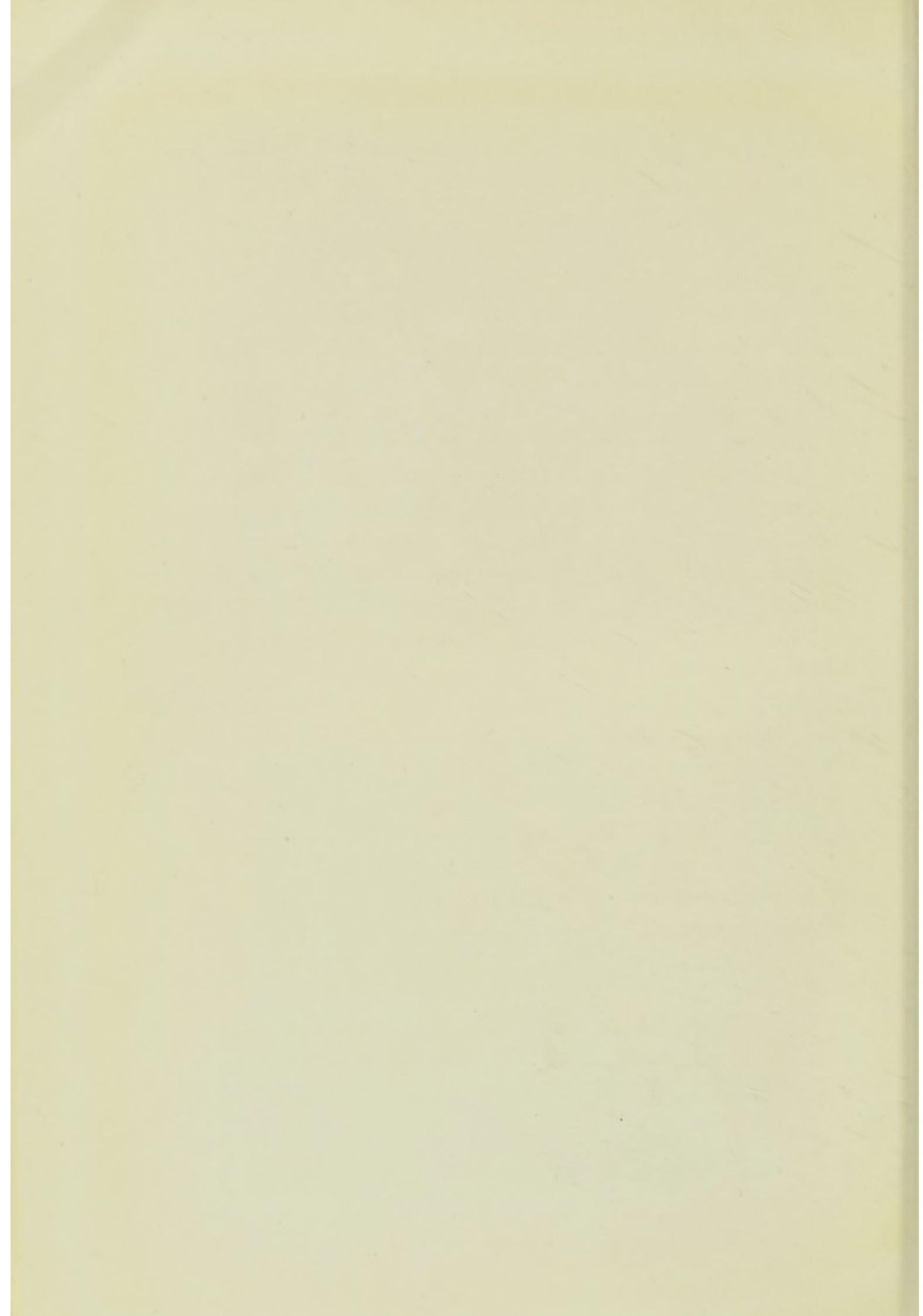
forms loose, spreading cushions, the ends of the leafy branches being rosetted. Numerous large, yellow flowers spring from the cushion, and these differ from other Androsaces in the greater length of the corolla tube, which is twice the length of the calyx. The free portions of the corolla spread to form a saucer-shaped structure. It is a rare plant, confined to Canton Valais.

THE PYRENEAN DRABA.

The Pyrenean Draba (*Draba pyrenaica*, Linn. = *Petrocallis pyrenaica*, Linn., natural order Cruciferæ, the Crucifer family), is another example of a High Alpine cushion plant, whose near relatives in the Alpine region proper, such as *Draba aizoides*, Linn., and *D. tomentosa*, Wahl., are rosette plants. At first sight the cushion of the Pyrenean Draba, with its pink or lilac flowers, might be easily mistaken for that of *Androsace glacialis*. It is, however, at once distinguished by the four petals, and the Crucifer type of the flower as a whole, and by the fact that the leaves at their tips are cleft into three or more lobes. It is not a very abundant plant, but is not infrequent on calcareous rocks and debris in the High Alpine region.

THE ERITRICHIUM.

The Eritrichium (*Eritrichium nanum*, Schrad., natural order Boragineæ, the Borage family) (Plate XXXV., Fig. 1) is in some respects the "belle"

of the High Alpines, on account of the wonderful bright, azure blue of the flowers, for which it is famous. It is closely allied to the Forget-me-nots, one species of which, *Myosotis alpestris*, Schmidt, is frequent in the Alpine and High Alpine regions. They so closely resemble one another, that the Forget-me-not is sometimes mistaken for the Eritrichium. The two are not uncommonly associated.

The plant forms rather loose cushions of highly branched, leafy shoots crowded together. The leaves are covered with shining, silky hairs, which are clearly seen in the photograph on Plate XXXV., Fig. 1). The cushions apparently attain to a considerable age, for, like nearly all the High Alpines, the Eritrichium is a perennial. A cushion thirty years old has been recorded. The flower-stems are leafy and a few inches in length. They bear, as a rule, from three to six flowers, arranged in a complicated inflorescence.

The High Alpine Alsines.

There are two High Alpine species of the genus *Alsine* (natural order Caryophyllaceæ, the Pink family) which are cushion plants. The Dwarf Alsine (*Alsine sedoides*, Frœl = *Cherleria sedoides*, Linn. = *Arenaria Cherleria*, Hook.f.) (Plate XXXV., Fig. 2) builds very compact, hemispherical cushions composed of an enormous number of small branches, clothed with awl-shaped leaves placed in opposite pairs. The flowers are interesting from the fact that they are small and comparatively inconspicuous, and thus the

PLATE XXXV.
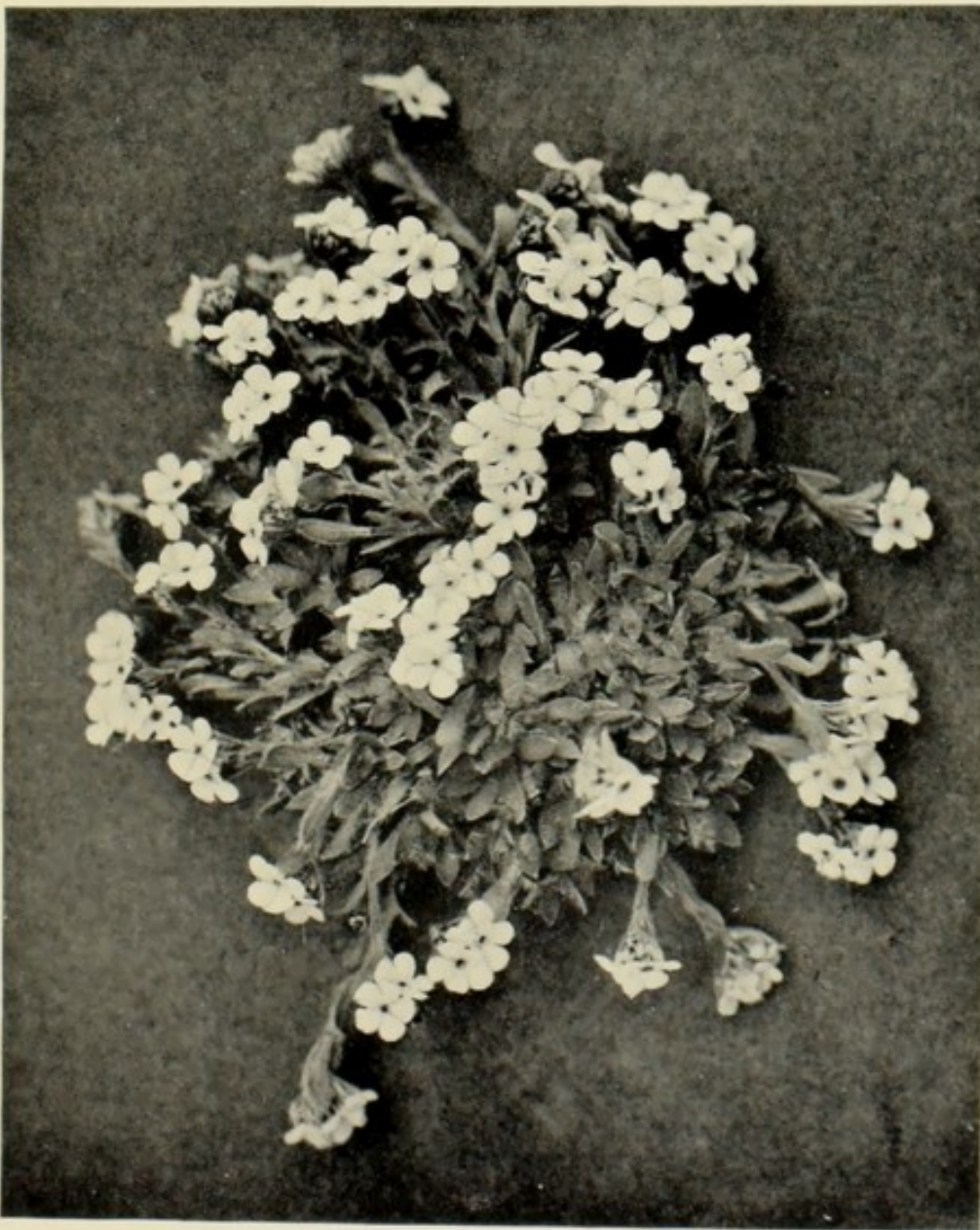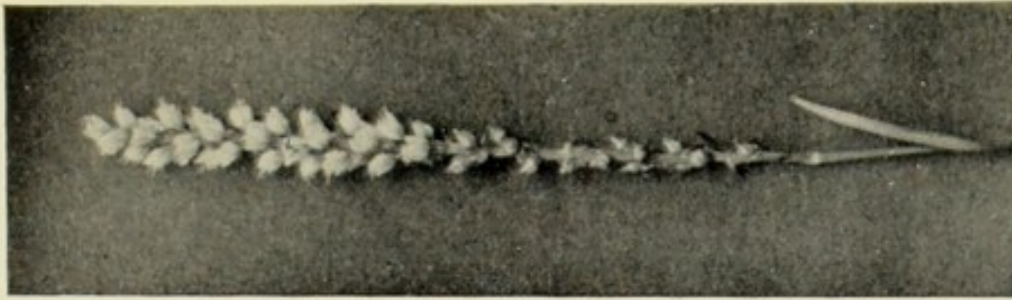
Fig. 2.—The Flowers and Bulbils of the Viviparous Polygonum (*Polygonum viviparum*, Linn.).

[*To face p.* 184.

Fig. 1.—The Eritrichium (*Eritrichium nanum*, Schrad.).
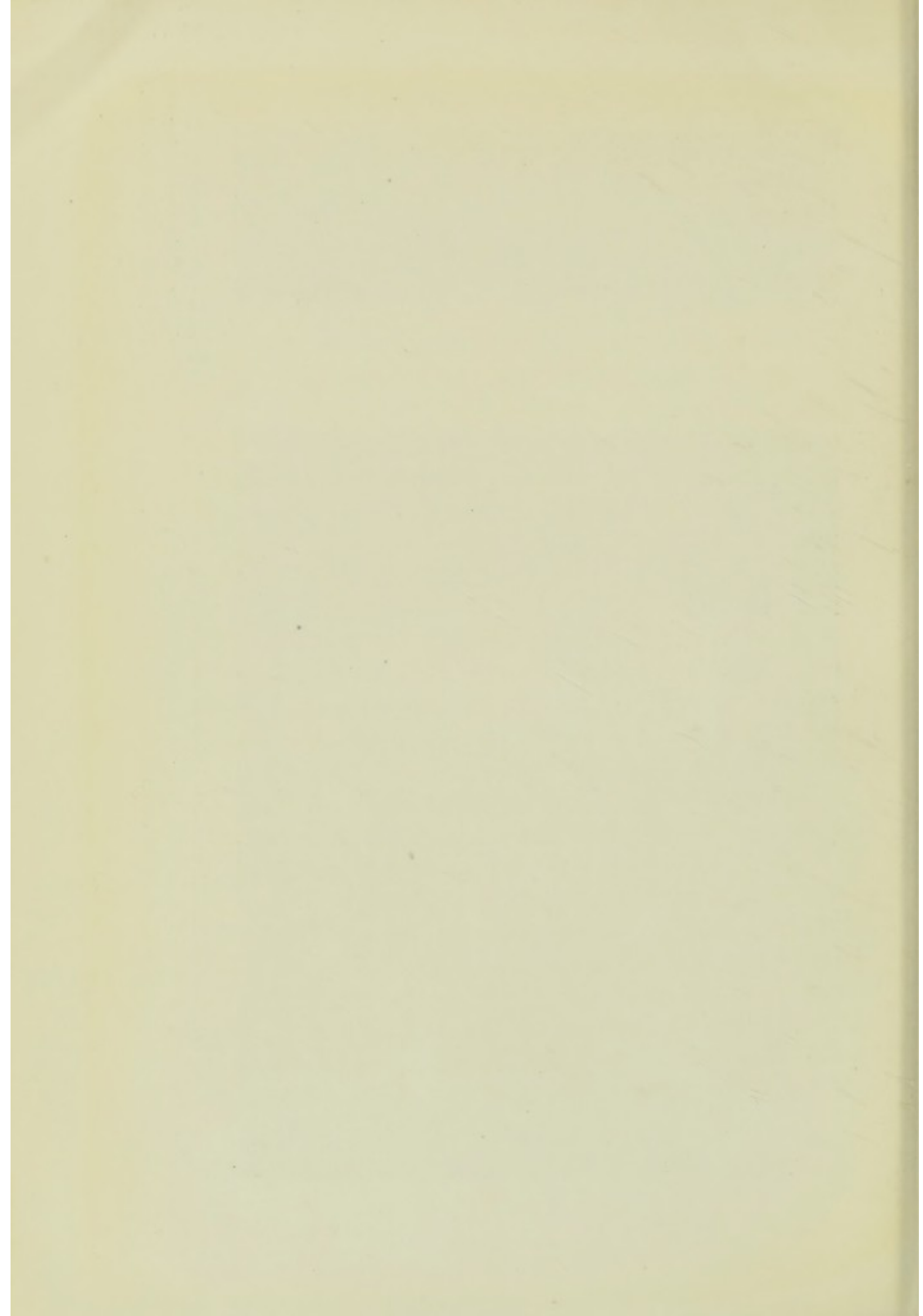
plant contrasts rather markedly with those already described. The flowers are borne singly, and are shortly stalked. As a rule, the corolla is entirely absent, or, if present, the petals are very reduced and minute. The sepals forming the conspicuous portion of the flower have membranous margins.

The other species, *Alsine aretioides*, M. K. (= *A. octandra*, Schur.), is confined to calcareous soils in Canton Valais. It builds similar cushions. The flowers in this case possess petals which, like the sepals, are four in number, while there are eight stamens, an unusual occurrence in this order of plants.

The High Alpine Saxifrages.

Many of the Saxifrages, as we have seen (Chapter III.), are typical rosette plants. A few form cushions by a close aggregation of bud-like shoots. Such species are not, however, confined to the High Alpine region, but also occur at lower elevations.

Sometimes in the High Alpine region *Saxifraga moschata*, Wulf (= *S. varians*, Sieb.), builds cushions, though the plant is only tufted at lower altitudes. *Saxifraga bryoides*, Linn., which probably is simply a High Alpine variety of the Rough Saxifrage (*Saxifraga aspera*, Linn.) (see p. 81), forms cushions by an aggregation of many bud-like shoots, arising in the axils of the leaves of older branches. The yellowish-white flowers are borne on erect shoots.

We have already discussed the Purple Saxifrage

(*Saxifraga oppositifolia*, Linn.) (Plate **XXXVI.**, Fig. 1) in Chapter III. (p. 78). We may, however, notice here that the tufted leafy branches of this plant form a loose cushion, less compact than those of many of the High Alpines. Though the Purple Saxifrage is found at great elevations in Switzerland, it is not a true High Alpine, for it is also common in the Alpine and Subalpine zones.

The large size of the flowers in comparison with the leaves (Plate **XXXVI.**, Fig. 1) is a striking feature of the plant. Often when this Saxifrage is in full bloom, the crowded flowers almost completely hide the cushion. The same feature is characteristic of many other cushion plants, though it is not universal.

The High Alpine Carpet Plants.

We have already discussed the peculiarities of a typical carpet plant in the case of the White Dryas (p. 106), the Trailing Azalea (p. 109), and other Alpines described in Chapter IV.

The Trailing Azalea is essentially a High Alpine plant. Another High Alpine which will be found described in Chapter IX., the Crowberry (*Empetrum nigrum*, Linn.), is a low, spreading shrub which, while not a true carpet plant, has some characteristics in common with typical instances of that kind of habit.

In the High Alpine region, the Willows form perhaps the most perfect examples of carpet plants to be found in the whole Alps.

PLATE XXXVI.
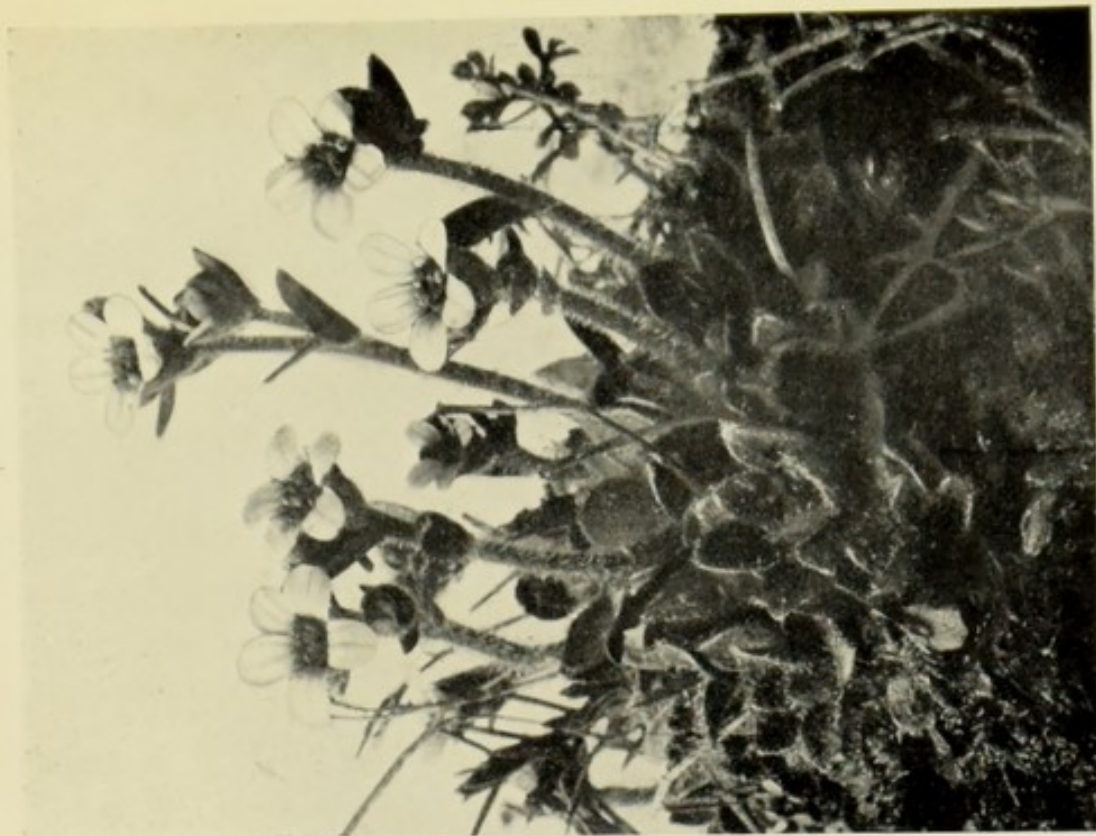
FIG. 2.—The Androsace-like Saxifrage (*Saxifraga androsacea*, Linn.).

[*To face p.* 186.
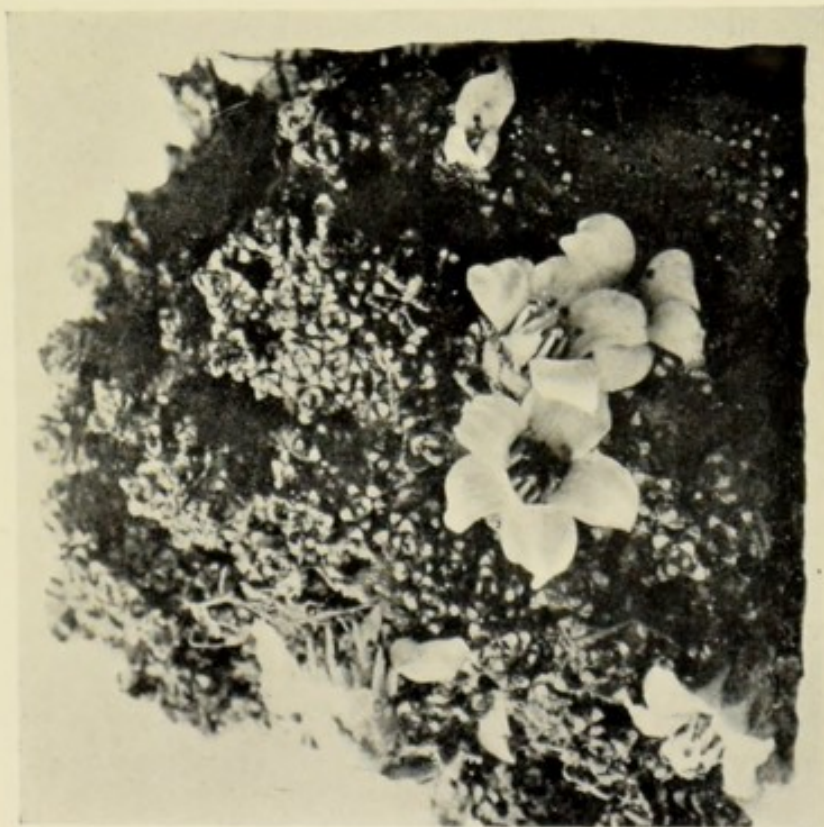
FIG. 1.—The Purple Saxifrage (*Saxifraga oppositifolia*, Linn.).
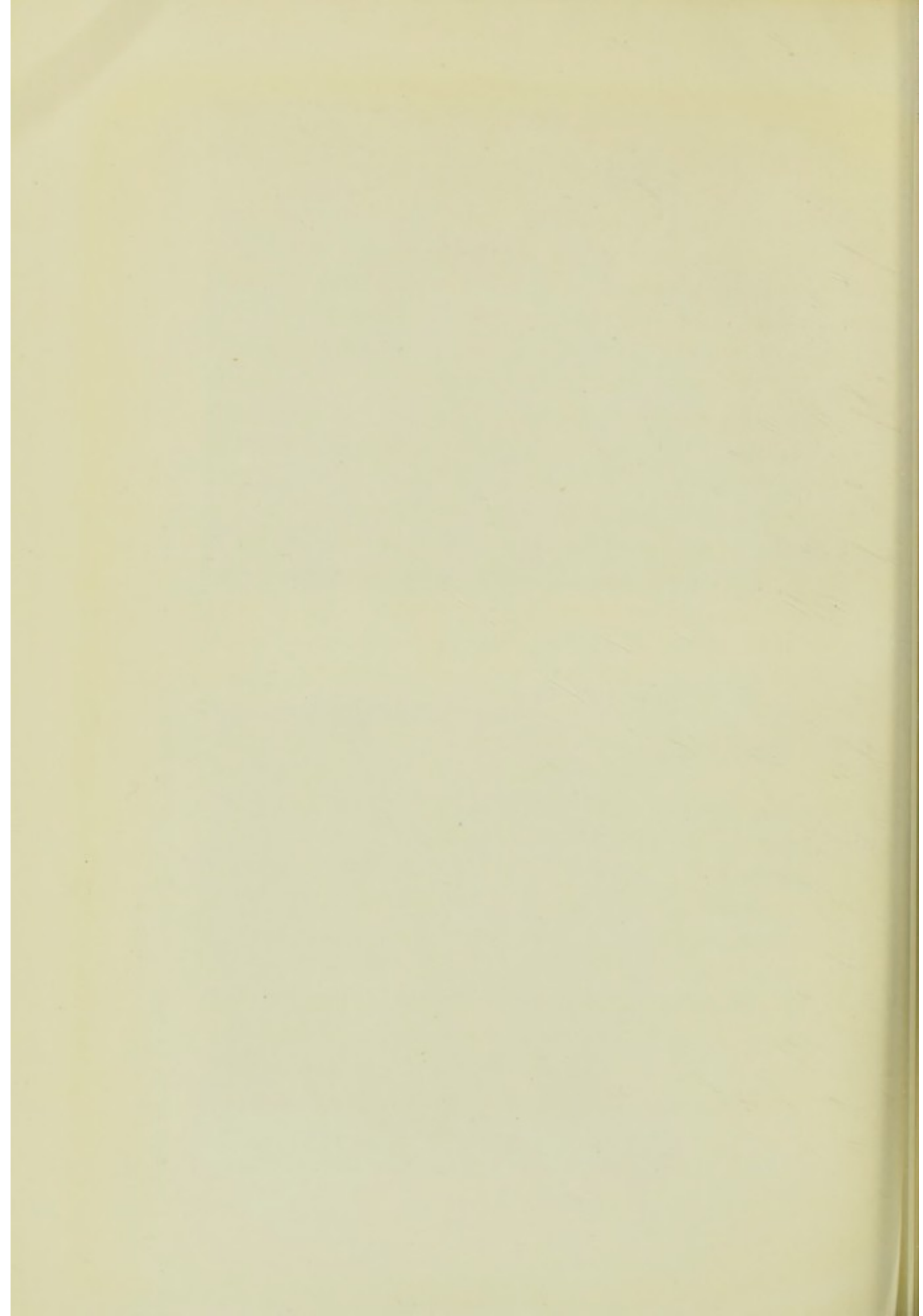
THE HIGH ALPINE WILLOWS.

We are accustomed to think of the Willows (natural order Salicaceæ) as being good-sized trees, as with us in England. Even in the Alps the Willows manage to hold their own, owing to their marvellous power of adapting themselves to a set of physical conditions, entirely different from those met with in the plains. As they ascend the Alps, they discard the tree habit. They gradually become reduced to dwarf shrubs, and then finally in the High Alpine regions to carpet plants, which are only slightly woody. The gradual dwarfing of a tree-form, as the altitude increases, is well seen in other plants, such as the Juniper and the Mountain Pine, which will be discussed in a later chapter, but nowhere is it found perfected to the degree met with in the High Alpine Willows.

The carpet-forming Willows do not belong to the same species as those found in the plains, nor are they regarded as varieties of Lowland species, as is the case with *Juniperus communis*, var. *nana*, Willd. There are two Carpet Willows confined to the High Alpine region, which we will now compare.

THE RETICULATE WILLOW.

The Reticulate Willow (*Salix reticulata*, Linn.) (Plate XXXVII.) is the best known and the handsomest of the Alpine Willows. It is usually very abundant on old or new moraines of glaciers,

which are excellent places on which to study these Willows, as well as other plants.

The habit of this species, as seen on Plate XXXVII., is that of a typical carpet plant. There is a stem, for the most part buried in the scanty soil, which gives off numerous branches, radiating in all directions and placed close to the ground. The plant may attain to a good age. Prof. Schroeter records forty-one years in one case. In other Alpine Willows the period may be even greater.

The large, elliptical leaves are very characteristic. The upper surface is smooth, shining, and dark green in colour; the veins are extremely prominent, and form a well-marked mesh-work or reticulation, clearly seen on Plate XXXVII. The prominence of the net veins is a special feature of this Willow; hence the specific name "reticulata." On the lower surface the leaves are covered with a fairly thick felt of bluish-white cotton-hairs. If we examine young leaves, we shall find that they are hairy all over. As the leaf matures, the hairs disappear completely from the upper surface. The leaves are quite entire—*i.e.*, not toothed at the margin. They are mounted on long, pinkish leaf-stalks. Sometimes the leaves are some-what rolled at the edges, an adaptation which, like the felt of hairs on the lower surface, serves to protect them against undue loss of water by evaporation, in the manner already explained.

The flowers of the Willows are very different to those of all the other Flowering Plants discussed in

PLATE XXXVII.

A High Alpine Carpet Plant, the Reticulate Willow (*Salix reticulata*, Linn.).

[*To face p.* 188.]
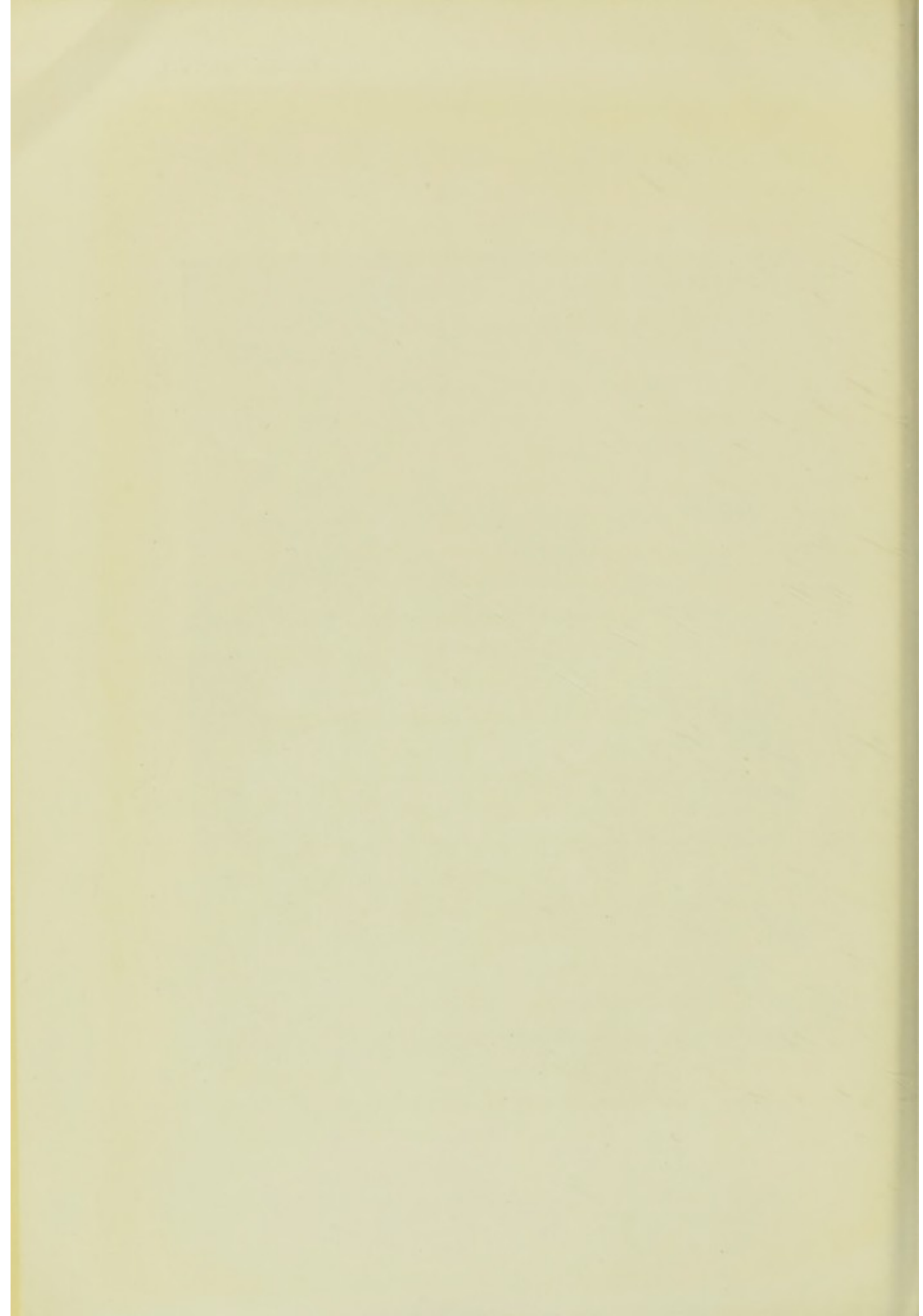
this volume. They are very reduced structures without either sepals or petals, and the male and female organs are borne on separate plants. Each male flower consists solely of two or more stamens, in the axil of a modified leaf or bract. Each female flower is composed of a single carpel, also in the axil of a bract. Both types of flower also contain a honey gland. The flowers, whether male or female, and the bracts, are arranged in dense spikes called catkins.

The photograph on Plate XXXVII. is of a male plant of the Reticulate Willow. The erect male catkins are borne on rather long, leafless stalks, springing from the ends of branches. The bracts of the catkins are brown in colour. The withered stamens, of which there are two to each flower in this species, can just be seen with the use of a hand-lens, the anthers projecting beyond the bracts. The catkins were past their prime when the photograph was taken.

The female flowers produce a large number of very small seeds. Each seed has a little tuft of hairs at the base, which helps it to fly on a windy day and so distributes it far from the parent. It will be often noticed that the Willow carpets growing on moraines are covered with a whitish fluff, somewhat resembling cotton-wool. This fluff consists of enormous numbers of seeds tangled together by their hairs. The Alpine Willow-herbs (*Epilobium*, natural order Onagraceæ) produce similar seeds, with hairs at the base, which often become entangled in much the same way.

The Reticulate Willow ascends to **10,450** feet on Monte Rosa. It is fond of calcareous rocks. It is, of course, a British plant, though confined to some of our loftiest hills in Scotland.

The Dwarf Willow.

The Dwarf Willow (*Salix herbacea*, Linn.) was described by Linnæus as "the smallest of all trees" (minima inter omnes arbores). It is essentially similar in habit to the Reticulate Willow, from which it differs only in detail. It is also a British plant.

The leaves are smaller, possessing only a short stalk, and are quite destitute of hairs underneath. They are green and shining on both sides, and have a net nervation. They are finely but bluntly toothed at the margin. The catkins are very small and few flowered, and are borne on short stalks.

There are several other Willows—such as *Salix glauca*, Linn., which is not infrequent in the High Alps, and has lance-like leaves with long, straight, silky hairs on both sides, also *Salix retusa*, Linn., *S. cæsia*, Vill., and others which are found in the Alpine zone—but only the Reticulate and Dwarf Willows are exclusively High Alpine.

High Alpine Rosette Plants.

In the typical rosette plant, the above-ground portion of the stem is very short, and the bases of the leaves are all crowded together in the form of a

rosette. This plan of architecture is by no means confined to Alpine species. Our British Whitlow-grass (*Draba verna*, Linn.), a Lowland species, is a typical rosette plant. This habit is, however, more common in the Alpine zone than in the Lowlands. We have already noticed some typical Alpine rosette plants in Chapters II. and III.

Within the Alpine zone, as has been already pointed out, a large number of species tend to become marked geophytes—that is to say, the stem is buried as deeply as possible in the soil, and the upper portion is reduced. The consequence is that the spaces (internodes) between the points of attachment of the leaves to the stem (nodes) are shortened. Thus the great feature of a rosette plant is, in botanical jargon, the suppression of the internodes of the stem. We can actually see this condensation of the internodes if we compare specimens of the Bavarian Gentian (*Gentiana bavarica*) from the lower and higher Alpine regions. At the lower level, this plant is not a rosette plant. Quite long spaces or internodes occur between the lower leaves. From higher habitats, however, the internodes will be found to become shorter and shorter, and finally an imbricated or overlapping rosette results.

It may be doubted whether the flora of the Higher Alpine region is so rich in rosette plants as the lower. Probably there are actually fewer above 8,000 feet than below. Some of the typical Alpine rosette species, as we have seen, take to cushion building, so

to speak, in the High Alps, as, for instance, the Androsaces. On the other hand, the Gentians are represented by two High Alpine species, *Gentiana brachyphylla*, Vill., and *G. tenella*, Rottb. (see Chapter II.), which are rosette plants, but the High Alpine Saxifrages, *Saxifraga androsacea*, Linn. (Plate XXXVI., Fig. 2), *S. Seguieri*, Spr., *S. muscoides*, All. (= *S. planifolia*, Lap.,) *S. exarata*, Vill., and *S. aphylla*, Sternb. (= *S. stenopetala*, Gaud.), are all tufted or cushion-building species, and not true rosette plants. Of the three High Alpine Rampions, *Phyteuma pauciflorum*, Linn. (*P. pedemontanum*, Schulz), alone has true rosettes, for *P. humile*, Schleich, and *P. hemisphæricum*, Linn., are tufted plants. The blue-flowered *Arabis cœrulea*, Haenke, however, with *Draba Wahlenbergii*, Hartm., and *D. carinthiaca*, Hoppe (= *D. johannis*, Host.), all three Cruciferous species, go to swell the number of rosette plants in the High Alpine zone.

HIGH ALPINE DWARF PLANTS.

For want of a better term, we may include under the heading of High Alpine dwarf plants, those species growing at great elevations in the Swiss Alps, which, as regards their habit, are not markedly dissimilar except in stature, from their near relatives in the Lowlands. Many of them rarely exceed 4 inches in height, and they are often less. The leaves, for the most part, are borne just above the surface of the ground, and though they are not arranged in true

rosettes, they are in many instances tufted. We will now notice a few of the more interesting examples.

The High Alpine Buttercups.

There are four Buttercups, if we include the Rue-leaved Callianthemum, which are confined to the upper portion of the Alpine zone, the High Alpine region. Of these the Glacial Buttercup (*Ranunculus glacialis*, Linn., natural order Ranunculaceæ, the Buttercup family) is especially interesting because, as we have seen, it is the highest plant found in Switzerland. It flourishes on very damp, gravelly or rocky places, and often on fully exposed, sunny slopes. The whole plant varies from 2 to 7 inches in height. There is a very short stem rooted in the gravelly soil, bearing leaves mounted on fairly long stalks. Each leaf is divided into three portions, which, again, are either lobed, cut, or divided. It is characteristic of the Glacial Buttercup that the leaves of different plants vary enormously in the degree to which the three segments are lobed or divided.

We should rather expect to find in a plant living at such great elevations—for the Glacial Buttercup rarely occurs lower than 7,600 feet—that the leaves would be covered with a thick coat of hairs, affording them some protection against the severe climatic conditions of these high places. Yet, except for the calyx, the whole plant of the Glacial Buttercup is, as a rule, quite smooth or nearly hairless, and, externally at least, shows no special adaptation to its particular

N

environment. It is only in the most elevated habitats that the very dwarf specimens become covered with hairs.

The flowers of this plant are very beautiful and are easily distinguished from all other Buttercups by the fact that the outer surface of the calyx is thickly covered with reddish-brown hairs. Usually only one flower, but sometimes as many as three, are borne on each flowering shoot, which also carries a few leaves, smaller in size than those found below. The colour of the corolla varies from pure white to rose-pink, or very dark pink-red. It is very inconstant, great differences in colour being often remarked among the flowers borne on the same plant, and even in the different petals of the same flower. The petals have a small honey nectary at the base on the inner side, and these organs, again, vary greatly in size and complexity, in different examples of the plant. Otherwise *Ranunculus glacialis* is quite a typical Buttercup, though of dwarf stature.

The three other Buttercups have white flowers, and also offer an interesting contrast when the shape of the leaves is compared.

The Pyrenean Buttercup (*Ranunculus pyrenæus*, Linn.), which is common at elevations from 6,000 to 8,000 feet or more, has one to three grass-like, lance-shaped leaves, blue-green in colour. The sepals are hairless. It is a dwarf plant, from 3 to 12 inches in height.

The rarer Parnassus-leaved Buttercup (*Ranunculus*

parnassifolius, Linn.), 2 to 6 inches high, shares with the Pyrenean Buttercup the distinction of being the only other Alpine species, which has undivided and non-lobed leaves. The thick leaves are here large and heart-shaped, and borne on leaf-stalks. The nerves on the upper surface are very well marked. The leaves on the flowering shoots sheathe the axis at their base. The whole of the lower portion of the plant is apt to be very hairy.

The Rue-leaved Callianthemum (*Callianthemum rutæfolium*, Reichb.), sometimes included in the genus *Ranunculus*, and its variety *C. coriandrifolium*, Reichb., by some considered as a distinct species, are among the rarer and more local High Alpines. They have highly compound leaves with long stalks, the segments of the leaves resembling those of the Rue (*Ruta*). The petals are white, with a yellow claw.

The Alpine Poppy.

The Alpine Poppy (*Papaver nudicaule*, Linn., natural order Papaveraceæ, the Poppy family) is a beautiful High Alpine of local occurrence, chiefly on calcareous soils. It varies from about 2 to 6 inches in height; otherwise it closely resembles the ordinary Lowland Poppies in habit, except that the flowering shoots are leafless. It is, however, a perennial plant, whereas many of the Poppies of the plains are annuals. This plant is remarkable for the large number of variations to be found in some of its principal

characters. The varieties are regarded by some authors as constituting distinct species.

The plants may have white flowers, and the leaves be destitute of hairs (*Papaver alpinum*, Linn.), or the flowers may be white with a yellow base, or again, the flowers may be yellow and the leaves hairy (*P. pyrenaicum*, Willd. = *P. aurantiacum*, Lois.). The shape of the lobes of the much-divided leaves also varies in great degree.

The Alpine Bittercress.

The Alpine Bittercress (*Cardamine alpina*, Willd., natural order Cruciferæ, the Crucifer family) is the representative of the Ladies' Smock or Cuckoo-flower (*Cardamine pratensis*, Linn.) in the High Alpine regions. It is a dwarf plant, from 1 to 5 inches in height, with many long-stalked, undivided leaves below, and numerous leafy shoots above. The simple undivided leaves contrast with the compound leaves of the Ladies' Smock.

The Short-stemmed Hutchinsia.

The Short-stemmed Hutchinsia (*Hutchinsia brevicaulis*, Hoppe) is possibly only a High Alpine variety of the Alpine species, *H. alpina*, R. Br. Both differ from our British Rock Hutchinsia (*H. petræa*, R. Br.) in the flowering stems being simple, unbranched, and leafless. The white petals are also much longer than the calyx, and therefore more

conspicuous, and the whole flower, though small, is larger than that of *Hutchinsia petræa.*   *H. brevicaulis* differs chiefly from *H. alpina* in the shorter flowering shoot, and the more compact and dwarf habit.   In these three species, all of which occur in Switzerland, one can trace each stage in the production of a dwarf High Alpine.

The Frigid and Smallest Potentillas.

The genus *Potentilla* (natural order Rosaceæ, the Rose family) is well represented in the Alps by numerous species.   Several British plants, including the Tormentil (*Potentilla tormentilla*, Neck.) and the Spring Potentilla (*P. verna*, Linn.), are frequent in the Alpine zone, where also many non-British species, such as the beautiful Large-flowered Potentilla (*Potentilla grandiflora*, Linn.), are as abundant.   In the High Alpine region we find two very dwarf species, both with stems only 1 to 2 inches high, and usually only one or two very small flowers on each shoot.   The leaves of the Frigid Potentilla (*Potentilla frigida*, Vill.) are dull green, and very hairy on both sides. Those of the Smallest Potentilla (*Potentilla minima*, Hall.) are smooth on the upper surface, and bright green in colour.   The Scotch Sibbaldia (*Potentilla Sibbaldi*, Haller, = *Sibbaldia procumbens*, Linn.) also occurs in the High Alpine region in Switzerland.

THE ALPINE OX-EYE DAISY.

The Ox-eye Daisy (*Chrysanthemum leucanthemum,* Linn. = *Leucanthemum vulgare,* Lam.) is very abundant nearly everywhere in the Alpine zone. In the high Alpine region we meet with the Alpine Ox-eye Daisy (*Chrysanthemum alpinum,* Linn.), a much smaller plant. Whereas the flowering stems of the former species are 1 to 2 feet tall, those of the latter are only $1\frac{1}{2}$ to 4 inches in height. The Alpine Ox-eye Daisy is, on the whole, closely similar to the Common Ox-eye Daisy, though it differs in some characters as regards the leaves.

PLATE XXXVIII.

Fig. 1.—Vital's Androsace (*Androsace vitaliana*, Lap.).

Fig. 2.—A Colony of the Common Butterwort (*Pinguicula vulgaris*, Linn.).
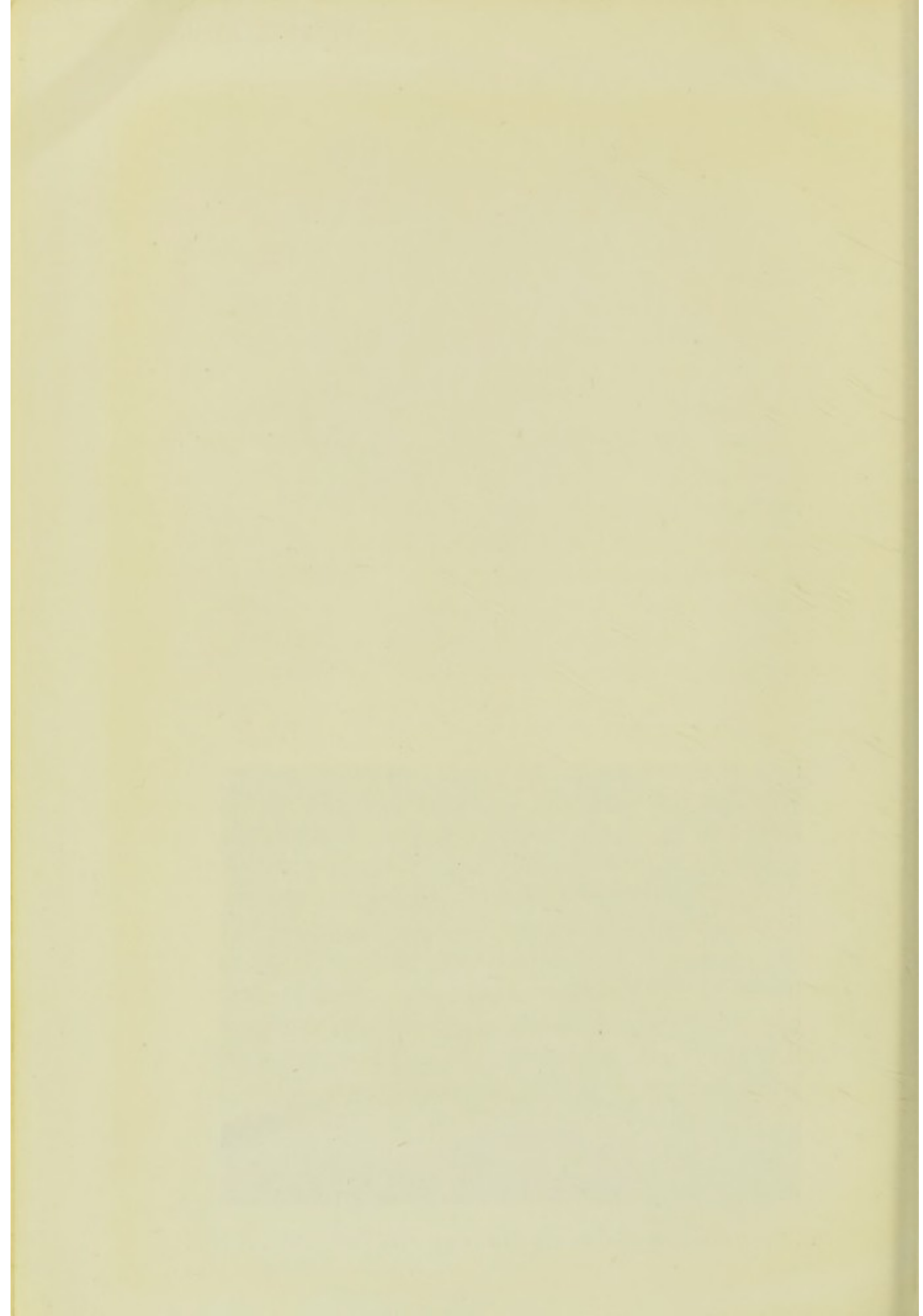
CHAPTER VIII

THE HIGH ALPINE PLANTS (*continued*)—MARSH PLANTS

THE methods and processes, by which some of the results achieved by Science are attained, are apt to be beyond the imagination of the lay mind. Most people are perhaps aware that the earth has on several occasions not only been measured but weighed. It is less widely known that Alpine plants have actually been made. How these matters are accomplished is too often regarded as the secret of the scientist, and certainly it would be difficult to demonstrate the method of ascertaining the volume and weight of the earth, without assuming a considerable knowledge of the groundwork of physical science. But the making of an Alpine plant is quite simple of comprehension.

We have discussed in the previous chapters the various types of habit, which are characteristic of Alpine plants. When, therefore, we say that Alpine plants have been made, we mean that Lowland plants transplanted to the High Alps have been found to assume one or other of those peculiarities of form

and structure, which we have seen to be distinctive of Alpine habitats.

Several botanists in the past have paid special attention to this matter. The experimental researches of Prof. Bonnier of Paris on the adaptation of plants to Alpine climates are of particular importance in this connection. We will now glance briefly at his methods and results. Prof. Bonnier studied a number of species, among others the Harebell (*Campanula rotundifolia*, Linn.), the Kidney Vetch (*Anthyllis vulneraria*, Linn.), the Bird's-foot Trefoil (*Lotus corniculatus*, Linn.), the Ling (*Calluna vulgaris*, Salisb.) and the Rock Silene (*Silene rupestris*, Linn.). Strong, well-grown examples of these plants from the Lowlands were divided into two halves, as nearly similar as possible. One half of each plant was transported to one or other of the experimental gardens on the Mont Blanc range, situated at 3,460 feet and 7,590 feet respectively, or in the Pyrenees to one of three small gardens at 2,470 feet, 4,950 feet, and 7,920 feet respectively. The other half was cultivated at Paris (105 feet above sea-level). The soil used in each case was identical, and everything was precisely similar, except the physical conditions of the climate of each experimental station, which varied with the altitude above sea-level.

The experiment was a particularly fair one, for the plant grown as a "control" in the plains at Paris was derived originally from the same individual as the plant in one of the Alpine gardens. In such

experiments "controls," or plants grown under normal conditions, are always used as the basis of comparison with the plants which are being investigated.

The results of Prof. Bonnier's experiments were remarkable. It will not be necessary to discuss here the different effects pro-duced on each of the very large number of species with which he worked. The con-clusions were similar in each case, though differing in detail. In several instances he found that the plants grown in the Alpine regions became dwarf plants, possessing many of the characteristics of Alpine species; in short, he *made* Alpine plants.
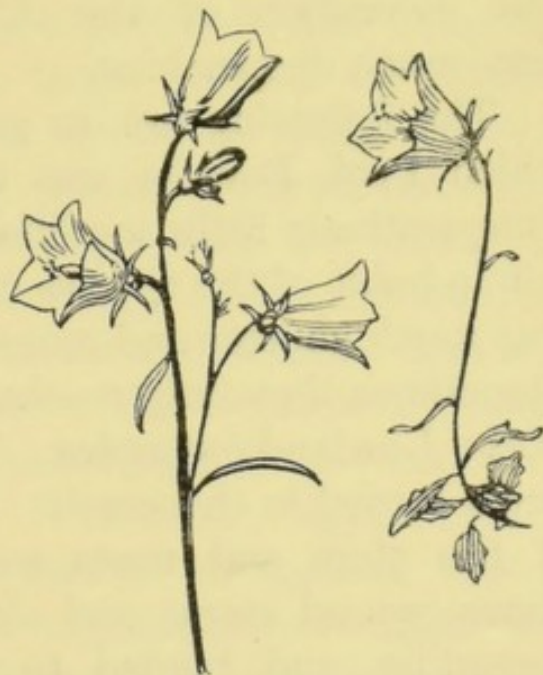
FIG. XVIII.—Plants of the Harebell (*Campanula rotundifolia*, Linn.).
That on the left grown in the Lowlands ; that on the right in an Alpine garden. (After Bonnier.)

The case of the Harebell (*Campanula rotundifolia*, Linn.)—of which two examples are seen in Text-fig. XVIII., taken from Prof. Bonnier's memoir—will afford a good illustration of the effect of the High Alpine climate. The plant on the left is the "control" grown at Paris. The one on the right is the other part of what was originally the same plant, grown in

one of the Alpine gardens. The latter is a dwarf plant. The stem is shorter, and the lower leaves closer together. The flowering shoot is much shorter and more hairy. It bears only a single flower, which is, however, larger than any one of the flowers borne in the branched raceme of the Lowland plant. The coloration of the Alpine specimen is also a very much deeper blue.

The following are, in general, the conclusions to which Prof. Bonnier was led, though in some cases comparatively little modification was observed. The whole habit of the species cultivated in the mountains was much shorter and more dwarf than in the plains. Sometimes they only reached one-tenth of the height of the Lowland examples. The stem was shorter, and much buried in the earth. The underground portions of the stem and roots were better developed, the above-ground stems and shoots were more hairy and spreading, and tended to cling closer to the soil. The internal structure of both stem and leaf was profoundly modified. The leaves were, in general, nearer together, more hairy, relatively thicker and smaller, and of a much deeper green colour, more chlorophyll (see p. 10) being developed. The flowers were relatively larger and more strongly coloured.

The three principal factors of the Alpine climate which call forth these changes are the more intense illumination, the drier atmosphere, and the lower average temperature. The first has a particularly powerful influence.

Some earlier experiments by the Viennese botanist, Kerner, made between 1875 and 1880, are worthy of consideration in conjunction with Prof. Bonnier's more recent work.

Kerner established an experimental garden near the summit of the Blaser (7,243 feet), a mountain in Tyrol, and the controls were grown in the botanical garden at Vienna. Of a large number of annuals raised from seed, many on the Blaser perished from the severe frosts in spring. Those which survived and flowered possessed extremely short internodes or lengths of stem between the leaves. Also, the number of internodes developed was often little more than half those found in the controls. The number of flowers was less, and they were smaller than in the controls.

A biennial plant, an Umbellifer, experimented with, produced only five umbels as against twenty found in the control. The internodes were again half as numerous, and the whole plant was less than a quarter the height of the Lowland example. So also with the perennials. In the case of the Grass-of-Parnassus, the stem in the Alpine cultivation was only one-third to one-quarter the height of the control, and the size of the leaves and of the flowers was smaller. In many species the flowers were more intensely coloured. Thus, Kerner's researches agree in several points with those of Professor Bonnier, and he, too, was inclined to lay special stress on the influence of the intense illumination of the Alps, as being the chief factor concerned in these modifications.

MARSH PLANTS.

The concluding part of this chapter will be devoted to the Alpine marsh plants—not a very large class.

To avoid excessive competition, and to mitigate the struggle for existence, plants have specialised in different directions. Some have taken to the water entirely, others to marshes or perpetually damp localities, while a third group favours soils with high water-contents, such as peat. On the other hand, certain plants, such as the Edelweiss, already discussed (p. 15), have specialised in quite the opposite direction, and flourish on soils and in situations where the water-supply is of the scantiest nature. There remain a third set of plants which exist under conditions midway between these two extremes. There is no doubt that all the Higher Plants (Angiosperms) which have become aquatic or adapted to marshy places have been derived from the last class, for although in the first place all land plants were evolved from aquatic ancestors, these ancestors existed at a very distant geological period, long before the Higher Plants came into existence. In the case of present-day aquatics, we have merely an interesting case of a return to the far-away and remotely primitive habitat.

In the present chapter we may consider the plants of the Alpine marshes, and more especially the species which are restricted to open situations, in which the soil is, as a rule, constantly moist.

THE MARSH MARIGOLD.

True aquatics are almost unknown in Alpine Switzerland. One or two species of Pondweed (*Potamogeton*, natural order Naiadaceæ), occurring in Alpine lakes, are the sole representatives of what in the Lowlands is an important plant association. Nor are marsh plants so numerous as at lower elevations. The British Marsh Marigold (*Caltha palustris*, Linn., natural order Ranunculaceæ, the Buttercup family) (Plate XXXIX.) is probably the most abundant representative of this class of plants in the Alpine region. Its flowers are interesting from the fact that, as compared with the Buttercup, its near relative, it has no petals. There are five large, yellow sepals, however, which are brightly coloured, and resemble the petals of a Buttercup rather closely, and also serve as an attractive insect advertisement. They furnish a good illustration of how Nature attains to the same end by a variety of means.

The Alps are an excellent hunting - ground in which to pursue a study of plants, which are also members of the British flora. Paradoxical as it may seem, our British flora can, in some respects, be better studied in the Alps than at home. Many of our more interesting British plants are rare or of very local occurrence, and unless we happen to be in a certain district at the right time of year, and further, to possess a more or less exact knowledge of the places in which they flourish, our chances of coming

across them are small. On the other hand, many of the plants, which are local with us, are in the Alps often extraordinarily abundant. Nearly all British Alpines are extremely common in Switzerland. Thus those who are to some degree familiar with our British plants can extend their knowledge by further studies within the Swiss Alpine zone.

It is also a matter of common remark that some of the most frequent of Alpine plants are also abundant with us in England. Here is our British Marsh Marigold, there our British Harebell, flourishing, if anything, more vigorously than with us! Thus those who are familiar with our wild plants will find many old friends within the Alpine zone in Switzerland. There are at least 250 Lowland species which ascend to heights of 5,000 feet or more in the Alps. Further, a very large number, certainly a majority, of Swiss Alpine plants which do not occur in Britain are very closely related to species or genera found wild with us. We will, however, reserve for the last chapter some discussion on the relationship of the Swiss Alpine flora to that of Britain and Northern Europe, and the theories as to its origin.

The photograph of a *Caltha* Marsh on the Engstlen Alp (Canton Berne), shown on Plate XXXIX., gives a good idea of how vigorously the Marsh Marigold thrives at an elevation of over 6,000 feet in the Alps.

PLATE XXXIX.
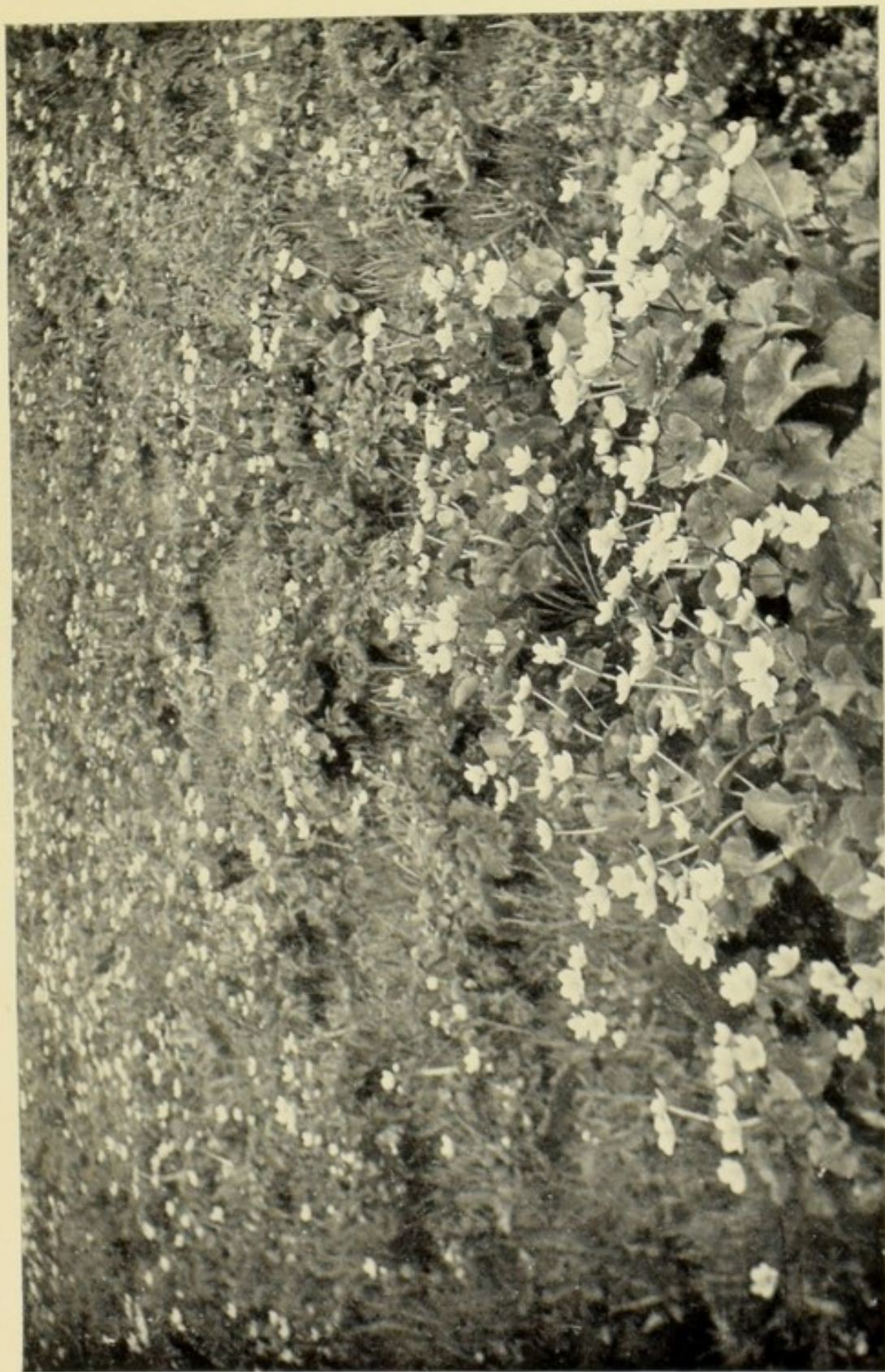
An Alpine Marsh of the Marsh Marigold (*Caltha palustris*, Linn.).
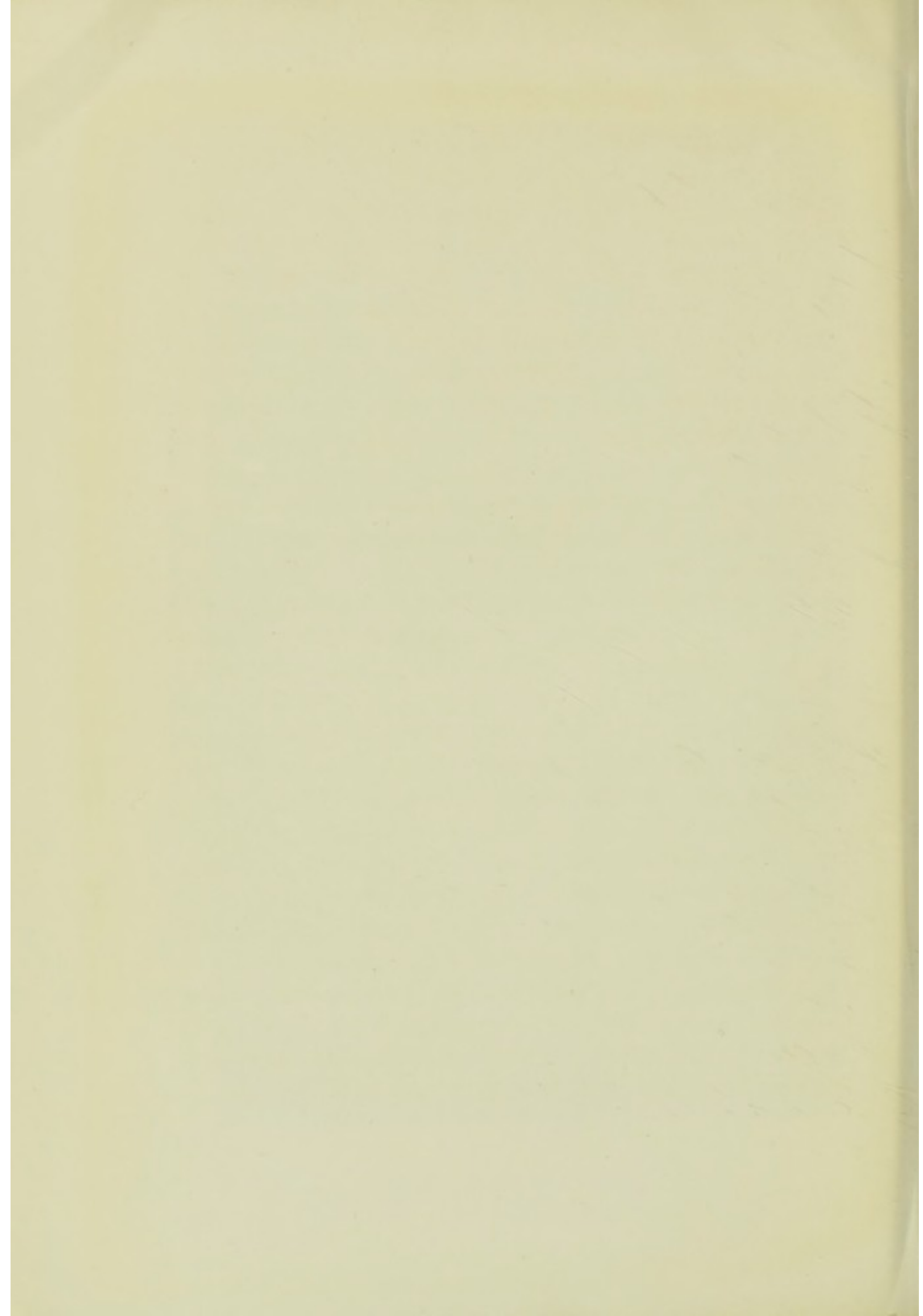
THE GLOBE-FLOWER.

The Globe-flower (*Trollius europæus*, Linn.) (Frontispiece), belonging to the same family as *Caltha*, is an abundant plant in more or less wet habitats in the Alps. With us in Britain it is much less frequent than the Marsh Marigold. In Switzerland it does not flourish, as a rule, in decidedly marshy places where *Caltha* may be found, for while apparently requiring a very damp soil, it is a much less pronounced marsh plant than the latter. At the same time, its distribution is rigidly restricted in accordance with the water contents of the soil, though its requirements in this respect are less exacting.

The flowers of *Trollius* are very interesting and somewhat exceptional. They never open. Here, again, it is the sepals, and not the petals, which form the conspicuous floral envelope. They may be ten to fifteen or more in number, and are yellow in colour. They are all bent on themselves, so that they converge towards the summit of the flower, overlapping one another, and forming, as it were, a dome-shaped roof over all the other parts or organs of the flower ; hence the name Globe-flower. The sepals here perform the same function as in *Caltha*. If we dissect them away, we shall find they enclose an equal, or nearly equal number, usually about thirteen, small, flat honey-glands, which by some are regarded as the real petals, considerably modified to serve as nectaries. Others hold that they are more probably derived by

modification of some of the outer stamens. The
real stamens, which are numerous, lie more internally
still, and then, in the centre of the flower, we find
several carpels quite free from one another. Honey-
glands, even more highly modified, occur in the flowers
of several other members of the same family, Ranun-
culaceæ, as, for instance, in the Hellebores (Christmas
Rose, etc.), where they are fairly large and horn-like
in shape, and in *Eranthis*, the Winter Aconite, where
they are tubular.

The presence of honey-glands and a copious
supply of honey implies that this flower is fertilised
by insects ; yet the dome-shaped roof of the converging
sepals never opens. How, then, do the insects manage
to get inside? The mystery can be explained by
anyone who will take the trouble to watch these
flowers for a few minutes on a bright sunny day.
Before very long, one or more small flies will be seen
to alight on the sepals, push their way between them,
and disappear bodily into the interior. Later on
they will be seen to creep out again. It is these flies,
attracted by the honey, which serve as pollen carriers
from flower to flower. No bee can get at the honey
because of the roof of sepals. Thus we have here an
interesting contrivance for cross-pollination.

Although the nectar, copiously secreted in the
honey-glands, is strictly reserved for certain small flies,
other insects, which are unbidden guests, make
determined attempts to reach the honey and to rob
the flower. Their chief difficulty is that their bodies

are too big to allow them to creep between the sepals.

The photograph shown in the Frontispiece is fortunate in that it exhibits examples of both the bidden and unbidden guests of this flower. On the top of the highest flower seen in the photograph, one of the small flies, a legitimate guest, is just visible (though not very distinctly) returning to the world. On the left side of the same flower, a much larger insect, a robber, probably a beetle, is at work. Unable to get within by legitimate means, it tries to bite through, and to tear off the sepals. Several of these flowers show sepals, the margins of which have been bitten away, and which consequently have turned slightly brown at the edges.

THE ACONITE-LEAVED BUTTERCUP.

A conspicuous plant in the Alps, growing under much the same conditions as the Globe-flower and belonging to the same family, is the white Aconite-leaved Buttercup (*Ranunculus aconitifolius*, Linn.) (Frontispiece and Plate XL.). With our neighbours, the double-flowered variety of this plant is known as the "Fair Maid of France."

In Britain we have a group of white-flowered Buttercups of aquatic habit known as the Water Ranunculi, which flourish in ponds, wet ditches, and gently flowing streams. These plants are specially adapted to their habitat, the submerged leaves being highly divided and quite different in form from

those which float or project above the surface of the
water.   These Water Ranunculi are entirely absent
from the Swiss Alpine region.   Their place is taken by
such species as the Aconite-leaved Buttercup, which is
extremely partial to damp, but not too wet, soils.   In
Plate XL. a photograph of an Alp covered with this
plant is seen.   But it will be noticed that it does not
grow everywhere.   It is distributed in bands, and
these bands represent the portions of the pasture
where the soil is dampest.   The higher and drier
areas are unoccupied.   Thus we have here a veritable
hygrometric chart of an Alp, the lines of highest
water contents being indicated by this plant.   Similar
zones may also be frequently observed in Alpine
meadows, traversed by one or more damp ditches or
depressions, which are, as a rule, marked out as bands
of pure white by this Buttercup.

Ranunculus aconitifolius is a large, highly
branched, spreading plant, the leaves resembling
those of the Winter Aconite (*Eranthis*).   A variety
of this plant, very similar in many respects, but with a
leaf like that of a Plane (*Platanus*), is by some
regarded as a distinct species (*R. platanifolius*, Linn.).
It, on the contrary, occurs chiefly in fairly dry
situations in the Alps.

The Butterworts.

The Butterworts, members of the genus
Pinguicula, belong to an order of insectivorous
plants, the Lentibulariaceæ, which stands near to the

PLATE XL.

A Damp Pasture covered with the Aconite-leaved Buttercup (*Ranunculus aconitifolius*, Linn.).

[*To face p.* 210
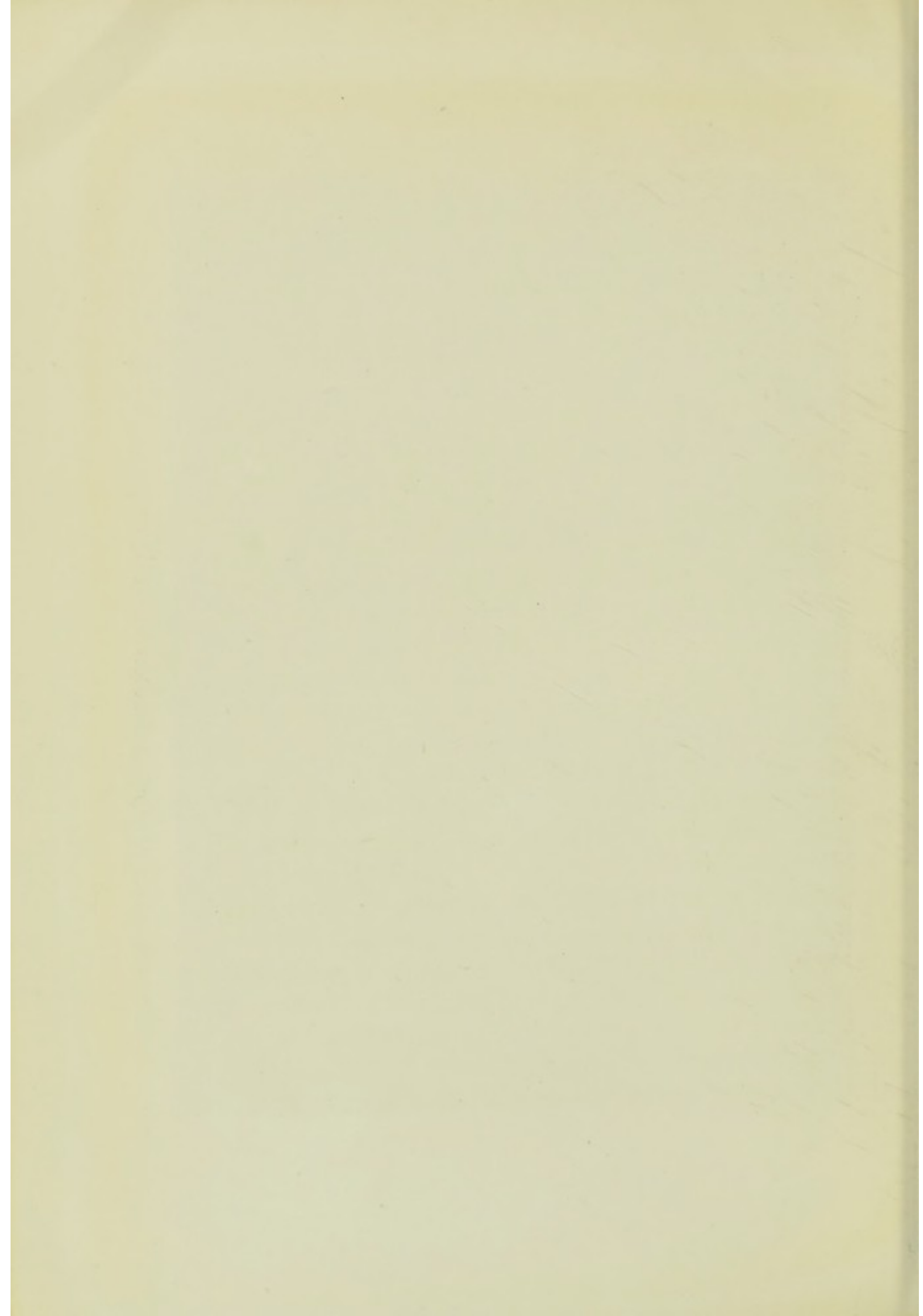
large order Scrophulariaceæ. There are three species
of British Butterworts, and in Britain we have also
other insectivorous representatives of the family in
the genus *Utricularia*, or Bladderworts. The latter
also occur in Lowland Switzerland, but are rare within
the Alpine zone, though one species has been observed
in boggy pools on the Julier road, above Silvaplana,
at 6,400 feet.

The Swiss Alpine Butterworts are easily distin-
guished. The Alpine Butterwort (*Pinguicula alpina*,
Linn.) has large white flowers, while the Common
Butterwort (*Pinguicula vulgaris*, Linn.) and the Large-
flowered Butterwort (*Pinguicula grandiflora*, Lam.)
have blue flowers. All the species are essentially
marsh plants, though they will flourish in many other
situations in which the soil is usually very damp.

We will commence with the Alpine Butterwort.
This is a British plant, though with us it is very rare,
and confined to a few districts on the west coast of
Scotland. In Switzerland, however, it is common
and widely distributed.

The build of the plant is characteristic. There is
a little rosette of light green leaves, close to the
ground, of which we shall have more to say presently.
From the rosette springs a single, long flower-stalk,
terminating in a solitary white, occasionally yellowish,
or even slightly purple flower (Plate XLI., Fig. 1).
The flower is built much on the same plan as that of
the members of the Scrophulariaceæ. Both the sepals
and the petals are united so that each forms a two-

lipped structure. The corolla has also a short spur, and often two yellow spots on the lower lip. But there are only two stamens, and the ovary has only a single compartment, in which the seeds are arranged in much the same manner as in the Primroses and Androsaces.

But we are not concerned here so much with the flower as with the leaves of this very interesting plant. If we examine the pale, yellowish-green leaves of the rosette, we shall find that they are sticky on the upper surface. This stickiness results from the presence of numerous glands, or secretory organs, arranged on the upper surface of the leaf. These glands secrete a viscid fluid, which plays an important part in the economy of the plant, as we shall see. By their means it obtains part of its food-supply. Many of the leaves will be found to be concave, for the edges curve somewhat inwards and upwards towards the centre of the leaf.

A cross-section of a leaf is shown in Text-fig. XIX., 1. On the upper surface, two kinds of glands will be seen, some which are stalked and others which are stalkless, the latter being the more numerous. In Text-fig. XIX., 3, a surface view of one of the stalkless glands is seen, while Text-fig. XIX., 2, shows a side view of the same. Both of these are highly magnified under the microscope. The glands themselves can, however, be made out by examining the upper surface of a leaf with a powerful hand-lens.

Kerner states that there may be as many as 25,000

PLATE XLI.

[To face p. 212.

Fig. 2.—The Rosette of Leaves of the Common Butterwort (*Pinguicula vulgaris*, Linn.), showing Flies and a Moth caught and digested by the Leaves.

Fig. 1.—A Colony of the Alpine Butterwort (*Pinguicula alpina*, Linn.).
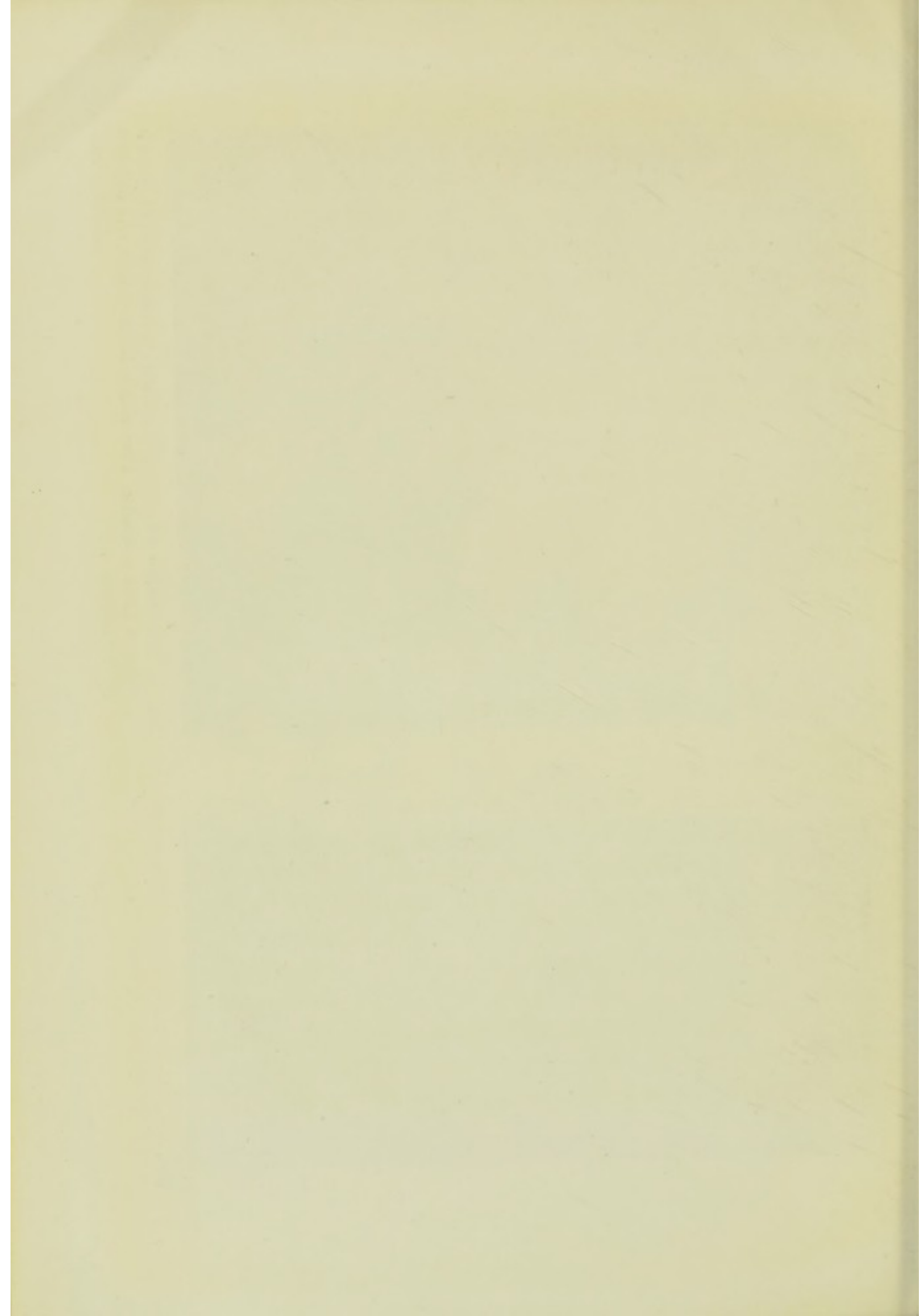
of these glands on a square centimetre of the leaf, and consequently a plant with a rosette of six to nine leaves is estimated to possess about half a million.

In the photograph on Plate XLI., Fig. 2, two rosettes of *Pinguicula* leaves are seen, thriving on a cushion of damp moss, which is itself attached to the root of a Spruce Fir. It will be noticed that numerous remains of dead insects, chiefly flies, occur on the leaves of the
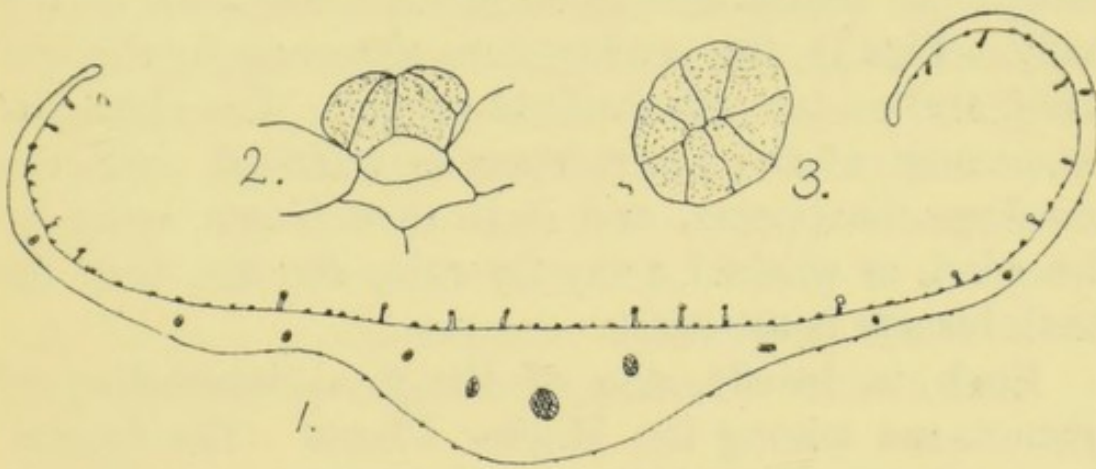
Fig. XIX.—The Common Butterwort (*Pinguicula vulgaris*, Linn.).

1. Transverse section of a leaf, showing the glands on the upper surface. Somewhat enlarged. 2. A side view of a gland. Much enlarged. 3. A surface view of a gland. Much enlarged.

larger rosettes, and in one case, on the uppermost leaf of the smaller rosette, growing below and slightly to the right of the larger rosette, the remains of a moth are clearly seen.

This plant has the power, not only of catching small insects on its leaves, but of digesting and absorbing them. What happens is briefly as follows. The glandular hairs of the upper surface secrete a sticky fluid, which attracts insects, probably under the

impression that honey is to be obtained there gratis.
If the insect is a small one, it becomes firmly glued to
the surface of the leaf by mucilage secreted by the
glands. Somewhat later, another substance, a
digestive fluid, known scientifically as a *ferment*, is
also secreted by the part of the leaf with which the
insect is in contact. The ferment has the power of
reducing to a liquid state and digesting the insect, all
except the indestructible chitinous investment of the
body. Finally, the products are absorbed by the leaf
itself, and go towards its food-supply. The chitinous
investment of the insect remains attached until the
mucilage disappears, and it is then blown away by
the wind, or washed away by rain, and the trap for
fresh insects is set again.

Such is, briefly, one of the most interesting of
phenomena among the Higher Plants. The insecti-
vorous habit, though not rare, is infrequent in the
vegetable kingdom. Examples occur in the case of
our British Sundews (*Drosera*) and Bladderworts
(*Utricularia*), some of which are also found in Lowland
Switzerland. Extreme or highly evolved adaptations
for a similar purpose are to be seen in the curious
tropical Pitcher plants (*Nepenthes*), commonly
cultivated in our greenhouses. Those who may be
interested to pursue this subject further should read
Charles Darwin's "*Insectivorous Plants*," which
contains a whole chapter devoted to the Butterworts.

In this connection, it may be worth while to call
attention to some further points, discussed by Darwin,

in the case of English specimens of the Common Butterwort, *Pinguicula vulgaris*, Linn. This species also occurs in Alpine Switzerland (Plate XXXVIII., Fig. 2). In one case Darwin records that 142 insects were caught by 32 leaves, giving an average of 4·4 insects per leaf. In addition, the small leaves of a Heath and other plant fragments were often blown by the wind on to the leaf accidentally, to which they adhered. He was also able to show that when objects which contain little or no soluble matter come to rest on the leaves, there is no secretion by the glands. But where the substance is nitrogenous, the secretion is copious, and the material absorbed by the leaf contributes to the food-supply of the plant, and helps to compensate for the limited extent of the root system by which nutriment is derived from the soil.

The fact that the leaves of the Butterworts contain a special substance was known for some hundred years before Science discovered its true nature. The ancient herbalist, John Gerarde, writing in 1597, says, "The husbandmen's wives of Yorkshire, do use to annoint the dugs of their kine with the fat and oilous juice of the herbe Butterwoort, when they are bitten with any venemous worm, or chapped, risted, and hurt by any other meanes." Kerner also states that a similar use of this plant is made in Switzerland. Linnæus, more than 150 years ago, related that the Common Pinguicula, which is frequent in the Arctic regions as well as in the

Alps, is used by the Laplanders to curdle milk. This can be easily confirmed by the experiment of placing a few pieces of the leaves in a little new milk, and letting it stand for some hours.

The other Alpine species of Butterwort, the Common Butterwort (*Pinguicula vulgaris*, Linn.), and the rarer Large-flowered Butterwort (*Pinguicula grandiflora*, Lam.), the latter not occurring in Britain, are biologically similar to the Alpine Butterwort, with which they are often associated in marshy places and on wet soils, such as a crevice in a rock filled with damp moss. They both have blue flowers and longer spurs than the Alpine Butterwort.

The Grass-of-Parnassus.

The Grass-of-Parnassus (*Parnassia palustris*, Linn., natural order Saxifragaceæ, the Saxifrage family) is another Lowland marsh plant, common in Britain, which ascends to the Alpine zone in Switzerland, where it is abundant. Like *Caltha* and many marsh-loving species, the whole plant is smooth and devoid of hairs. The leaves, which spring from a very short perennial stem, have fairly long stalks, and are heart shaped. Each year the stem sends up an erect flowering stem, which bears a single leaf, and ends in a large white flower, the structure of which is very interesting.

There are five small, green sepals, and five white petals, the latter with conspicuous translucent veins, which add considerably to the attractiveness of the

flower. More internally we find five normal fertile stamens, and then five barren stamens, greatly modified in form. The latter are branched structures, reminding one of a group of small pins arranged in a cushion in a fan-like manner (Text-fig. XX.). The ovary is seen in the centre of the flower, and divides above into four stigmas. The fertile stamens, when young, are bent inwards over the ovary. They shed their pollen one at a time, and then bend backwards and outwards, one by one, the filament or stalk also elongating considerably.

There has been much speculation as to the use of the modified stamens to the plant. The flower is cross-fertilised by flies. The anthers shed their pollen before the stigmas are ripe, and thus self-fertilisation is impossible.

Fig. XX.—A Staminode from a Flower of the Grass-of-Parnassus (*Parnassia palustris*, Linn.). Much magnified.

Honey is secreted at the base, and on the inner side of the modified stamens. But at first sight the little yellow knobs, glistening in the sun at the tops of the pin-like lobes of the branches of these organs, appear quite like drops of honey. These are really false nectaries, and not true honey-glands. Flies are constantly being deceived by them, and have been watched licking the false glands under the impression that honey would be forthcoming.

The precise function of these false nectaries cannot, however, be said to be fully understood at present. They may be additional allurements to flies—*i.e.*, insect advertisements—or they may constitute a sort of fence, which forces the insect to enter the flower, and reach the concealed honey in a particular way, which is favourable to cross-pollination.

THE ALPINE LOUSEWORTS.

The Louseworts, genus *Pedicularis* (natural order Scrophulariaceæ, the Foxglove family), are quite characteristic plants in marshy places in the Alpine zone. More than ten species occur, as opposed to two in Britain, so the genus is a very successful one in Alpine Switzerland. They are quite similar in build to our British Louseworts, except *Pedicularis verticillata*, Linn., in which the leaves are whorled. The flowers, as a rule, are, however, rather larger than with us, and are either yellowish-red or reddish-black, according to the species.

The interesting point to notice about the Louseworts is that they are semiparasites. This peculiarity they share with several other genera, nearly related and belonging to the same section of the family, such as *Euphrasia*, Eyebright; *Melampyrum*, Cow-wheat; *Rhinanthus*, Rattle; and *Bartsia*—all common in Alpine Switzerland.

In temperate floras parasitic Flowering Plants are rare, though they are common in the tropics. They are plants which attach themselves to other living

plants—the hosts, as they are called—and draw from them the whole or part of their nourishment. The Dodder is a familiar instance of a plant wholly parasitic on Thyme and a variety of other hosts. The Mistletoe is a semiparasite. It attaches itself to the branches of the Apple and some other trees, and while it draws part of its nutriment from the host, yet, by means of its leaves, it manufactures a portion, at least, of its food-supply itself. In the Alps parasites of either type are rare, with the exception of the members of the order Scrophulariaceæ mentioned above.

Euphrasia and the other related genera are semiparasitic on the roots of Grasses, which they rob of part of their food-supply. If we dig up a Lousewort, and separate the plant from the turf very carefully, we shall find that its roots are often attached to those of certain Grasses. At the same time, these plants, by means of their leaves, manufacture a portion of their nutriment.

CHAPTER IX

THE ALPINE THICKETS AND FORESTS

THE shrubby plants, forming the Alpine thickets and the fringe of the Pine forests, are very interesting, and well repay attention.

The Alpenroses and the Alpine Rose, which are commonly found growing in such positions, have been already discussed in the first chapter. The former are perhaps the most characteristic plants of the Alpine thickets, and frequently form regular terraces on the hillsides. With them are often associated many other plants, especially the Bilberries and Honeysuckles, which we will discuss in the present chapter.

It is rather remarkable that the fruits of nearly all the shrubby plants of the Alpine thickets, with the exception of the Alpenroses and a few others, are berries or other succulent fruits, for bird-life is remarkably scarce in the Alpine world. In the Lowlands such fruits are greedily devoured by birds, which distribute the seeds to some distance from the parent plant, the fleshy pulp of the berry being an

adaptation to attract birds. In the Alps, however, while a certain number of berries are no doubt eaten by Black-Cock, Ptarmigan, Grouse, and other birds, such as the Snow-Finch, the Ring-Ouzle, and the Alpine Chough, the number of berries produced annually seems to be greater than the demands of bird-life require.

THE BILBERRIES.

Under this name we may group together the three Alpine species of *Vaccinium*, all of which are common British plants. This genus is a member of the Heath family (natural order Ericaceæ), though by some it is placed in a separate order, Vacciniaceæ. *Vaccinium myrtillus*, Linn., is the True Bilberry; *V. uliginosum*, Linn., is the Bog Vaccinium; and *V. vitis-idœa*, Linn., the Cowberry or Red Whortleberry (Plate XLII., Fig. 1). All three are often associated in the Alps.

Vaccinium myrtillus, Linn.

The True Bilberry (*V. myrtillus*) is distinguished from the other two species by the fact that the leaves are toothed, and the stem is triangular in section. The leaves are thin, and are shed each autumn. The berry is blue-black in colour.

The flowers are by no means conspicuous, and quite scentless. The corollas are pale, greenish-white in colour, globular in form, and nearly as broad as long.

The plant is a low, thick shrub, with long under-

ground runners, by whose aid it manages to cover large areas.

Vaccinium uliginosum, Linn.

The Bog Vaccinium has a round stem. The leaves are not toothed, but, like those of the True Bilberry, they are thin, and shed in the autumn. When young they have a bluish-green tinge, and are much veined. The berry is also blue-black in colour.

The bush of this species is taller and more upright than that of the other Bilberries. Otherwise the plants are very similar.

Vaccinium vitis-idœa, Linn.

The Cowberry (Plate XLII., Fig. 1) is easily distinguished from the other species by the red berry and the thick evergreen leaves, which are not toothed at the edges. The shrub has also numerous runners below the surface of the soil, from which fresh shoots spring.

The leaves are rolled at their edges, the under side being studded with glands, which appear to the naked eye as brown dots. The corolla is also shaped quite differently from that of either of the two other Bilberries.

Like the other Bilberries, *Vaccinium vitis-idœa* has its enemies. It is largely attacked by parasitic Fungi, which grow both in the leaves and in the berry, greatly to the detriment of the plant.

PLATE XLII.
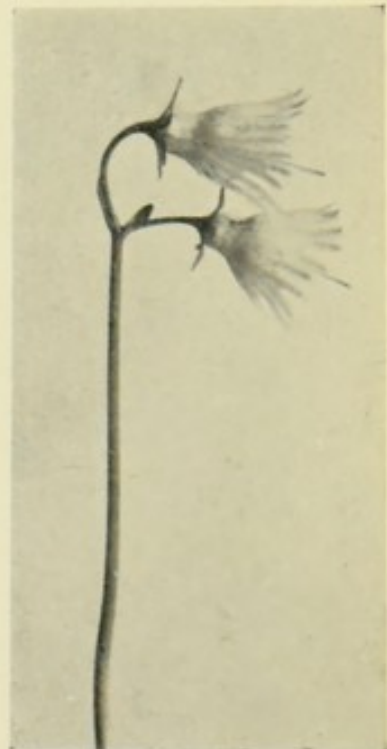
Fig. 1.—The Cowberry (*Vaccinium vitis-idæa*, Linn.).
Figs. 2, 3.—The Flowers of the Alpine Soldanella (*Soldanella alpina*, Linn.).
Fig. 4.—Two Flowers of the Blue Honeysuckle (*Lonicera cærulea*, Linn.).
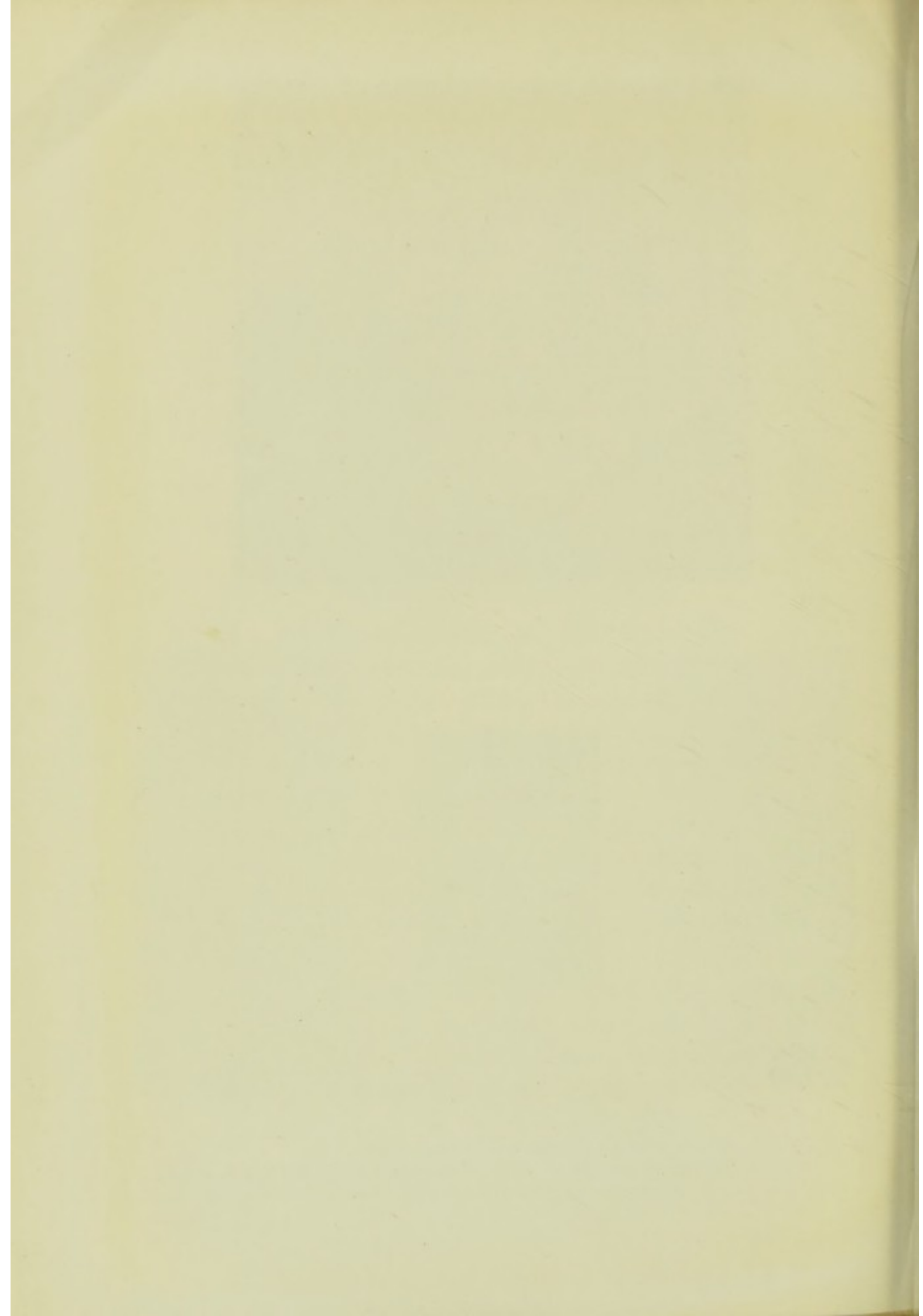
The stamens of the Bilberries, especially the True Bilberry and the Bog Vaccinium, are interesting, and should be examined with a pocket-lens (Text-fig. XXI.). Each stamen consists of a flattened stalk, bearing above and on its inner side two flagon-shaped structures, placed side by side. Each flagon is really a half-anther, and it opens at the top by a pore, through which the pollen escapes. From the stalk, continued up the back of the flagon, a little horn-like process projects from each half-anther. When a bee visits a flower in search of the nectar at the base of the stamens, it touches these horns with its proboscis, and thus shakes the anther, and is dusted with pollen thrown out through the pores at the top of the stamen. This pollen may be carried to another flower, in which the stigmas are ripe, and thus cross-fertilisation is effected.
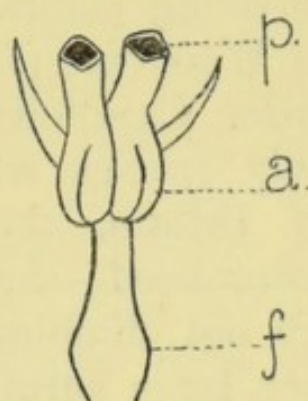
Fig. XXI.—Stamen of a Bilberry (*Vaccinium*).

p, pores at the apex of the anthers, through which the pollen is shed; *a*, anther; *f*, filament.

In the Red Whortleberry the half-anthers are not horned, but the tips of the flagons are produced into long spout-like structures, with a pore opening at the top of each. In this species the mouth of the corolla is not contracted—an adaptation to ensure that the insect strikes the horns of the stamens—but is widely open, and the spout-like tips of the stamens no doubt play a similar part to the horns, in conjunction with the contracted throat of the corolla found in

Vaccinium myrtillus and *V. uliginosum.* Horned anthers, though somewhat different in shape, are also found in *Arctostaphylos alpina,* another shrub, which we shall mention presently, belonging to the same family, Ericaceæ.

The Alpine Honeysuckles.

The Alpine Honeysuckles are exceedingly interesting plants. Unlike our English Honeysuckle, or Woodbine (*Lonicera periclymenum,* Linn.) (natural order Caprifoliaceæ, the Honeysuckle family)—the only species which is regarded as a true native of Britain, though two others commonly occur naturalised—the Honeysuckles of Alpine Switzerland are not climbing plants, but erect bushes—often, in fact, large shrubs. They are frequent in the dwarf thickets and on the margins of forests, and often extend considerably higher than the tree limit. They are commonly associated with the Alpenroses and Bilberries.

There are three species in the Alpine zone, which differ greatly as regards their flowers. These are not nearly so conspicuous as in our British Woodbine, where they are bunched together in heads, and thus gain in conspicuousness by massing. In the Alpine species the flowers are borne in pairs, arising in the axils of the leaves, by which they are partly hidden.

Lonicera nigra, Linn.

The Black Honeysuckle (*Lonicera nigra,* Linn.), so called from its black berry, bears two flowers, placed side by side on the end of a very long common flower-stalk, usually more than three or four times the length of the flowers. As in the other Alpine Honeysuckles, the flower arrangement is really in threes, one flower being central, and the other two lateral, on either side of the central flower. But in these plants only the lateral flowers are present, the central one being entirely suppressed. This type of flower arrangement, which may be well studied in the Ragged Robin or the Rock Catchfly (Plate XVI., Fig. 2), is termed by the botanist a simple cyme or dichasium.

In the typical cyme, each flower is subtended by a leaf or bract. In the Alpine Honeysuckles this bract may or may not be present, but two small leaflets occur, which are known as *bracteoles.* Thus the inflorescence here consists of the two lateral flowers of a cyme, each with a pair of bracteoles at the base.

The interesting point in regard to the flowers and fruits of the Black Honeysuckle, in comparison with the other species described below, is that the two ovaries of the flowers, and later the two berries, are slightly united for less than half their length at the base. The four bracteoles of the flowers are also united in pairs, and in the flowering stage sheathe the lower portions of the ovaries. The two berries, which

P

are quite distinct, although partly united in one plane, are longer than the bracteoles.

A similar state of affairs is found in the Lowland plant (*Lonicera xylosteum*, Linn.), which sometimes occurs in Britain.

Lonicera alpigena.

Let us now compare the flowers of the Mountain
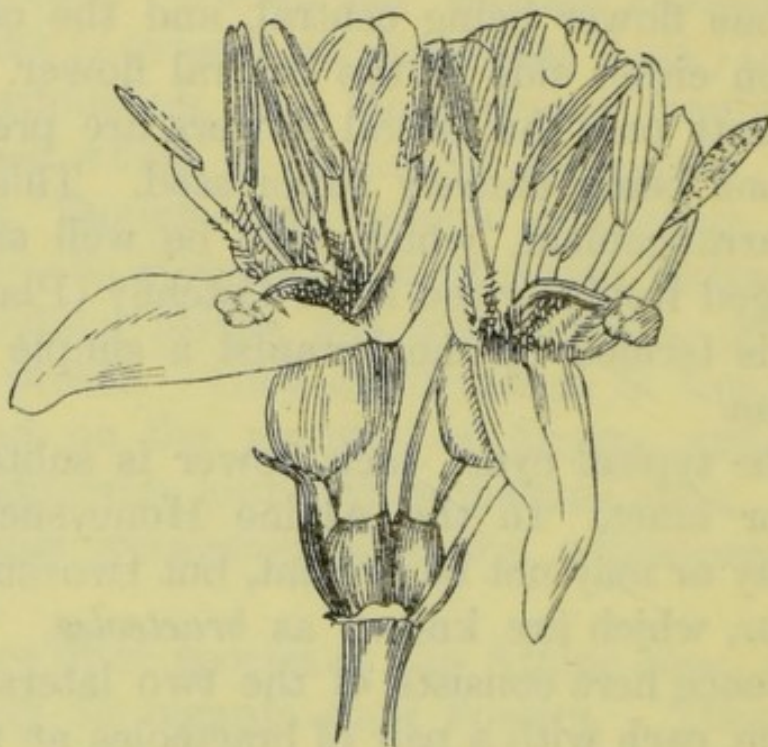
FIG. XXII.—Two Flowers of the Mountain Honeysuckle (*Lonicera alpigena*, Linn.), with Ovaries partially united. (After Hermann Müller.)

Honeysuckle (*Lonicera alpigena*, Linn.) (Text-fig. XXII.) The two flowers are here also mounted on long flower-stalks, but only a single berry results, which is red. If the ovaries of the flowers are examined, it will be found that they are completely united in the median plane. The result is a double

berry, formed by the fusion of the two ovaries; and as the fruit ripens and becomes globose, the distinction between the two ovaries, from which it originates, is gradually lost. The double berry, however, bears two scars near the apex, marking the position of the calyx of each flower (Text-fig. XXIII.). The bracteoles in this species are small and unimportant.

Curiously enough, while the formation of a double berry is constant wherever this plant is found in Switzerland, in India, where it also occurs, the berries are always free and not united.
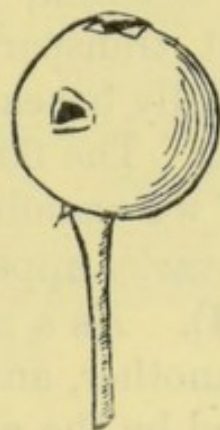
The fruit of the Mountain Honeysuckle forms an ex- cellent illustration of the botanical axiom, that the ex- planation of many features presented by flowers is to

Fig. XXIII.—The Fruit of the Mountain Honeysuckle (*Lonicera alpigena*, Linn.), formed by the complete union of the two berries.

The scars of the two calyx rings can still be seen.

be sought for in the fruit. The flower is merely a stage towards the fruit, and the fruit is only a con- trivance for the distribution of one or more seeds at a distance from the parent plant. In the case of the Mountain Honeysuckle, the idea appears to be, that if the seeds of two flowers are contained within a single berry, they will have a greater chance of being all distributed, should some bird devour the berry, than if two berries containing the same number of seeds were produced.

Lonicera cœrulea, Linn.

In the flowers of the third Alpine species, the Blue Honeysuckle (*Lonicera cœrulea*, Linn.), a very curious state of affairs is found, quite unlike that in *L. nigra* and *L. alpigena*. The leaves of this shrub are also very different, being delicate in texture, to some extent transparent, and of a bluish-green colour, especially beneath. The berry is black, with a bluish bloom. The flower-stalks are short.

If we examine the flowers, we shall find that the two ovaries appear to be entirely united (Plate XLII., Fig. 4). As a matter of fact, they are quite free from one another, and what we see externally is a sheath formed by the union of the bracteoles (p. 225), which, when the ovaries are mature, entirely enclose them, and are partly united to them.

As the fruit ripens, the growth of the bracteolar sheath keeps pace with the growth of the ovaries containing the seeds, and forms the fleshy substance and the skin of the single "false berry" which is not very dissimilar in appearance to that of the Mountain Honeysuckle. Here, however, it is the bracteolar sheath and not the ovary walls, which form the outer substance of the berry, and this assumes eventually a bluish-black hue. In the peculiar origin of the "false berry," the Blue Honeysuckle stands quite alone among the members of the genus.

A very striking feature of the Alpine flora is its extreme poverty in climbing plants, whereas our

British flora contains quite a fair percentage of species which climb by some means or other, while in the forests of the tropics the number is very much greater. We have already noticed that the climbing Honeysuckles do not occur in the Alps. In the Alpine zone there are also no Convolvuli, no Ivies, and no Traveller's Joy. Neither are any Vetches nor Peas, with modified climbing leaves or tendrils, indigenous to this zone. Of the hook-climbers — plants which scramble up over other plants by means of recurved hooks — certain species of Bramble (*Rubus*) and Bedstraw (*Galium*) are frequent in Alpine Switzerland, as in Britain. There remains only one other climbing plant, the *Atragene* or Alpine Clematis.

THE ATRAGENE OR ALPINE CLEMATIS.

The Alpine Clematis or Atragene (*Clematis alpina*, Miller, also known as *Atragene alpina*, Linn., natural order Ranunculaceæ, the Buttercup family) (Plate XLIII.) is a near relative of our British Traveller's Joy (*Clematis vitalba*, Linn.), which occurs also in Lowland Switzerland and ascends to nearly 3,000 feet. It is a woody plant, not infrequent in the Alpine thickets, climbing up over other plants, though not, perhaps, very common in the lower portion of the Alpine zone.

This genus is remarkable among the Buttercup family as being the only one which has opposite leaves. The Alpine Clematis climbs, not by means of tendrils, but with the aid of its long, sensitive leaf-stalks, which

twine round any support within their reach. The leaf-stalks are so sensitive, that mere contact with the support is sufficient to stimulate them to twine around it.

The flowers (Plate XLIII., Fig. 1) are large and handsome, and mounted singly on long stalks. Externally there are four long, lance-shaped sepals, deep blue in colour. These enclose four spade-shaped petals, much smaller in size, and whitish in colour. There are many stamens and carpels, as in most of the other members of the family.

The fruits (Plate XLIII., Fig. 2), enclosing each a single seed, have long feathery awns, quite comparable to those we have already described in the case of certain Anemones, the White Dryas, and the Avens. They are distributed by wind.

THE BEARBERRIES.

The Red Bearberry (*Arctostaphylos uva-ursi*, Sprengel) and the Alpine Bearberry (*A. alpina*, Sprengel (natural order Ericaceæ, the Heath family), both British plants, are common in Switzerland, on the hillsides, and in the neighbourhood of the Alpine thickets. They are low carpet plants, highly branched, each branch covered with leaves, which in the Red Bearberry are thick, leathery, entire, and evergreen, while in the Alpine Bearberry they are thin, toothed, and shed at the end of summer. A hillside covered with the Alpine Bearberry in autumn furnishes one of the most wonderful sights to be seen in the Alps,

PLATE XLIII.
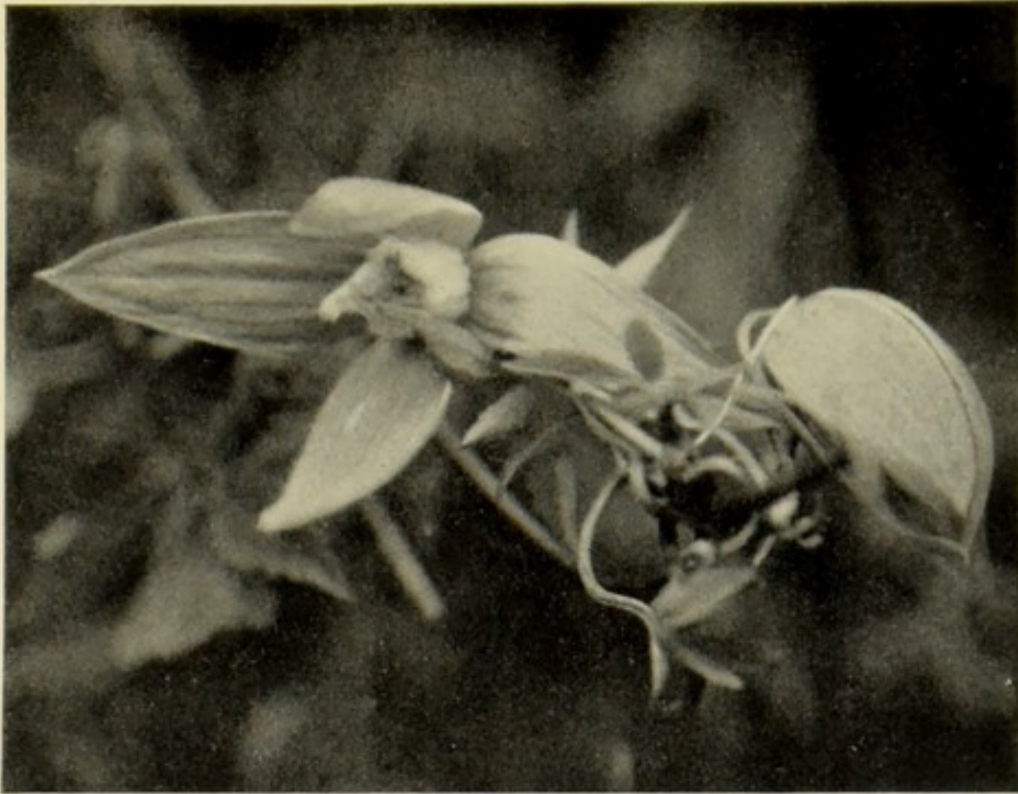
FIG. 1.—The Flowers.

FIG. 2.—The Fruits.

The Atragene (*Clematis alpina*, Miller).
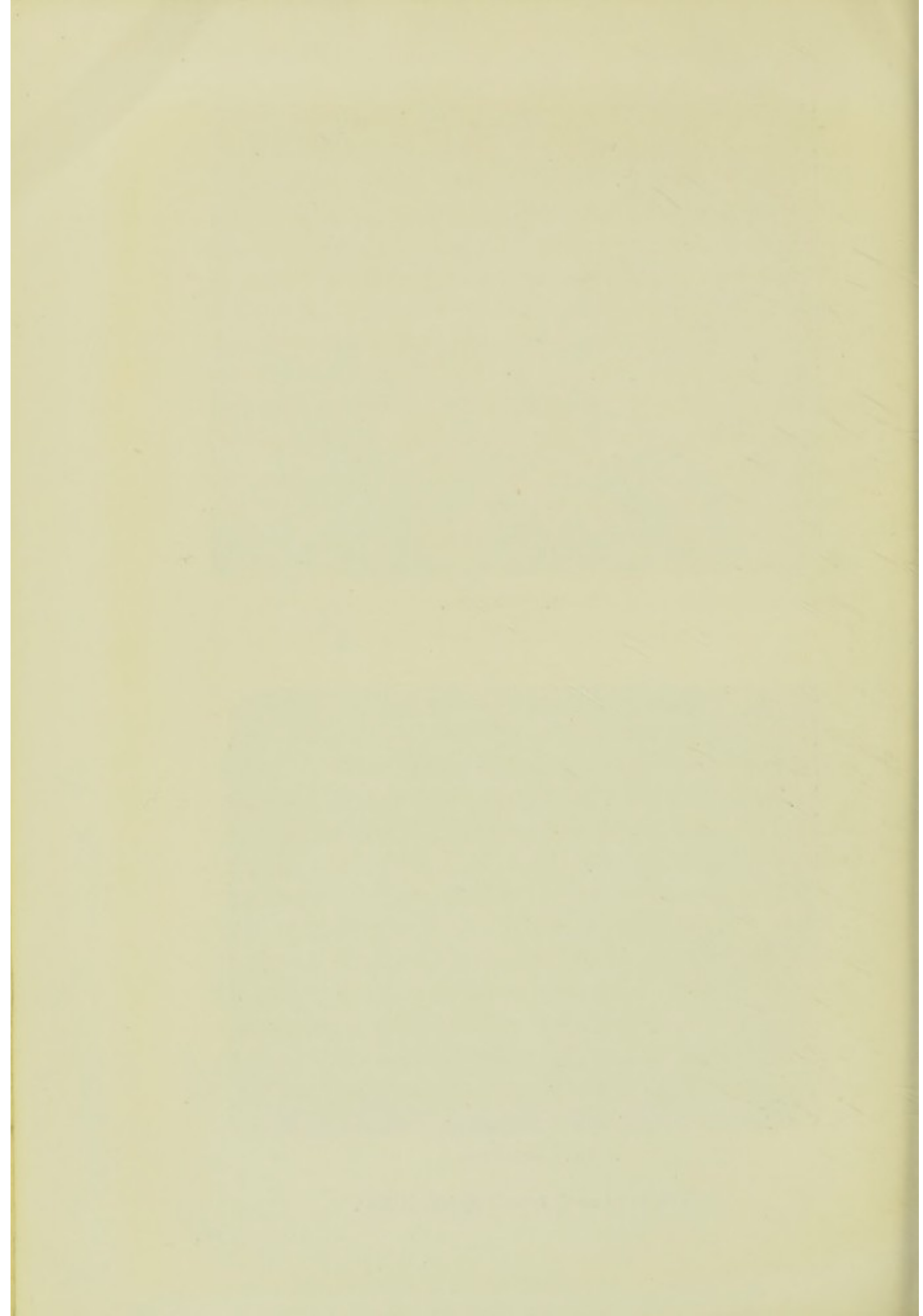
on account of the intense, ruby-red colour, which the leaves assume just before they are shed.

The flowers are fashioned quite like those of the Alpine Heath (*Erica carnea*). The stamens are horned, and the same mechanism to ensure cross-fertilisation exists as in the Vacciniums described on p. 223. The fruits are berry-like, but botanically of the type termed drupes, with one to five stones, as in the Crowberry, next to be described. Those of the Red Bearberry are red, while the Alpine Bearberry has black fruits.

The Crowberry.

The Crowberry (*Empetrum nigrum*, Linn., natural order Empetraceæ, the Crowberry family) is a low, spreading, heath-like shrub, rarely more than a foot in height, common in the dwarf thickets of the High Alpine regions, and often associated with the Trailing Azalea. There is only one species of this genus, which, however, is very widely distributed, occurring in Britain and Northern Europe, and even in the Andes of South America. The plants often reach a considerable age in the Alps, although the stem and the annual rings of growth are very small indeed.

The branches are closely set with leaves, which are needle-like in shape, and evergreen. The general form of the leaf resembles that of a Heath. The leaf is rolled, so that the edges meet below. The margins are interlocked with hairs, and thus enclose an oval cavity, lined by the lower surface of the leaf on which

the stomata and also glandular hairs are situated. This is another adaptation, similar to those to which attention has already been drawn, for reducing the risk of excessive loss of moisture from the leaf by means of the stomata, which are here protected by their position in the half-closed chamber formed by the rolling in of the leaf.

The flowers, which are very small and stalk-less, are often produced in great numbers near the tips of the twigs. As a rule, each plant is either male or female—that is, all the flowers on one plant belong to one sex. The pollen of the male flowers is carried to the stigmas of the female by the agency of the wind. In some cases, though rather rarely, the flowers are hermaphrodite—*i.e.*, they contain both male and female organs in the same flower.

The fruit is like a berry externally, but, in its structure, it more closely resembles that of a Cherry or a Peach, in that the inner portion is hard or stony. This type of fruit is distinguished botanically as a drupe. In the drupe of the Crowberry, there are from six to nine stones. The fruits are not eaten in Switzerland, but, in Scandinavia, the Laplanders and Finns make use of them. In Northern Europe these fruits grow naturally much larger and are more juicy than in the Alps, as is also the case with the fruits of several other Alpines which occur in Scandinavia.

THE DWARF JUNIPER.

The Dwarf Juniper (*Juniperus communis*, Linn., var. *nana*, Willd., class Coniferæ, natural order Cupressaceæ, the Cypress family), which is very frequent in the Alpine and High Alpine zones, is regarded as simply a variety of the Common Juniper. In habit it is a large carpet plant, the branches, densely clothed with leaves, being pressed close to the ground, so that the height of the plant is quite small. This form of habit is no doubt well calculated to withstand the great weight of the winter snow, which lies over the shrub for several months each year.

It is often abundant in or near Alpine thickets, and also grows commonly on rocks. In some respects it is an important coloniser of bare rocky places, like the plants discussed in Chapter IV. It is probably the highest woody plant occurring in Switzerland, having been recorded on Monte Rosa at an altitude of 11,700 feet. The fruit is a berry, and here again we have another example of an Alpine shrub with a succulent fruit.

THE GREEN ALDER.

The Green Alder (*Alnus viridis*, D. C., natural order Betulaceæ, the Birch family) is a common shrub in the thickets, bordering the mountain streams. It is interesting as being one of the few representatives in the Alpine zone of the tree

families, with deciduous leaves and catkin-like inflorescences, so characteristic of the Lowlands of Europe. Dwarf Willows, p. 187, also occur, especially in the High Alps.

The Green Alder has no very striking peculiarities. It resembles the Alders of the plains, except that it is rather dwarfed in stature.

THE CONIFEROUS FORESTS.

The Coniferous forests are a highly characteristic feature of the lower portion of the Alpine zone. They consist essentially of two trees: the Spruce and the Larch, the former, as a rule, prevailing. Thus, although it is customary to speak of the Pine forests of the Alpine region, this term is not strictly accurate in a botanical sense, since neither the Spruce nor the Larch are true Pines. They are indeed very closely related to them—so closely, that whether we call the forests Coniferous or Pine is a small matter, if we bear in mind that the only true Pines found in Alpine Switzerland, the Stone or Arolla Pine, and the Mountain Pine, are not nowadays forest formers in the Swiss Alps.

The race of plants, the Coniferæ, to which the Larch, Spruce, Pines, Firs, and Junipers belong, is quite distinct from that to which all the other Alpines discussed in this volume are assigned— namely, the Flowering Plants, or Angiosperms. These two races differ greatly, not only in their general structure, and in their life histories; but it

is impossible, without entering on a lengthy and technical botanical discussion, to indicate precisely in what these differences consist. It may suffice to say that the Conifers do not bear flowers. The organs which produce the pollen and the ovules, which when fertilised become seeds, are borne on special, complicated fertile shoots known as cones. These produce either pollen or ovules, but never both, and are thus spoken of as male or female cones. Both types may occur on the same or on different trees, according to the genus. All the Coniferæ are wind fertilised.

At a height of about 5,000 feet (which we here regard as the lower limit of the Alpine zone), the Beech, so characteristic of the Subalpine region, is, as a rule, entirely replaced by the Spruce and Larch. Forests in which these trees figure largely are of course common also in the Lowland and Subalpine zones, but they are there associated with other trees, not found in Alpine habitats.

The Coniferous forests extend upwards to a height which depends on a great variety of circumstances. Often the upward limit is as low as 6,000 feet, but in the Zermatt region it is as high as 7,600 feet. No general rule can be laid down, for the upper frontier depends on various local conditions such as the height of the floors of the neighbouring Alpine valleys, the nearness or remoteness of the snow-line, and the situation, or aspect of the particular district.

The best way to view the vertical distribution of

the Pine forests is in relation to the altitude of the floors of the Alpine valleys on the one hand, and the snow-line on the other. The upper limit of the forests, which is as a rule very sharply defined, bears a definite relation to both. In the case of a wooded Alpine valley, the following sequence can generally be determined :—

Region of Perpetual Snow.

Higher Pastures.

Forests.

Alpine Meadows.
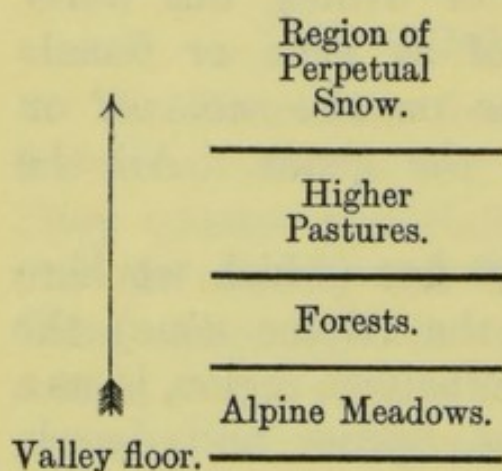
Valley floor.

Immediately above the valley floor and the Alpine meadows the forests rise, clothing the valley - sides for 1,000 or 1,500 feet. The gap between the upper frontiers of the forest and the snow-line is filled by the treeless higher pastures, extending upwards for some 2,000 to 2,600 feet.

It has already been explained (p. 170) that the height of the snow-line varies in different parts of the Alps. The upper limit of the forests, for the most part, varies in height according to the position of the snow-line in that particular district, and keeps at a respectful distance of 2,000 feet or more from it.

Further, just as the mean level of the floors of the Alpine valleys varies in elevation, so the vertical distribution of the Larches and Spruces which clothe their sides changes. Probably exposure to wind is one of the great factors that determines the upward limit of the forests. So long as they are in some measure protected by the "brow of the hill," the trees can flourish.

Of course, many desolate, treeless valleys are to be found in the Alps. Here the forests have either been entirely destroyed by human agency, or there may be some other special reason, such as a particularly sunless aspect or configuration, or the fact that in winter the valley is the track of frequent avalanches, or that the soil is barren or absent.

Forests were at one time very much more extensive in Switzerland, as a whole, than they are to-day. How greatly they have been destroyed can be appreciated by a study of some of the older Swiss maps. Many localities, which are there indicated as thickly forested, are almost treeless to-day, or perhaps only a group of Spruces or Larches survives. The same is also the case in England, which in the Middle Ages was a highly wooded country.

In 1862, according to official estimates, quoted by Dr Christ, the forest area comprised only 15·4 per cent. of the whole of Switzerland. It was estimated that the country consisted of :—

Barren land	31·6 per cent.
(including snowfields, glaciers, etc.)	
Pastures	33·0 ,,
Arable land	20·0 ,,
Forest	15·4 ,,
	100·0 ,,

The percentage of forested land in Switzerland was then less than half that met with in the Jura. No doubt at the present day the percentage is still smaller.

The great enemy of the forest has been man. Before the introduction of State legislation, and the institution of forestry police in 1876, the Switzer had for centuries cut down the trees ruthlessly, sometimes even wholesale, without any thought for the morrow. The wood was chiefly required for fuel, though it was also much made use of in building. Sometimes a commune sold a whole forest for a tithe of its value to speculators, who promptly cleared the ground. In other cases, wholesale destruction was undertaken in order to increase the acreage of the pastures or meadows.

Nowadays, happily, a better condition of affairs prevails. The forests are protected by stringent laws and regulations with regard to cutting, thinning, and replanting. In many situations, exposed to avalanches in winter, all interference with the forests is forbidden. But the damage has been done.

Great as has been the destruction wrought by man, he is not responsible for the whole. Every year, especially in winter-time, hundreds, perhaps thousands, of noble trees perish beneath avalanches, Alpine storms, or lightning. In addition, the goats and cattle are a constant menace to the seedling plants, the former being particularly partial to their young shoots. Again, these trees have other enemies. They are liable to be attacked by certain specific diseases, either of insect origin, or caused by parasitic fungi, such as the Larch disease, which in recent years has destroyed many a fine giant in Switzerland.
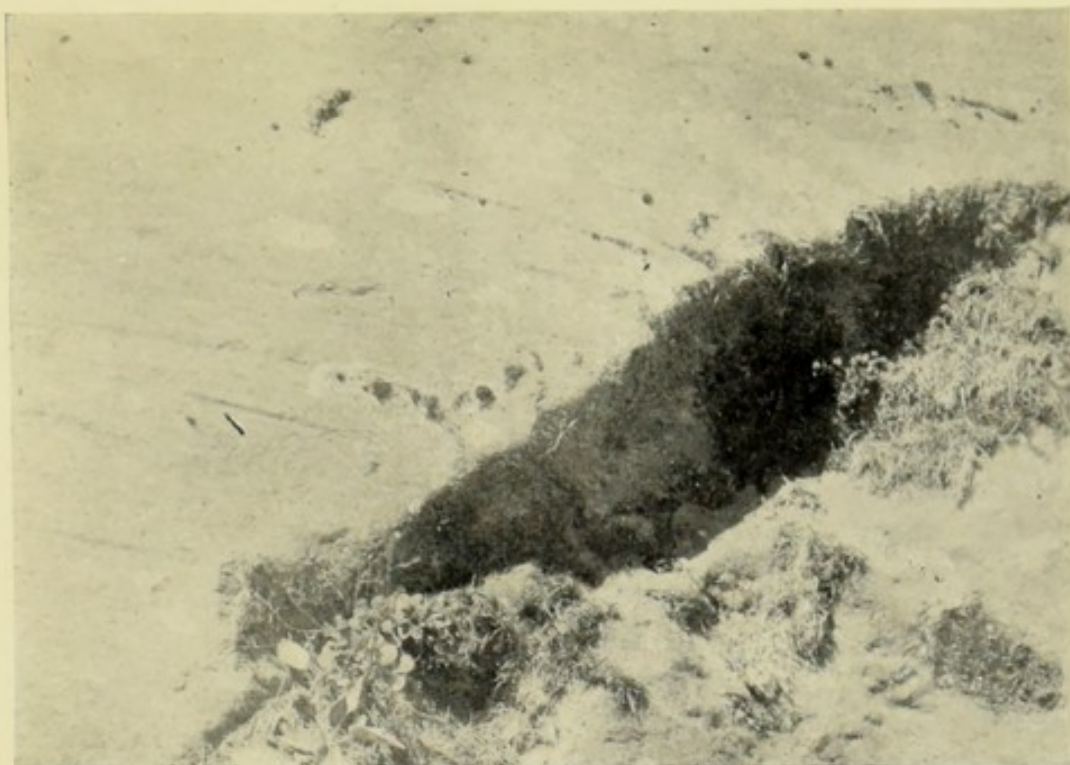
PLATE XLIV.

FIG. 1.—Rock Colonisation : A Bare Slab of Rock in a Forest showing a
Primitive Soil composed of Pine-needles.

FIG. 2.—The Lichen (*Usnea*) growing on the Branches of a Coniferous Tree.
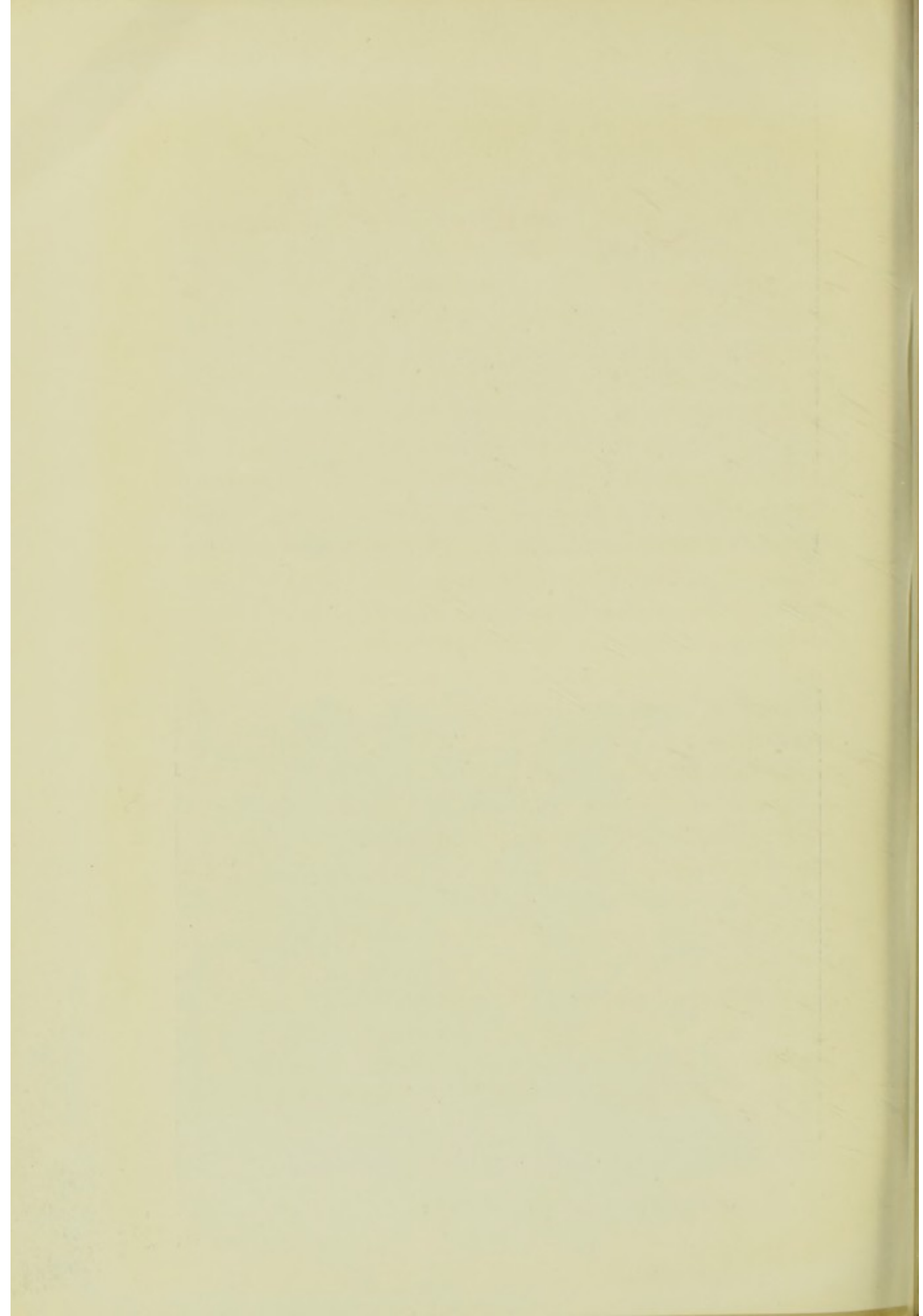
On the other hand, the Lichen (*Usnea barbata*) (Plate XLIV., Fig. 2), known as the Old Man's Beard Lichen, so frequently seen depending from the boughs, especially the dead branches of the Spruce or Larch, to which it is attached, is not, despite statements to the contrary, known to be directly harmful to the tree.

It has been well said that "the Pine forests play a most important part in the natural economy of the Alps, and their preservation is a matter of vital consequence to the future inhabitants." What follows when a country has been deprived of its forests is well seen in certain districts in India and Ceylon. The nature of the climate has been changed, and has become drier and hotter than formerly. A forested country tends to produce a more humid atmosphere than a treeless district, and, in Switzerland, the atmosphere is probably drier to-day than it was a hundred years ago. Again, to a greater degree than is usually realised, the forests afford the only efficient safeguard which prevents the valleys and lower pastures being overwhelmed with avalanches in winter and floods in summer. Often the former fail to melt completely for several summers after their fall, and the ruin of the Alpine meadows and pastures is rendered still more complete by the confusion of rocky debris which they bring down in their train.

We will now discuss the trees forming the Alpine forests.

THE SPRUCE.

The Spruce, Spruce Fir, or Norway Spruce (*Picea excelsa*, Link.) (= *Pinus picea*, Dur. = *Abies excelsa*, Poir.), like the Larch, is a familiar tree in Britain, where it has been much planted and become naturalised, though not originally a native. Young Spruces with us, as in Germany, are universally used as Christmas trees. The Spruce is easily distinguished from the Pines by the fact that the leaves are borne singly on the branches and spirally arranged, and not in groups of two or more on very short shoots. The female cone terminates the shoot formed during the previous year. It is first erect, but later becomes pendulent, when the seeds, which may number over 300, drop out and are distributed by the wind, aided by the wing-like expansion of the seed.

As the specific name "excelsa" implies, it is one of the loftiest trees found in Europe. Some specimens are said to reach 150 to 180 feet in height. In the Alps the average height is considerably less, and the Spruce is usually overtopped by the Larch. Immense forests of Spruce occur also in Scandinavia and Northern Russia.

The Spruce is an extremely useful tree. It yields a resin from which turpentine is extracted, and it is also largely used as timber in the construction of the chalets so characteristic of the pastures. The deep, reddish-brown colour of the old Alpine chalets is caused by changes in the resinous substances of the

wood, brought about by long exposure to the intense light and heat of the Alpine summers. It may be of interest to note in this connection that amber is simply the fossil resin of a species of Pine, *Pinus succinifera*, long since extinct. Specimens of the wood of this tree are known, containing pieces of amber, or fossil resin, in the resin-forming tissues, which are quite similar to those of living Conifers.

THE LARCH.

The Larch, *Larix europæa*, D. C. (= *Abies larix*, Poir.), is easily distinguished from the Pines and the Spruce and from all European evergreen Coniferæ, by the fact that the leaves are shed each autumn. These, like those of the Pines, and unlike the Spruce, are borne on short branches. They occur in clusters of fifteen to thirty. They are long, fine, soft, and needle-shaped. The cones formed in early spring are small, erect, and brightly coloured. They ripen during a single year, whereas those of the Pines require two or more years before the seeds mature. The male cones terminate short, leafless shoots, and the female, short, leafy branches.

The Larch rarely forms pure forests in the Alps. As a rule, it is mixed with the Spruce. The distribution of these trees is best estimated in winter-time, when the light brown of the leafless Larches is sharply contrasted with the dark green of the evergreen Spruces. Pure woods of Larch do, however, occur

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exceptionally in certain localities, as in the Zermatt and Saas Valleys.   At one time it was thought that the Larch altogether avoided limestone soils, but it is now known that this is not the case.   The Larch, like the Spruce and Pines, yields resin and turpentine, and the bark is sometimes used in tanning.

THE STONE OR AROLLA PINE.

The Stone Pine, or Arolla Pine as it is sometimes called in Switzerland, *Pinus cembra*, Linn. (Plate III.), is a very handsome tree, easily distinguished from all the other Alpine Conifers, by the fact that the leaves are arranged in little bundles of five, on very short shoots, and by the absence of any wing to the seed. It is a tall tree, sometimes reaching a height of 70 feet.

There is reason to believe that extensive forests of Stone Pines once existed in Switzerland, but most of these have long ago perished beneath the woodman's axe.   At the present day the Stone Pine is distinctly uncommon, and, as a rule, only isolated examples or small groups are met with at infrequent intervals. It is perhaps the rarest as well as the most handsome of Alpine Conifers.   Dr Christ states that forests of these Pines, much gnarled and twisted, occur on the slopes of the Kleine Scheidegg (on the Grindelwald side) and elsewhere in the Bernese Oberland.   Some of the finest examples are found in the Valaisian valleys on the south side of the Rhone valley, especi-

ally at Arolla and on the Riffelalp. Some grand trees of this species also occur on the Engstlen Alp (Canton Berne). A fine forest of Arolla Pine mixed with Larch is traversed by the path to Fuorcla Surlej from Silvaplana in the Engadine.

The Stone Pine produces large cones. The seeds are nearly as big as a hazel-nut and are edible.

The Mountain Pine.

The Mountain Pine (*Pinus montana*, Mill.), is nearly related to the Scotch Fir (*P. sylvestris*) from which it is usually to be distinguished by the dwarf habit alone. The leaves are borne in pairs on short shoots, and the seeds are small and winged, but the cones are stalkless, or nearly so, whereas those of the Scotch Fir are stalked.

In the Pyrenees, the Mountain Pine forms extensive forests, but this is rarely, if ever, the case in Switzerland, though considerable masses of this tree may occur exceptionally.

In one respect the Mountain Pine is one of the most extraordinary plants to be found in the Alps. The habit varies from that of an erect tree, 30 feet high, to that of a low straggling shrub, 7 feet or less in height. The largest trees, with stout, erect, and straight trunks and smaller lateral branches, are apt to be mistaken for those of other species. Some of the best examples of this type occur in Canton Grisons, especially at Wolfgang (the pass traversed

by the railway between Klosters and Davos), near Lenzer Heide, and at the Maloja Pass around the Chateau Belvédère. In the Valais also, between Almagell and Saas Fee, good examples of the erect tree form can be seen.

As a rule, however, the specimens of this tree met with are dwarfs or semi-dwarfs. Either the lateral branches, at some little distance from the base of the trunk, grow more vigorously than the main stem, or these branches arise just above the level of the soil, and are quite prostrate on the ground, only the smaller leafy shoots being erect. Thus a bush habit, in certain respects not unlike that of the Alpenroses or the Bilberries, is attained. In addition, all sorts of minor variations may be observed. Sometimes the bush is fairly symmetrical, at others it is extremely unsymmetrical, the plant being one-sided and growing more or less in a straight line along the ground, or down a steeply sloping bank. Curiously enough, the cones are almost as variable in shape and symmetry as the stems.

The Mountain Pine is of quite common occurrence, especially above the limit of the Spruce and Larch forests. Usually the dwarf bushes grow singly or in small clumps, though here and there they may form little miniature forests, inviting comparison with the Coniferous woods at lower elevations.

The Scotch Pine.

The Scotch Pine or Fir (*Pinus sylvestris*, Linn.), so familiar to us in Britain, is rarely found above 5,000 feet in the Alps, though it is common enough in the Lowlands and the Subalpine zone. The same is true of the Silver Fir (*Abies pectinata*, D. C.) (= *Pinus picea*, Linn.), which is a characteristic Subalpine tree, only rarely occurring in the Alpine zone.

CHAPTER X

THE SHADE PLANTS OF THE ALPINE FORESTS

In the present chapter we will discuss some of the commoner and more interesting plants, chiefly herbaceous, which thrive for the most part only in the shade of the Alpine forests and thickets. The physical conditions which prevail in such habitats are markedly different from those of the open pastures. In the first place, the intensity of the illumination is much less. Here and there direct sunlight may penetrate in fine weather, but as a rule only very diffuse light prevails. Again, the soil is generally rich in humus or vegetable debris, derived from the thick carpet of discarded leaves of the Spruce or Larch which covers the forest floor. Many plants avoid soils rich in humus, while others are very partial to them. Another difference is found in the fact that the shade plants are, to some extent, protected from the weather, especially the wind. Their roots also probably receive less moisture than if they grew on the open Alp.

Of all the characteristic conditions under which

such plants live, the diffuse nature of the illumination has probably the most powerful influence, not only on the external form, but on the internal structure of the plant (see p. 202). The dependence of the green plant on light, for the maintenance of assimilation through the agency of the chlorophyll, or green pigment of the leaves, etc., has been already explained (p. 10).

This being so, we should naturally look to the leaves of shade plants for some indication of the conditions under which they grow. In many cases, but not by any means all, it will be found that the leaves of shade plants are larger, broader, and thinner, and at the same time more intensely green than those of plants thriving fully exposed to the sun. They are often hairless or only slightly hairy, but no rule can be laid down as to the presence, or absence, of hairs on the leaves of shade plants. Some, while hairless on the upper surface, are covered with a thick hairy felt on the lower. The leaves of the Lily of the Valley, the May Lily (Plate XLVII., Fig. 2), and the Two-flowered Violet (Plate XLVI., Fig. 2) are quite typical of a shady habitat. We also find in a number of cases, that where the shoots bear many scattered leaves, the successive leaves are separated by fairly long internodes, as in Solomon's Seal.

If we examine closely any large Spruce forest, the influence of sunlight can be readily seen. Where the trees are dense and their branches interlace overhead, the carpet of "needle" leaves will be found to

be almost entirely bare of herbaceous undergrowth, the absence of which seems only to intensify the prevailing gloom, through which no direct sunlight ever penetrates. But here and there the trees are more scattered, or some monarch Larch or Spruce has fallen. A fair amount of sunlight reaches such spots on sunny days, and a more vigorous undergrowth will be observed, though the vegetation is still distinctly sparse. In the less dense portions of the forest, where several trees have fallen, either from natural causes or beneath the axe, the glade will be found thronged with plants all vigorously competing for the available sunlight.

A flowery glade in a Larch forest presents a pleasing contrast to the condition of affairs met with in the denser Spruce woods. However, the undergrowth of a typical Swiss forest is never really luxuriant, nor can it compare with the dense vegetation beneath the giants of a tropical forest, where the intensity of the illumination is relatively greater, and the air more highly charged with moisture.

We will now discuss some characteristic species of the forest shade.

The Linnæa.

Probably there is no more dainty or delicate plant to be found in the whole of the Alps than the slender Linnæa of the Pine forests (Plate XLV.). *Linnæa borealis*, Gronov. (natural order Caprifoliaceæ, the Honeysuckle family), is the name plant of the great

PLATE XLV.
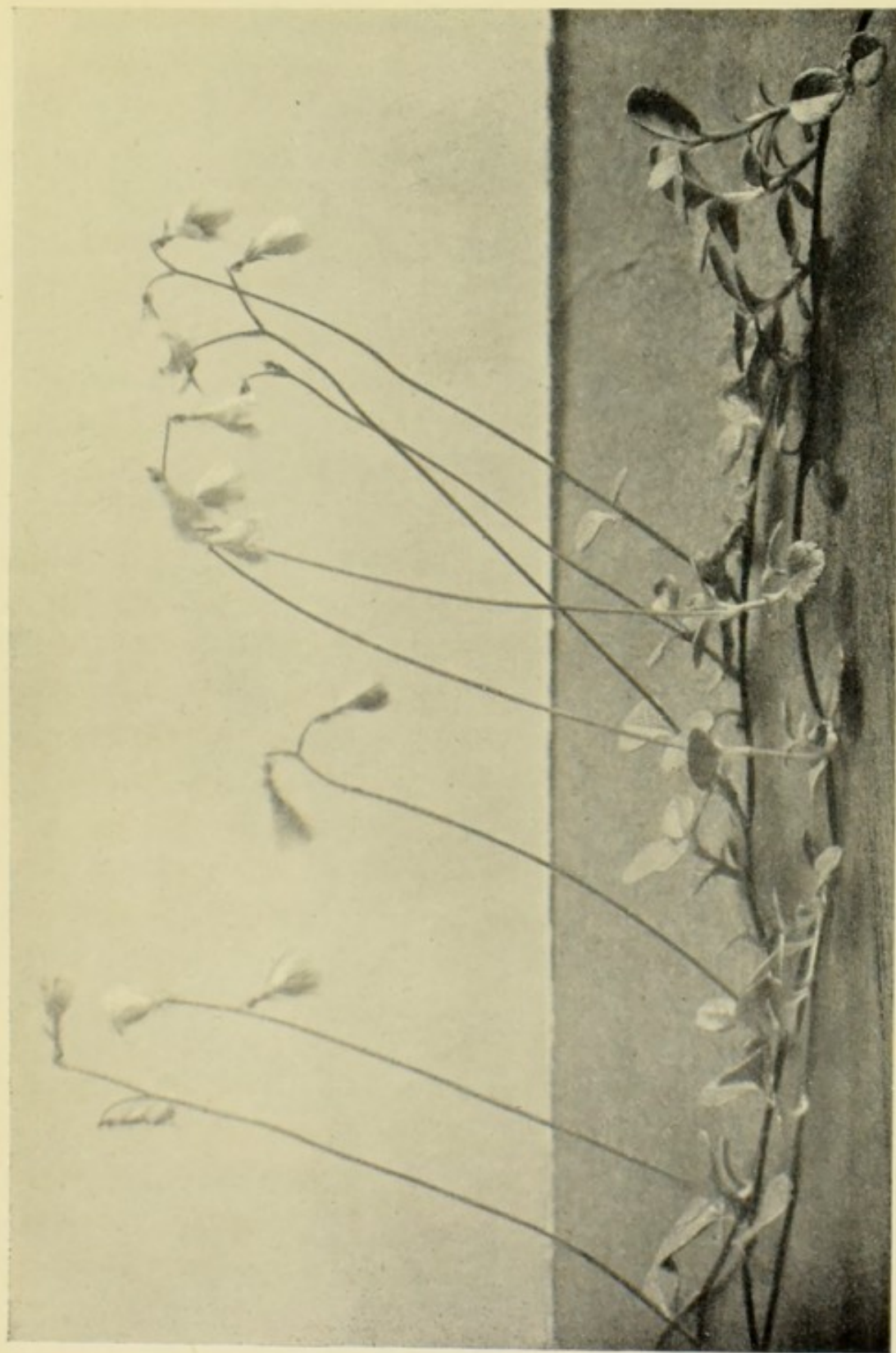
The Linnæa (*Linnæa borealis*, Gronov.).
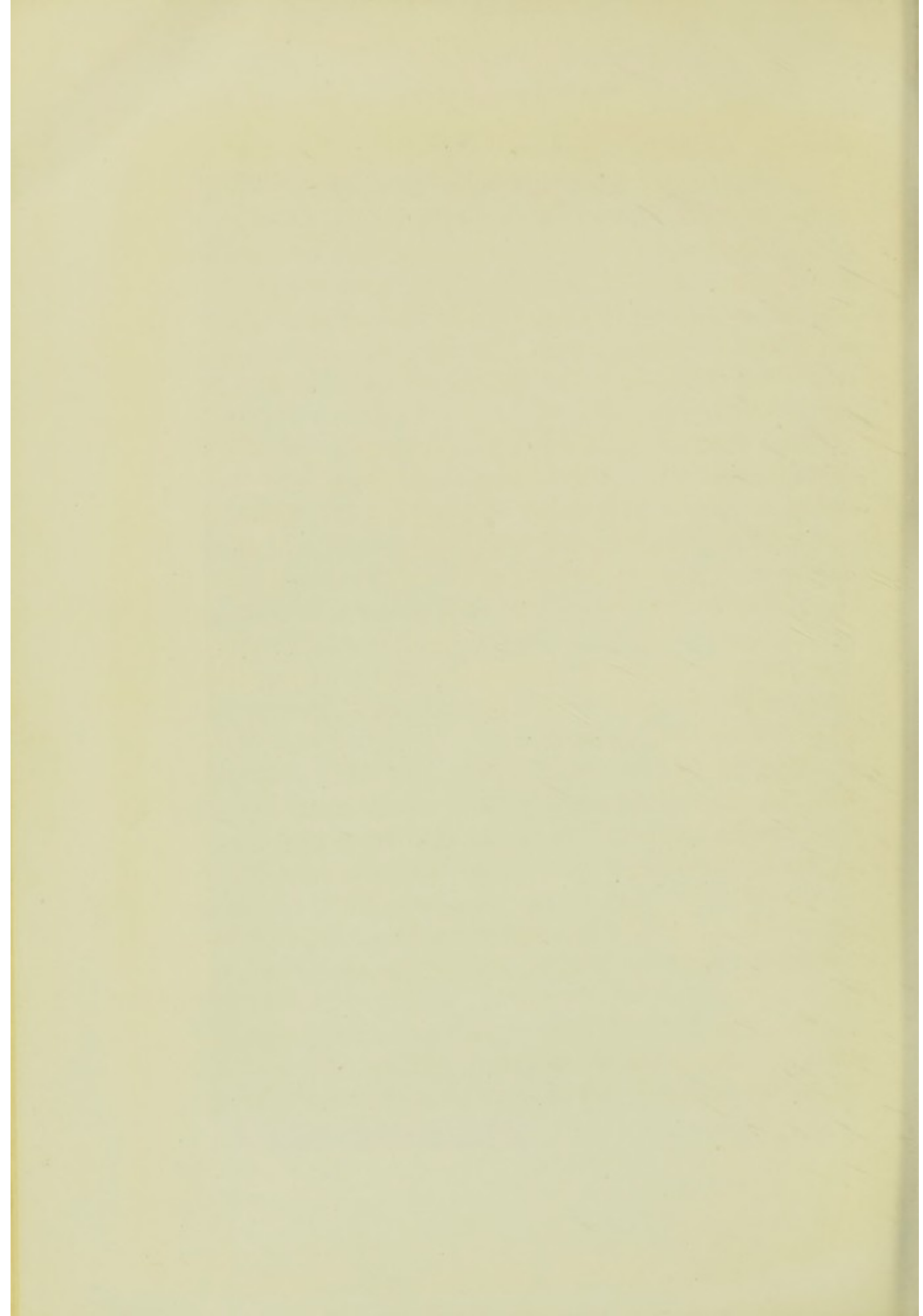
Swedish naturalist, Linnæus (1707-1778), the Father of Botany. Linnæus invented the system, now universally adopted, of giving two Latin names to each animal and plant, the one generic and the other specific, in order to distinguish them from one another. He also laid the foundations of the present system of classification of both animals and plants, and thus practically called the sciences of Botany and Zoology into being.

The Linnæa, which is a common plant in Scandinavia, was well known to Linnæus, with whom it was a particular favourite. He specially selected this plant to bear his name, and although the term *Linnæa borealis* was first recorded by Gronovius by the wish and consent of Linnæus, it was the latter who first pointed out its true affinities. A spray of *Linnæa* will be found engraved on nearly all portraits of the great northern naturalist, and he himself adopted it as his crest.

There is only a single species of this plant in existence, but it is very widely distributed. It is abundant in Scandinavia and the Arctic regions. It is found throughout the whole Alpine chain of Central Europe, and also in the mountains of Asia and North America. It even occurs in a few localities in England and Scotland, as one of our rarer British plants.

The Linnæa is a little creeping or trailing shrubby plant, a foot or more in length (Plate XLV.). It frequently grows on flat-topped rocks, and is fond of

soils rich in humus. The leaves are rather small, and broadly egg-shaped. They are arranged in opposite pairs, and are evergreen. Here and there, the stems send up erect flowering branches, each of which has two or three pairs of leaves, and terminates in a long flower-stalk branching into two at the top. From each fork, a single, graceful, white or pale pink flower droops. The sepals and petals of the calyx and corolla are five in number, but there are only four stamens. The flowers have a faint vanilla-like scent, which is said to be more powerful by night than by day. The Laplanders make a decoction of the flowers, which they use as a remedy for certain complaints, such as rheumatism.

In some cases the lower portion of the plant is almost hairless, in others it is distinctly hairy. The calyx and the flower-stalks, however, are nearly always covered with sticky bristles, which can be readily seen under a hand-lens. They probably serve as a protection against unbidden guests in the shape of crawling insects, which otherwise might creep up from below, and rob the flower of its pollen. Such insects would only very rarely visit another flower, and thus could be of no use to the plant as cross-pollinators. The drooping position of the flower is an additional protection against the visits of all but flying insects, which alone can be of service to the plant.

The sticky hairs on the lower portion of the flowers also help in the distribution of the fruits.

The ovary in the fruit becomes a nut, and remains enclosed in the two little leaves on the flower-stalk, just below the flower, which at this stage increase greatly in size. They are covered with glandular hairs, which catch in the furry coat of any passing animal, and thus the fruits are distributed to a distance from the parent plant.

THE BOX-LEAVED POLYGALA.

We are all familiar with our little Common Milkwort (*Polygala vulgaris*, Linn., natural order Polygaleæ, the Milkwort family), which, with other Alpine species, is frequent also in Switzerland. But in the Alpine woods and forests we often find another species, the Box-leaved Polygala (*Polygala chamæbuxus*, Linn.) (Plate XLVI., Fig. 1), forming little carpet-like patches on the rocks. The whole habit or build of this plant is quite unlike that of the Common Milkwort. It is a low creeping shrub, with leathery evergreen leaves, like those of the Box (*Buxus*), and quite unlike the typical shade-leaves of most Alpine forest plants. There is a good reason for this difference. The fact is that the Box-leaved Polygala is an immigrant from the Mediterranean flora, like the Alpine Heath (*Erica carnea*, Linn.) and *Biscutella lævigata*, Linn., among other southern plants which have successfully invaded the Alps. It has retained several of the characteristic features of the subtropical flora of Southern Europe, such as, for instance, the evergreen leaves and the shrubby habit.

The flowers are produced quite early in spring, in April or May. They have even been recorded in bloom on Christmas Eve at altitudes of over 5,000 feet.

The flowers bear a curious resemblance to those of a member of the Pea family (Leguminosæ), but as a matter of fact, they are constructed quite differently. This will be seen by anyone who takes the trouble to compare a flower of the Kidney Vetch (*Anthyllis vulneraria*, Linn.), or of the Bird's-foot Trefoil (*Lotus corniculatus*, Linn.), usually to be obtained not far away, with that of this Polygala. The structure of the typical Leguminous flower will be found described in Appendix II. Here the conspicuous organs are formed entirely by the petals, the upper petal being the "*standard*," the two side petals the "*wings*," and the two lower petals uniting to form the "*keel*." The calyx remains small and green.

In the Box-leaved Polygala, on the other hand, two of the *sepals* at the sides of the flower are much enlarged, and are bright yellow in colour, spreading or bending outwards to form the *wings*. Hence in this plant the showy portion of the yellow or rose-coloured flowers, borne singly or in pairs in the axils of the leaves, is formed partly by the calyx, and partly by the corolla.

Now we turn to the *petals* of the Polygala. As a rule, there are only three, two being absent altogether or rudimentary. The lower petal, however, is very large, and is shaped quite like the boat-

PLATE XLVI.

Fig. 1.—The Box-leaved Polygala (*Polygala chamæbuxus*, Linn.).
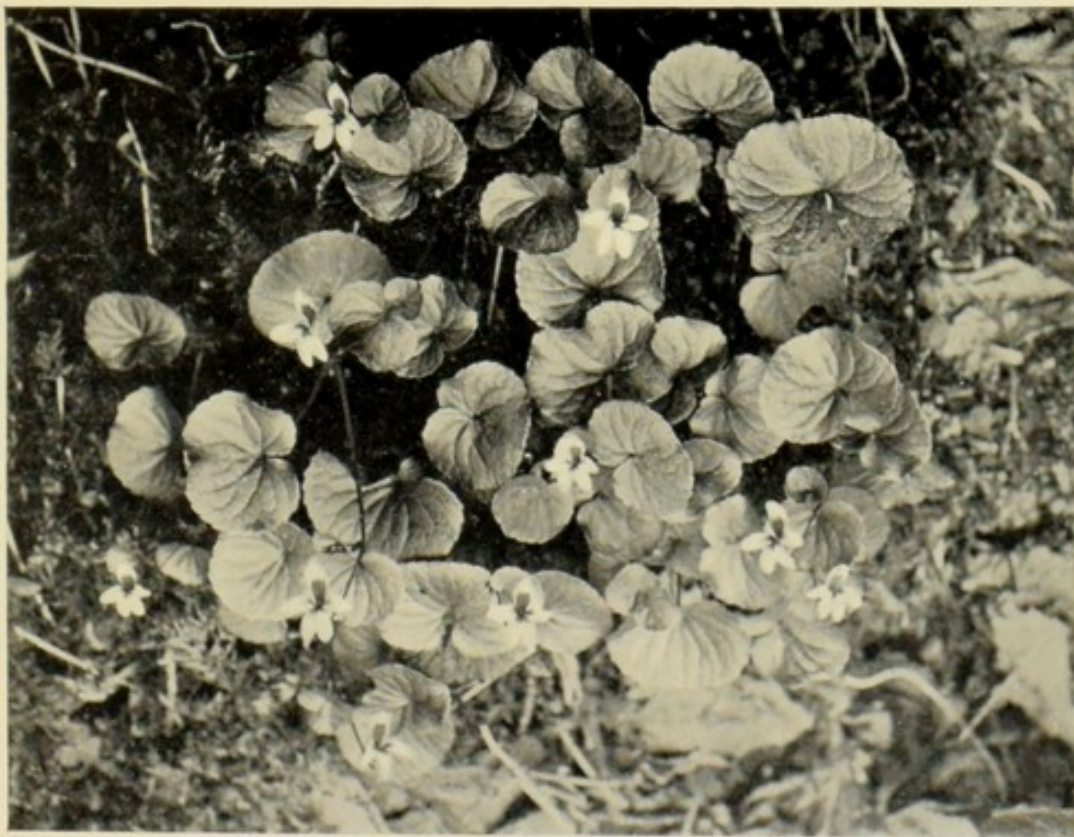
Fig. 2.—The Two-flowered Violet (*Viola biflora*, Linn.).
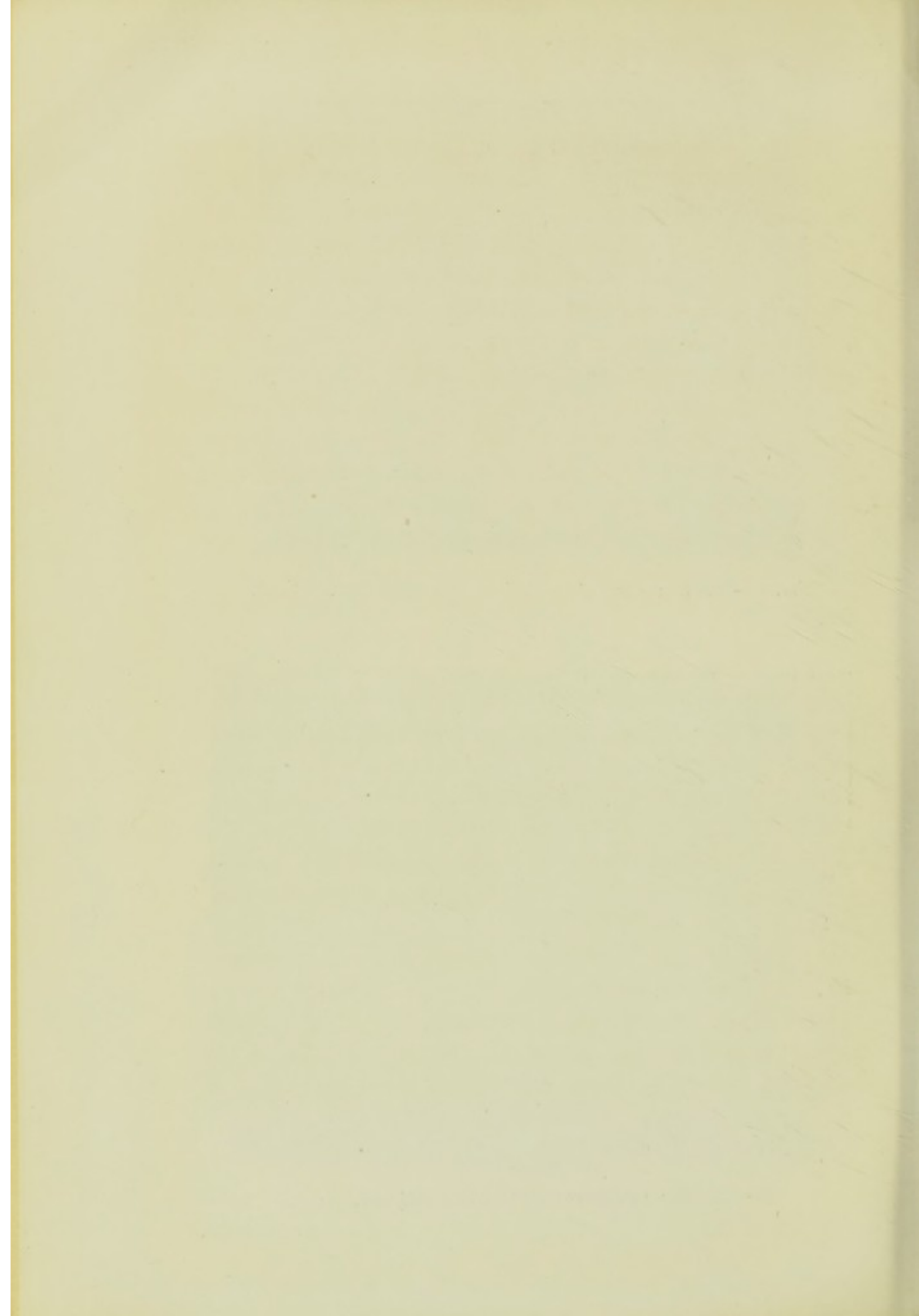
shaped *keel* of the Leguminous flower, while the two upper petals form a sort of *standard*. There are only eight stamens, all united into a bent tube, split on one side. In this, again, we find a curious resemblance to the Pea family, where, however, there are ten stamens. The anthers open by pores. The style lies inside the tube of stamens, and is likewise bent in conformity with the shape of the *keel*.

The explanation of the curious parallelism between the shape of the flower of this Polygala and that of a Leguminous plant is to be sought for in the mode of pollination. The whole structure of the flower is adapted to that end, and though it differs in some details, the manner of fertilisation is quite similar to that of a typical member of the Pea family (see p. 328).

The Box-leaved Polygala has the distinction of being the sole member of the genus, in which the stem is woody, all the other species being herbaceous.

THE TWO-FLOWERED VIOLET.

One of the most delicate and graceful plants of the Alpine forests is the little Yellow-flowered Violet (*Viola biflora*, Linn., natural order Violaceæ, the Violet family) (Plate XLVI., Fig. 2). This plant loves the damp, shady dells among the Pines, where it forms characteristic clumps. The slender shoots bear usually two large, kidney-shaped leaves, quite typical examples of shade-leaves (p. 247). They are thin and delicate structures, light-green below, but

much darker in colour above. The veins are very prominent.

Despite the specific name, "*biflora*," each shoot usually bears only a single flower, and not two, in the Alps. The flowers are the smallest of any Swiss Violet. They are bright yellow in colour, streaked with brown. The plant attracts flies, which abound in the forests, and is cross-pollinated by their agency. The mechanism for ensuring cross-fertilisation is much the same as in the case of the Field Pansy, described on p. 161.

The flowers of this Violet probably correspond more closely to the ancestral form, than those of any other Swiss member of the genus. In the Field Pansy (*Viola tricolor*, Linn.), the colour has become wholly or partly changed from yellow to blue, and the size of the flower has been greatly increased in order to make them acceptable to humble-bees and butterflies. In the case of the Long-spurred Violet (*Viola calcarata*, Linn.) (p. 128), the flowers have specialised for butterflies exclusively. To this end, the colour has become "fixed" to a pale blue, the size of the flower still further enlarged, and the spur enormously lengthened.

THE MAY LILY.

One particular section (Convallarieæ) of the Lily family, Liliaceæ, consists almost entirely of shade-plants, which differ in several important respects from other members of the order. The underground stems

are of the type known botanically as rhizomes, and not bulbs. The foliage is of the large, thin, shade-leaf type, and the fruits are berries.

The best-known British example of this group, the Lily of the Valley (*Convallaria majalis*, Linn.), is rarely, if ever, found within the Alpine zone, though it is sometimes frequent at lower elevations. Above 5,000 feet, its place in the forests is taken by the May Lily (*Maianthemum convallaria*, Weber = *Smilacina bifolia*, Schult.) (Plate XLVII., Fig. 2), one of our rarest British plants.

From the creeping root-stock, this plant sends up each year a flowering shoot, bearing two large, shortly-stalked, heart-shaped leaves, placed at different levels on the shoot. Some other Alpine plants produce only two leaves each year, such as the Lesser Butterfly Orchis (*Habenaria bifolia*) (Plate XXXI., Fig. 2), and the Twayblades (*Listera ovata*, R. Br., and *L. cordata*, R. Br.), though this is a comparatively rare feature among either British or Swiss plants. The flowering shoot of the May Lily ends in an inflores-cence (raceme) of white flowers, which are probably smaller than those of any other plant belonging to the same group. They are interesting from the fact that there are only four perianth members and four stamens, whereas the usual number found in this order is six.

The three British species of Solomon's Seal (*Poly-gonatum*), though rare or infrequent with us, are to be found in the Alpine woods. Another plant, which,

however, is not British, the Knot-foot, *Streptopus amplexifolius*, D. C. (Text-fig. XXIV.) is also some-
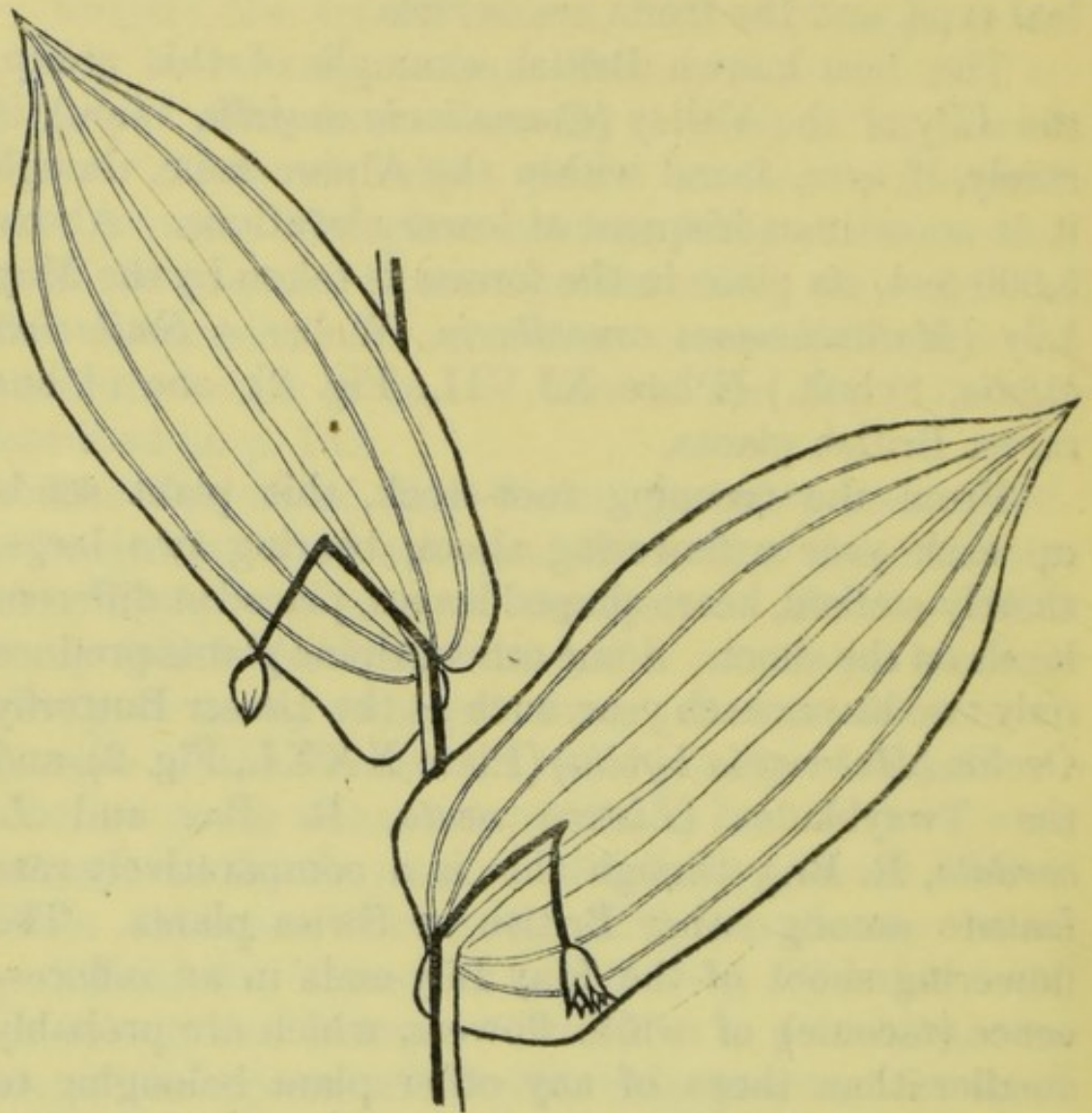
Fig. XXIV.—A Flowering Branch of the Knot-foot (*Streptopus amplexifolius*, D. C.).

Showing the flower-stalks united to the axis for the length of the internode above their insertion, and the flowers thus hanging below the leaf next above that in the axil of which they arise.

times met with, though it is rather local in its distribution. It is an interesting species in many respects. The flowering shoot is zigzag in form and

knotty. It bears several large leaves, not very unlike those of the May Lily in shape, but stalkless and attached directly to the axis, which they clasp by their bases. The flowers arise singly or in pairs, in the axil of each leaf, and are mounted on long stalks. The most curious point about this plant is that the flower-stalk is united with the portion of the axis between the leaf in whose axil it arises, and the next leaf above it. The free portion of the flower-stalk lies below the upper leaf, and is bent at right angles, so that the flower hangs downwards.

The Herb Paris.

Another forest shade plant, belonging to the same section of the Lily family as the May Lily, is the Herb Paris (*Paris quadrifolia*, Linn.). This species is one of the most curious and unmistakable plants in the Alps, as regards its build or habit. The white, underground rhizome sends up each year a flowering shoot, about a foot high, which ends in a single flower. A few inches below the flower are four, very large, egg-shaped, net-veined leaves, arranged in the form of a cross, and attached directly to the axis. The parts of the flower are also arranged in fours, and not in whorls of three, as in typical Liliaceous flowers. Further, the outer and inner whorls of the perianth are dissimilar. The four outer perianth members are much broader than the four narrow, inner members, and both are yellowish-green in colour. There are also eight stamens.

R

Though two whorls of four are usually met with, other numbers, such as 3, 5, 6, or 7, may occur both in the perianth and stamens, and then, as a rule, a corresponding number is found in the whorl of leaves below the flower. The flowers do not produce honey, and have an unpleasant smell.

THE MARTAGON LILY.

The Martagon Lily, or Turk's Cap (*Lilium martagon*, Linn.) (Plate XLVII., Fig. 1) is a tall leafy plant about 3 feet high, with turban-shaped flowers. It is not common, though it is sometimes to be found in the forests and thickets, and may occur even in the Alpine meadows, as at Saas Fee. The flowers are borne in a large inflorescence, containing twenty-five or more drooping flowers. The tips of the perianth members are curled upwards and backwards, hence the name Turk's Cap Lily. On their inner sides they are rose-coloured and spotted with dark brown. They are thick in substance, and have a waxy surface. Outside, as seen in unopened buds (Plate XLVII., Fig. 1), the perianth segments are clothed with matted white hairs. Each, near its base on the inner surface, has a deep groove, arched in and protected by a little flap on either side. This groove is full of honey, which can be made to ooze out by pinching the segment at its sides.

The stamens produce great quantities of rust-coloured pollen, the anthers swinging freely on their stalks.

PLATE XLVII

FIG. 2.—The May Lily (*Maianthemum convallaria*, Weber).

[*To face p.* 258]

FIG. 1.—The Flowers of the Martagon Lily (*Lilium martagon*, Linn.).
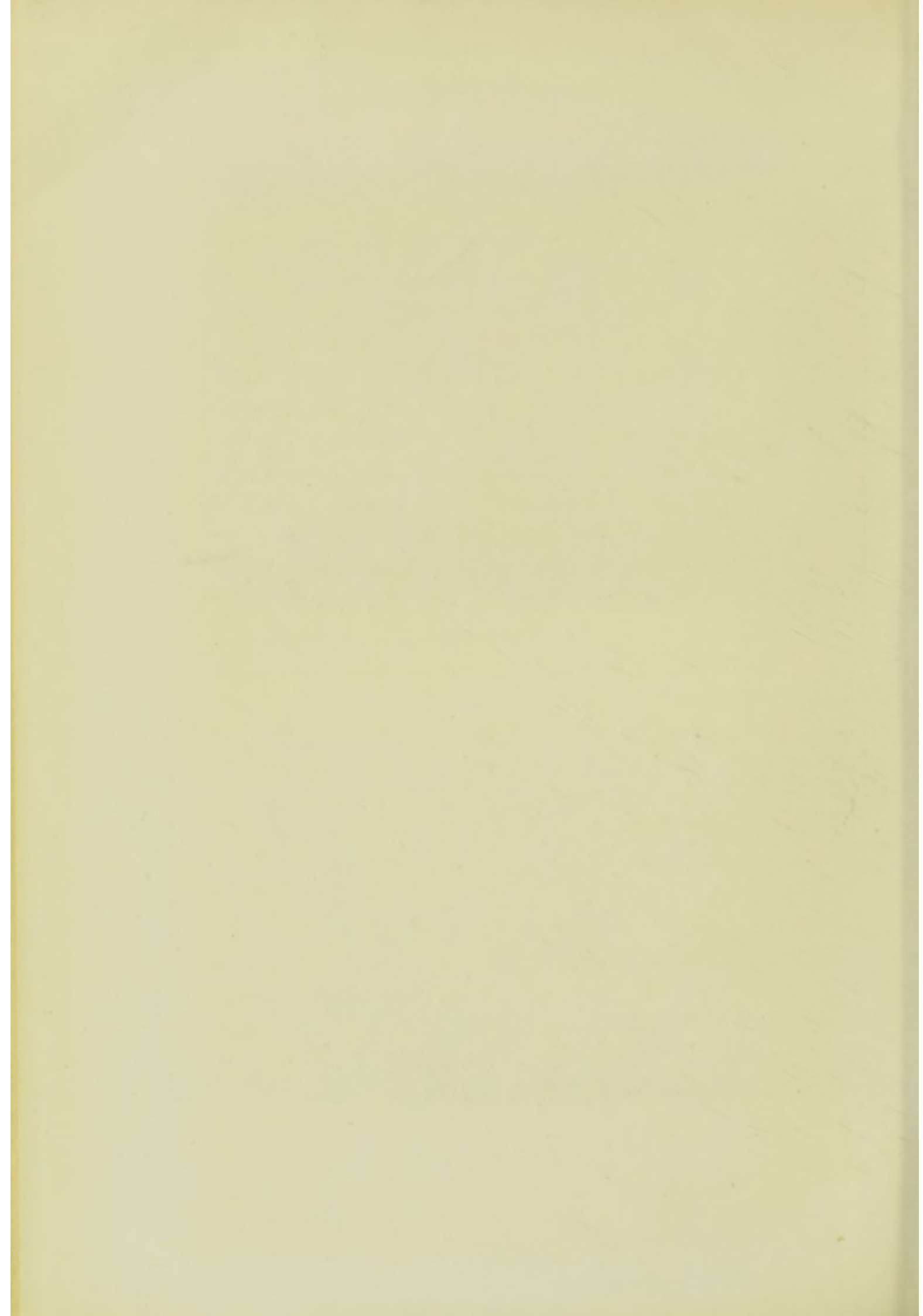
The flowers are not very conspicuous, and by daytime have hardly any scent. But towards evening they emit a sweet odour, which attracts night-flying insects such as moths, which are of service as cross-pollinators. The flower is so constructed that it can only be entered by insects on the wing. The drooping position, and the recurved perianth segments are designed for this very purpose, and the latter, with their smooth, waxy, inner surface furnish no "alighting place" for an insect. To get at the honey, the moth or other visitor has to hover on the wing below the flower, and thus its proboscis or tongue comes in contact with both the stamens and the stigma. These organs both mature at the same time, so it sometimes happens that the pollen is deposited by the insect on the stigma of the same plant, and thus self-fertilisation, as well as cross-fertilisation, may take place.

Though the flower, both in the bud and when fully opened, droops as above mentioned, when the fruit is mature, the stalk straightens out and the capsule is borne erect.

The Mezereon.

The Mezereon (*Daphne mezereum*, Linn., natural order Thymeleaceæ, the Daphne family) is one of the three Daphnes, and the only British species, found in Alpine Switzerland, though the Spurge Laurel (*Daphne laureola*, Linn.) occurs at lower elevations. It is built on much the same lines as the Alpenroses,

to which it has an extraordinary resemblance in habit. It is an erect shrub, 1 to 3 feet high, much branched at the base, the lower portions of the shoots being bare and leafless, though showing numerous leaf scars, marking the position of former leaves. Little tufts of leaves are borne near the ends of the branches, and are shed each autumn. In this respect the Mezereon differs from the Alpenroses, which are evergreen.

In the spring the flowers appear before the leaves, as in our British Coltsfoot and other plants. They are borne in clusters, each of several flowers, in the axils of the leaves of the previous year. The leaves themselves disappeared last autumn, but their position is indicated by the scars on the branches. The flowers are destitute of a corolla. The four sepals, however, are united into a rose-coloured tube, and perform the attractive function. They are sweet scented, and much visited by flies and other insects. The fruit is a red berry.

Although the Mezereon is frequent in the forests, it is not confined to that particular habitat, but is often to be found growing in the rocky pastures. The two other species, *Daphne alpina*, Linn., and *D. striata*, Tratt, are easily distinguished by the fact that the flowers are arranged in umbrella-shaped clusters, and appear with or after the leaves. The former species has white flowers, the latter white or rose-coloured sepals. The calyx tube of *Daphne striata* is longer and narrower at the mouth than that of the Mezereon,

and is specially adapted to fertilisation by insects with long tongues, such as hawk-moths. The strong, sweet scent is emitted chiefly in the evening.

THE WINTERGREENS.

All the five British species of the genus *Pyrola* (natural order Pyrolaceæ, the Wintergreen family, by some botanists included in the Ericaceæ, to which they are closely related) occur in Switzerland, and most of them may be met with in the Alpine forests. A non-British species (*Pyrola chlorantha*, Sw.) is also found in Switzerland, but it is a rare plant.

The Wintergreens are herbaceous perennials with, as the name implies, evergreen leaves. The leaves are stalked, and spring from the creeping stem, close to the surface of the ground. From among them erect flowering shoots arise, bearing either a single flower or a number of flowers arranged in a raceme. The petals are quite free from one another, and fall off one by one, when the flower begins to fade. The anthers open by pores at the tips.

The Single-flowered Wintergreen (*Pyrola uniflora*, Linn. (= *Moneses grandiflora*, Gray) has a single solitary pendulous flower, much larger than those of the other species. The flowers, though conspicuous, are quite honeyless. In the other species the inflorescence is a raceme and the flowers are smaller. The Larger Wintergreen (*Pyrola rotundifolia*, Linn.) differs from the Common Wintergreen (*P. minor*, Linn.) and the Intermediate Wintergreen (*P. media*,

Swartz.), chiefly in certain peculiarities of the styles. These three species are very nearly related, and are often difficult to distinguish. The Serrated Wintergreen (*Pyrola secunda*, Linn.) is easily recognised by the fact that all the flowers of the raceme or inflorescence are turned to one side. The leaves are also more strongly toothed than in the other species.

The pollen-shedding mechanism of the Wintergreens offers a very pretty study, and is worth investigation. If we examine the pendulous flowers of *Pyrola secunda* or *P. rotundifolia*, we shall find that when they have just opened, the stalks of the stamens are bent in an S-shaped manner, and are held in position by the pressure of the petals. The stalks are in a high state of tension, like a bent spring. At this stage the tips of the anthers, where the pores are placed, are directed towards the base of the flower. When an insect visits the flower, and pushes back the petals, the pressure on the spring-like stalk is released, and it straightens out. The result is that the anther performs a sort of somersault, turning through 180°, the tips now pointing to the mouth of the flower. At the same time, the jerk caused by the release of the spring shakes out a shower of pollen dust through the pores on to the back of the insect. This process can be imitated by simply pressing back the petals of a flower in which the stamens are ripe, having first carefully noted the position of the anthers in the undisturbed condition.

In the Single-flowered Wintergreen the arrange-

ment is somewhat different. The petals here are spreading, and do not hold the stamens in position. The latter, however, have spring-like stalks, which are so arranged that, when an insect visits the flowers, they become released, and straighten out in much the same way as in the other species above described.

The fruit or capsule of the Wintergreens, containing many very small seeds, opens by little slits. The fruits, like the flowers, are pendulous, so the slits arise at the top of the fruit, which is really the base. No valves are, however, formed, such as are found in the fruits of the Bell-flowers (p. 88, Text-fig. IX.). In wet weather, when there is a serious danger of the seeds, still enclosed in the capsule, becoming damp, the slits close.

THE WOOD SORREL.

Our graceful little Wood Sorrel (*Oxalis acetosella*, Linn., natural order Oxalidaceæ, the Oxalis family), is often to be found in the forests of the lower region of the Alpine zone. The creeping, slender root-stock sends up a number of long-stalked, characteristic leaves, each composed of three egg-shaped, delicately green leaflets. These leaves are believed to be those to which the name "Irish Shamrock" was first applied, though the leaves of a species of Clover are now more generally used as that emblem.

The flowers are borne singly on long stalks, which arise among the leaves. They are large and white or pinkish-white, the petals being extremely delicate.

The leaves of the Wood Sorrel are of great interest botanically, for they possess the power of movement — a rare occurrence among the Higher Plants. At night, or in very strong sunlight, each of the three leaflets falls, so as to hang with the apex pointing directly downwards, and thus to lie parallel with the leaf-stalk (Text-fig. XXV., 2). Under ordinary circumstances, in daylight the leaflets are

1.   2.
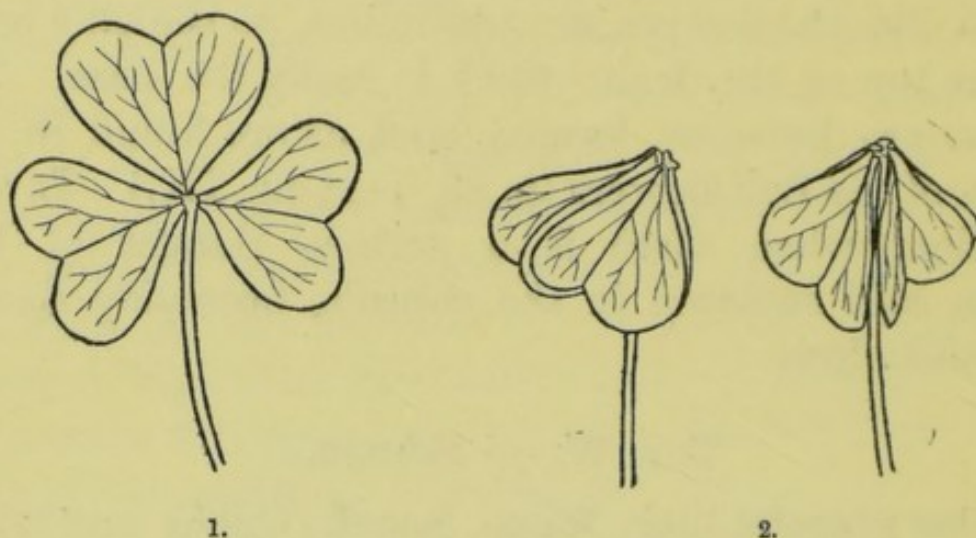
FIG. XXV.—The Leaves of the Wood Sorrel (*Oxalis acetosella*, Linn.).

1. In the day position.   2. In the sleep position.

held at right angles to the stalk (Text-fig. XXV., 1). This means that they receive the maximum of illumination, whereas in very strong sunlight, by assuming the second, or sleep position as it is called, the light only falls very obliquely on the delicate leaflets. At night, the sleep position protects the leaflets from excessive loss of heat by radiation. The mechanism of movement is seated in the very short stalks of the leaflets, and the changes in

position are effected by certain tissues becoming more turgid or more flaccid, by absorption or loss of water. According as these tissues are swollen or limp, so the leaflet is held horizontal or sinks to the vertical sleep position.

It may also be mentioned here that the minute chlorophyll grains, which contain the chlorophyll (p. 10) or green pigment of the leaf, have the power of changing their position in the cells, according to the intensity of the light. In dull or diffuse light, they spread themselves so as to obtain the maximum illumination. In stronger sunlight, they collect around the walls of the cells, and place themselves parallel to the rays of light, so as to receive less illumination, while, after long-continued sunlight, they all gather together in groups at the ends of the cells.

The fruits of the Wood Sorrel are interesting from the fact that the seeds are shot out one by one, often to considerable distances. The pod, or capsule as it is termed botanically, is five-chambered, each chamber possessing two seeds, placed one above the other, and attached to the central column. Each seed possesses two coats. Some of the cells of the inner layers of the external coat, when mature, are in a high state of strain. They become very tense or turgid. When each chamber of the fruit opens, the inner strained layers of the external seed-coat swell up and burst the outer, non-strained layers, and thus the external seed-coat is turned inside out. This violent jerk shoots out the seed itself, enclosed in its

shining black internal coat. Thus the Wood Sorrel presents the curious case of a seed shooting itself off from the parent fruit by sacrificing one of its seed-coats. We have already seen how in the Field Pansy (p. 162) a similar effect is attained in quite a different way.

THE ALPINE LETTUCE.

Everyone is familiar with our British Coltsfoot (*Tussilago farfara*, Linn.), so common on dry bare slopes, such as newly-made railway embankments, where it is often the first plant to obtain a footing. The pale yellow flower-heads of this weed appear in spring, some little time before the large, broad, heart-shaped leaves.

In Alpine Switzerland the Coltsfoot is not very abundant, though, as with us, it is common enough in the plains. It is then replaced by another near rela-tive, the Alpine Lettuce (*Homogyne alpina*, Cass., natural order Compositæ, the Composite family). Such replacements will be frequently noticed within the Alpine zone. Our Common Daisy (*Bellis perennis*, Linn.) is replaced by the Alpine Daisy (*Bellidastrum michelii*, Cass.), while in the High Alpine region the Alpine Ox-eye Daisy (*Chrysanthemum alpinum*, Linn.) takes the place of the Common Ox-eye Daisy (*C. leu-canthemum*, Linn.) of the Alpine, Subalpine, and Low-land zones.

The Alpine Lettuce is, however, a very different plant to the Coltsfoot. It is essentially a shade plant,

and, though not confined to the forests, it favours, as a rule, only the shadier spots in the pastures. The Coltsfoot, on the other hand, is a marked sun plant, living in situations not only fully illuminated, but of the driest description. On the other hand, the Alpine Lettuce loves a damp situation, a shady retreat, and a large percentage of humus in the soil. Its leaves are much smaller, heart-shaped or kidney-shaped, and very dark bluish-green on the upper surface. The nerves are very prominent, and, on the lower surface, are covered with hairs. The leaves appear at the same time as the flower-heads.

Only a single flower-head is produced, and this is borne on a long, brown stalk. The flowers are of a dull, brownish-red tinge, which is quite unmistakable. The corollas of the outer ray (female) flowers are not strap-shaped, as in the Coltsfoot, or Arnica, or Ox-eye Daisy, but divided into thread-like segments—a very rare feature among the Compositæ.

CHAPTER XI

ADAPTATIONS AMONG ALPINE PLANTS

THE present chapter will be devoted to a discussion of certain adaptations found among Alpine plants. In the previous sections we have repeatedly drawn attention to the mutual dependence or alliance which exists between a large number of Alpine flowers and members of the insect world. We may now enter on a more general consideration of this subject.

FLOWERS AND INSECTS.

It is a matter of common observation that insect life abounds in Alpine Switzerland; so do conspicuous and beautiful flowers, and for the good reason that a large percentage of Alpine plants are specialised for cross-pollination through insect agency. They have found that, to ensure and maintain the fertility and robustness of the stock, the ovules of one flower must be fertilised by pollen brought from another plant, and not by the pollen of the same flower. The two chief agencies which act as pollen carriers are insects and the wind. Such is a plain

statement of the case from the plant's standpoint. From the insects' point of view, an abundance of flowers is essential, for many of them live entirely on a diet of honey or pollen, or both combined. We have no evidence that insects ever visit flowers for philanthropic or disinterested motives. They go bent on the serious business of marketing, just as many human beings go daily to the markets to obtain the necessaries of life.

These facts must always be carefully borne in mind. They form the key to the origin of many of the varied peculiarities in the form and structure of the flower, to be met with in the Alps. The botanist who first clearly noted these facts was Joseph Gottlieb Kölreuter (1733-1806) of Karlsruhe. He was shortly afterwards followed by Christian Konrad Sprengel, to whom reference has already been made (p. 2). Thus Kölreuter and Sprengel are the honoured Fathers of the study of the manner of pollination of Flowering Plants.

There is no doubt whatever, from the evidence of palæontology, that insects existed long prior to the first appearance of the Flowering Plants (Angiosperms). It is conjectured that the earliest primitive flowers were wind pollinated, but owing to the probability that they were soon visited by insects, who robbed them of their pollen, the plants appear to have determined that, if they must suffer robbery, they might as well make use of the insects in some way, and consequently they hit on the happy idea of

making them the pollen distributors. So successful was the move in this direction, that it quickly became "fashionable" to adapt the flowers especially to insect visitors. Since then many plants have become more and more specialised, as regards the flowers, in relation to insects, and all sorts of floral mechanisms have been devised, some of which have been discussed in the preceding chapters.

We will now notice some further points in this connection. The late Hermann Müller, our greatest authority on the fertilisation of Alpine flowers, calculated that the proportion of insect- to wind-fertilised plants in the Alps was as follows :—

Insect-fertilised species	.	590	=	84 per cent.
Wind-fertilised species	.	109	=	16 ,,
Total species	.	699		100 ,,

Another prominent worker in the same field, Loew, found that the proportions in the plains and lowlands of Central Europe is :—

Insect-fertilised species	.	981	=	78 per cent.
Wind-fertilised species	.	271	=	22 ,,
Total species	.	1252		100 ,,

Thus there is a relatively larger number of insect-fertilised plants in the Alps than in the Lowlands, and a smaller number of wind-fertilised plants.

The chief insect-fertilisers in the Alps are butter-flies, moths, humble-bees, and honey-bees. Certain flies also cross-pollinate some flowers, such as the Globe-flower (p. 207) and the Two-flowered Violet

(p. 253). Müller showed that in the Alps, butterflies play a more important part in this connection than in the plains.

Flower Advertisements.

Flowers may be said to be the most ancient of advertisers. Those which are pollinated by insect agency specially lay themselves out to attract insects. Their advertisements are of two main types: colour and scent. As a rule, in the Alps both exist together; in other cases colour alone is relied on, and the flowers are scentless. But many plants go even a stage further: they provide "free samples" of honey or pollen for some or all of the insects whose compound eyes they have managed to attract by their advertisements.

Conspicuousness may be more or less confined to the flowers themselves, or other parts of the plant may share in it. We have already seen (p. 124) how different parts of the flower may be specialised as the conspicuous organs. We have also discussed, in the case of the Gentians (p. 58), the evolution of the coloured pigments of flowers. Frequently one or more organs or sets of organs are greatly enlarged, and highly coloured, and are thus rendered more conspicuous. A good example of this may be found in a comparison of the corollas of the Field Pansy (p. 161) or Long-spurred Violet (p. 128) with that of the Two-flowered Violet (p. 253). Or, again, conspicuousness may be increased by the massing of a

large number of flowers in an inflorescence, to form a head, as in the Rampions or Composites. Or, again, if the inflorescences become one-sided, all the flowers turning in one direction, as in the Bearded Campanula, and many Boragineæ, conspicuousness is markedly increased.

As regards scent, the odours of many flowers are well known to be characteristic, such as those of the Mignonette, or Jasmine. Yet other quite unrelated plants often possess exactly the same kind of scent. A good example is the vanilla scent, typical of the fruits of a tropical climbing Vanilla Orchid, which is possessed by many other flowers, among them the Black Nigritella (p. 135) and the Linnæa (p. 250).

Again, many plants possess what to us are unpleasant or nauseous odours, which apparently are quite acceptable to certain insects. Such flowers are rare in the Alpine zone, the most unpleasant being *Thalictrum aquilegifolium*, Linn., which has the Elder-odour.

We now turn to the "free samples" offered to insect visitors. Pollen alone is rare, though in the Alps the flowers of the Alpine Anemone (p. 37) and the Narcissus-flowered Anemone (p. 41), the Alpine Poppy (p. 195) and *Thalictrum aquilegifolium*, Linn., possess no nectar. As a rule, however, nectar or honey together with pollen are the inducements which entice insects to enter the flower.

Honey is secreted by special glands known as nectaries, the position and shape of which varies in

different flowers. In the case of the Yellow Gentian (p. 58), we saw that the nectary was a ring-shaped swelling at the base of the ovary. In other flowers certain of the stamens are modified to form honey-glands, and have quite lost their original function. Such cases are well seen in the Globe-flower, the Hellebores, and the Monkshoods. In the Violets (p. 161) and Orchids, as well as many other plants, the nectary or nectaries are situated in a spur.

In some plants, such as the Yellow Gentian and the Marsh Marigold, the nectar and pollen are freely open to all insect visitors, which arrive on the wing, though not to crawling insects. In other cases the flowers are specialised for certain insects alone, such as humble-bees and butterflies, which possess very long probosces or tongues. This implies concealment of the honey or some adaptation by which such visitors can alone enter the flower. In the previous chapters we have discussed several instances. In some Gentians, the throat or entrance to the corolla is closed, by means of scales, to all except the more powerful insects, and the same adaptation is met with in other plants. Again, as in members of the Pea family, the flower may be so shaped that only certain insects can force their way within. The honey may be concealed at the end of a long corolla tube of fine bore, as in *Daphne striata* (p. 260), or in slender spurs, as in *Viola calcarata* (p. 129), so that it can only be reached by long-tongued insects. In the case of the

Globe-flower (p. 207), only very small flies can reach the honey.

The different contrivances to be met with in flowers adapted to particular insect visitors are extremely numerous, but it will not be possible to enter into this subject fully here. These remarks, supplementary to the observations scattered through the preceding chapters, may, however, serve to indicate the chief points of interest of this nature to be met with among Swiss Alpine plants.

Before we leave the subject, we may explain how insects recognise the flowers they visit. This subject has been much discussed, and there is still a great deal to be learnt in the matter, but certain facts seem now clearly established. The eyes of insects are compound, and further, they are immovable. The number of "facets" in a single eye may vary from 4 to 25,000. Despite this fact, insects are extremely short-sighted. At one time it was thought that each facet reflected the image of a flower, so that if 10,000 facets occur in a single eye, the insect would receive 10,000 different images of the flower from one eye alone. This view, multiple vision as it was called, is now abandoned, and it is believed that each facet only receives the image of a small part of an object, the whole object being seen by the total sum of the images of each facet. This may perhaps explain the short-sightedness of insects. At any rate, it appears clear that though insects are attracted to a particular flower from a considerable distance, it is by the sense

of smell, and not by sight. When the insect begins to get near the flower, then the colours attract its eyes, and often "honey guides" (p. 161) are furnished by the plant to help it to find the entrance.

Protections against Unbidden Guests.

We have seen how certain flowers are specialised for certain types of insects, and we are now in a position to appreciate the safeguards possessed by many Alpines, whereby insects or unbidden guests, which can perform no service to the flower by acting as cross-pollinators, are warned off or excluded. Some plants, not so well adapted to meet this difficulty, are frequently robbed of their honey or pollen, by insects which are not likely to visit another flower of the same species.

Unbidden guests are of two classes: those which approach the flower on the wing, and those which crawl up from below by means of the flower-stalk. The former are excluded, as we have seen, by the concealment of the honey, or by the special shape of the flowers, which precludes their entrance, or by the closure of the throat of the flower by special means such as scales, or by the presence of tufts of hairs or bristles inside the flower, which prevent some insects penetrating as far as the honey. In certain species, such as the Martagon Lily (p. 259) and *Lychnis vespertina* (p. 165), which are adapted for fertilisation by night-flying Lepidoptera, the plants

do not emit scent in the daytime, and thus do not attract many visitors.

The inflated calyx of *Silene cucubalus* (p. 164) probably serves to protect the honey from robber bees, who try to steal it by biting through the base of the corolla.

Some subtropical and tropical plants have remarkable methods of protecting themselves from unbidden guests whether visitors to the flowers or leaf-destroyers. They actually hire other insects to protect them, and produce nectaries outside the flowers, as an inducement to their protectors to stay and fight their battles for them. Kerner states that the flower-heads of *Centaurea alpina*, and some other Composites in Southern Europe, maintain a colony of ants by means of special nectaries, on the involucral bracts of the flower-heads, on which they feed. These ants act as a body-guard against certain beetles or other unbidden guests, which eat the flower-buds. The ants are able to drive away the beetles, ejecting formic acid if necessary, and they thus perform a good service to the plant. Several other tropical plants go much further. They form a group called myrmecophilous plants. They not only feed, but actually house standing armies of fighting ants, which keep off leaf-cutting insects and other unwelcome or injurious visitors.

We now turn to the other class of unbidden guests, the crawling insects. A very simple device, which is sometimes adopted, to keep such insects

away from the flower, is the production of nectaries for their benefit on other parts of the plant. Or, again, the stems, leaves, and the stalks of the flowers may be armed with stiff hairs, prickles, or thorns, which prevent soft-skinned creeping animals, or very small insects from climbing up to the flowers. Hairs frequently occur on the calyx and on the petals, which serve the same function, especially where the flower droops, the bell of the corolla pointing directly downwards to the soil. Examples of these types of protection occur in the Bearded Campanula (p. 89), the Tufted Campanula (p. 91), and the Linnæa (p. 250).

In other plants, the flower-stalks are rendered slippery by a coating of wax, or the very smooth, polished surface of the petals affords no hold for the insect climber, or the secretion of some sticky material by glandular hairs, on the stems or leaf-stalks, or calyces, serves the same function. In other cases different contrivances are met with, all fashioned to the same end, but the above will perhaps suffice as some indication of the commoner types of protection met with in the Alps.

Wind-pollination and Self-pollination.

Although, as we have seen, insect pollination is the rule among Alpine plants, there are many exceptions which are either wind-pollinated or self-fertilised. The Coniferous trees and shrubs, for instance, are all wind-pollinated. The same is true of the Green Alder, the

whole of the Alpine Grasses, Rushes, and Sedges, and some others. In such plants the individual flowers are nearly always small and inconspicuous, and either devoid of calyx and corolla, or possess a very reduced, inconspicuous perianth. Another striking feature of wind-pollinated plants is that the flowers are often aggregated into dense clusters, or inflorescences.

Self-fertilisation—the fertilisation of the ovules of a flower by pollen derived from the anthers of the *same* flower—is also common, and the seeds that result may be either quite fertile or abortive. Many flowers, which are normally cross-pollinated by insect agency, may, if no insect visits the flower or no foreign pollen is brought to their stigmas, fertilise themselves at the end of the flowering stage. Some flowers possess special adaptations to ensure self-fertilisation, if cross-pollination fails.

Some plants produce flowers which never open —cleistogamous, as they are called botanically—in addition to ordinary flowers. This phenomenon is not very frequent in the Alps, though it is sometimes to be found in the case of certain Gentians, *Gentiana tenella*, Rottb., and *G. campestris*, Linn., and in the Wood Sorrel. As a rule, such cleistogamous flowers in the Alps are of quite normal structure, though, either through lack of sufficient light or warmth, they never open. In the Lowlands some plants produce flowers which never open under any circumstances, such as certain Violets and Dead Nettles (e.g.,

Lamium amplexicaule, Linn.), which are differently constructed from the normal flowers borne by the same plants.

The extraordinary phenomenon called parthenogenesis, which sometimes occurs both in plants and animals, in which the ovule is able to develop normally without having been fertilised at all by the male sperm produced by the pollen grain, has so far only been observed in the Alps in the case of certain species of Lady's Mantle, genus *Alchemilla* (natural order Rosaceæ, the Rose family). Another case is known in the Arctic regions—namely, *Antennaria alpina*, Gærtner (= *Gnaphalium alpinum*, Linn.), a plant nearly related to the Swiss Everlastings (see p. 21). Not only are no male flowers of this species known in the Arctic regions, but the female flowers, which in this genus are borne on different plants to the male, regularly set their seed without having been pollinated at all.

Before leaving this subject, we may note that in the tropics certain flowers are fertilised by animals other than insects, such as bats, humming, and honey-sucking birds, snails, and slugs.

The Protection of Pollen.

Everyone who has travelled in the Alps has been impressed, often in a disagreeable manner, by one fact —namely, the variableness of the weather. In the mountains the changes in the condition of the weather are often extremely rapid. For instance, the early

morning may show a bright sun, shining in a cloudless sky : yet before the afternoon, everything is changed. The peaks are wrapped in clouds, mists fill the valleys, and rain descends in torrents, or snow may take its place. The traveller caught afield under such changed conditions compared with those under which he set forth, seeks some form of protection from the weather. But how do the flowers meet this difficulty ? Here is a meadow, or there an Alp in full bloom. That is to say, the stamens of the flowers are shedding the precious pollen dust, on which so much depends. The pollen, in nearly every case, is ruined at once if thoroughly soaked. It is drowned, as it were, and all the labour of the plant and flower will, in that case, be in vain. This is a possibility against which an Alpine plant has to be specially on its guard.

The contrivances to be found among Alpine flowers are as varied as they are interesting. In many cases the permanent drooping position of the flower at the end of a bent stalk meets the case admirably. We have already discussed examples of pendulous flowers, as, for example, the Alpine Bell-flowers, the Soldanellas, and the Water Avens. In other plants the flower is so placed that the tube of the corolla is held horizontally parallel to the soil, and thus the petals shield the stamens. This method of protection is especially effective when the throat or entrance to the corolla tube is contracted or closed in some way. Examples of such plants are to be

found in the Alpenroses, the Primulas and Androsaces, the Butterworts, Violets, and Monkshoods.

More rarely the stamens are never exposed at all to the weather. In the Globe-flower (p. 207), the sepals form an arched roof over the stamens, while in the flowers of the Pea family (Leguminosæ) and in the Box-leaved Polygala (p. 253), the stamens remain enclosed in the petals.

But in other plants where the flowers are held with their stamens freely exposed to the weather, special contrivances exist to protect the pollen. We have seen how, in the case of the Carline Thistle (p. 125), the bracts of the flower-head curve up over it in bad weather. The flowers of the Anemones, Gentians, Crocus, Colchicum, and others close entirely. In other plants, such as the Common Daisy and the Jacob's Ladder (p. 151), the flower-stalks curve at night and in bad weather, so that the flowers, instead of pointing upwards, nod towards the soil. Other plants in which the stamens are freely exposed, such as the Thalictrums, the Plantains, the Globularias, and the Lady's Mantles (*Alchemilla*), meet the difficulty by simply closing the anthers and ceasing to emit pollen until a more favourable season. The anthers of *Thesium alpinum*, Linn., are said to close within thirty seconds of their being moistened.

It is obvious that the heavy night dews of the Alps must have an effect similar to that of a slight shower of rain, as regards danger to the pollen. Hence, most of the types of movement mentioned above are normally

to be observed towards evening. It is probable that rapid changes in the illumination give the signal to the plant to close its flowers or anthers, or to droop the flower or flower-head. Atmospheric changes of a marked nature are usually foreshadowed in the Alps by some variation in the intensity of the illumination.

These special contrivances to prevent the flower or the stamens becoming water-logged are extremely interesting botanically, for they necessitate the movement of one or more sets of organs. Yet, speaking generally, the power of movement is as comparatively rare among plants as it is common among animals. Hence the mechanisms which effect the opening and closing of flowers and the like are of great importance, though unfortunately it is not possible to enter into the matter here in detail.

SEEDS AND FRUITS.

In the preceding chapters we have called attention to some of the chief difficulties to be faced, as regards climate, by plants living at high altitudes in Switzerland. It must not, however, be imagined that the Alpine region, even with its manifold disadvantages, is unsuited to support plant life. This is far from being the case. The High Alps are extremely favourable to life, provided only that plants can adapt themselves to the special conditions which there rule. Early flowering and perennial existence are two of the necessary conditions. Another is an abundance

of seed-production, implying in many cases a wealth of blossom.

A large number of the seeds set and ripened each year are doomed to failure. The seeds or fruits are the new colonisers, which, transported to a distance from the parent plant, by one agency or another, seize upon such new ground as is available. They have to fight not only against climatic conditions, sufficiently severe to eliminate the majority of the seeds annually distributed, but to compete for space, light, air, and moisture with the seeds or seedlings of other plants, or to contend with an established adult population, for the most part of a perennial nature. The existence and welfare of the species is dependent on the prosperity of the new generation, which begins with the seed. The first step is the successful establishment of the seedling, if possible at some distance from the parent. It may now be well to consider how this object is furthered among Alpine plants.

Early flowering and an abundance of flowers are simply the means whereby a few, out of a large number of seeds matured, may gain a hold in their new surroundings, before the short summer and autumn merges into winter. The contrivances for the distribution of the seed or a group of seeds, either free or still enclosed in the fruit, are as varied in the Alps as in the plains of Britain, but they are not, for the most part, dissimilar to those met with in this country.

In the majority of cases the seeds are shed
individually from the fruits, and distributed chiefly by
the agency of wind, which plays an especially
important part as a disseminator within the Alpine
zone. Dr Vogler has shown that the number of wind-
distributed species in the Alps is nearly 60 per cent.
of the whole flora—that is, more than half as much
again as the number in the Lowlands (38 per cent.).
The percentage of animal-distributed plants is only
3 per cent., whereas in the plains it is 15 per cent.

The great majority of Alpine species have very
minute seeds, as in the case of the Saxifrages,
Campanulas, and Primulas, which are shed individu-
ally from the capsule or fruit. As a rule, these seeds
possess no special adaptation to wind-distribution,
beyond their small size and lightness.

Some seeds, however, possess tufts of hairs which
render them admirably adapted for wind-distribution,
as in the case of the Willowherbs (*Epilobium*) and the
Alpine Willows (*Salix*). More frequently the seed
remains enclosed in the fruit, which may develop
hairs adapted to dispersal by the wind. Such fruits
are common to many members of the order Com-
positæ. The parachute-like hairs of the fruit of
the Dandelion (*Taraxacum*) afford an excellent
example.

In the case of *Atragene* (p. 230), *Dryas* (p. 108), and
some species, but not all, of *Anemone* (pp. 36 and 39),
the style of the ovary develops into a long, feathery
awn, which enables the fruit, which here encloses

only a single seed, to travel considerable distances with the wind (Plate XLIII, Fig. 2, and Plate V.).

In a few plants the seeds are thrown out by the agency of the fruit itself, as has been already explained in the case of the Violets (p. 162). In other cases, such as the Geranium, the ovary divides into five fruitlets, which are shot off from the plant to a considerable distance by the sudden splitting of the fruit.

The fruits, distributed by the agency of animals, are of two kinds. The first are succulent and edible and attract animals, especially birds. The second possess some form of clinging apparatus, such as hooks, by which they become attached to passing animals, and are thus carried to a distance from the parent plant.

We have in an earlier chapter (p. 220) commented on the number of plants producing berries in the Alps. The other types of succulent fruits are few in number. In the Wild Strawberry (*Fragaria*) the receptacle of the flower becomes fleshy, and the fruits, each of which only contains a single seed, are the little black bodies scattered over the red flesh of the ripe fruit. The "hips" of the Roses (*Rosa*) are complicated structures, in which the persistent and flesh-coloured calyx tube of the flower grows round and encloses the true fruits, each of which also contains a single seed.

Hooked fruits are comparatively few in the Alps. We have already noticed (p. 158) the hooked style of

the Geums. The fruits of species of the Cleavers (*Galium aparine*, Linn.), also a common British plant, are covered with hooked bristles, the clinging power of which is too well known to need description.

It is believed that some seeds in the Alps are distributed by ants. There is a delicate little woodland plant, the Cow-wheat, *Melampyrum sylvaticum*, Linn. (natural order Scrophulariaceæ, the Foxglove family), common in the Pine woods, and, like the Louseworts (p. 218), a semiparasite on the roots of other plants. The fruits contain two (sometimes only one) white, shining seeds, which are of quite unusual appearance, and very conspicuous. If the ripe fruit be squeezed slightly, the seeds will pop out suddenly, and are shot away for some little distance. If we place some of these glistening, white seeds among the roots of a Pine, about which there are sure to be a number of ants busily engaged, we shall find that the ants instantly turn their attention to them and eagerly carry them off to the nest, as if they had at length found a great prize. Whether the seeds of the plant are distributed only by the agency of ants is as yet "not proven."

The Diseases of Alpine Plants.

It is too little recognised that plants, like animals, are subject to various diseases, often infectious and frequently fatal. Alpine plants form no exception to the rule. These diseases arise from two sources: parasitic plants and parasitic animals. The former

are, as a rule, the more numerous, as well as the more disastrous. The subject of plant disease is too difficult and complicated to be discussed here, except in the barest outline. We may, however, learn how to recognise the conspicuous signs of disease so commonly to be met with in the Alpine zone.

We will first notice the effects of certain diseases due to the presence of parasitic plants, living on or within the *host*, as the plant attacked by them is termed. These parasites nearly all belong to the group of Fungi, a race of plants consisting of threads of cells, destitute of green colouring matter or chlorophyll. The Mushroom is one of the higher and more advanced of the Fungi, as regards organisation. The Moulds, Mildews, and Rusts are other examples, lower in the scale. Some of them are saprophytes, living on dead and decayed vegetable or animal matter. Others are parasitic on or in living tissues.

Some fungal parasites may only infect certain portions of the host plants, such as the leaves, at any rate during some stages of the disease. They are thus local in their effect. They injure certain portions of the leaves or the stems of the host plants, but they do not, as a rule, imperil their existence. But, more commonly, the injuries are more widely spread throughout the plant. The very small threads of colourless cells—often quite invisible to the naked eye unless many thousands of them are matted together into a felt, as in the Moulds and Mildews— not only rob the host of its own nourishment, but

actually eat up the substance of the host plant itself. If the leaves are attacked, the plant loses its power of assimilating (p. 10).   If the flowers or fruits are attacked, as in the case of the Smuts on wheat, few or no seeds result.   The loss on crops of wheat, rye, oats, and other cereals may amount to many millions sterling in one country alone in a single year, when a particularly bad epidemic of disease has prevailed.

The commonest signs of disease are the presence of spots, patches, or swellings on the leaves or shoots of the host, often dark in colour, or again, brightly pigmented.   Little pustules of various colours also break out on the surface of the stem or leaf.   Often the plant loses some of its green colour, and becomes whitish, or shows some other obvious signs of ill health.   The number of plant diseases known is almost endless.   Each disease has its own symptoms, and these depend on the nature of the life history of the particular parasite in question.

One special feature connected with many plant diseases, is that the host has the power of accommodating itself to the disease in various ways.   The presence of a parasite, whether plant or animal, may stimulate the host plant to adapt itself against the invader by producing certain modifications of its normal form.   The growth of the branch or other organ attacked may be either arrested or greatly increased, or some other abnormality may result.   In some cases the host becomes reconciled, as it were, to the parasite, and goes out of its way to provide for

its needs. Thus the gravity of the attack is often minimised, and the disease restricted to local areas.

The well-known " Witches' Brooms," frequently seen on Cherry, Spruce, and many other trees, afford an excellent example of abnormal growths in response to the attack of a Fungus. These shoots are always quite erect, however drooping the ordinary branches may be. They arise from diseased buds which grow abnormally. Such shoots never produce flowers or fruits. They are branches specialised for the fungus in which the parasite finds a home suited to its needs, and thus the disease is localised, and does not spread throughout the whole plant.

Diseased organs are thus frequently dissimilar in appearance to healthy structures. This is often well seen in the case of the House-leeks (*Sempervivum*) (see p. 98). If we examine the rocks in summer-time, in a locality where these plants are abundant, we shall often find that some rosettes occur in which the leaves are either very pale or red in colour. They are also distinctly larger, as well as three or more times as long as those of the healthy rosettes (*cf.* Plate XXIV., Fig. 2, with Fig. 1 of same Plate. These rosettes are attacked by an internal parasitic Fungus, known as *Endophyllum sempervivi*, and in the large size of the diseased leaves we see an adaptation to the invader.

Another excellent example of dissimilarity between a healthy and a diseased plant may be frequently observed in the case of a Spurge (*Euphorbia cyparis-*

sias, Linn., which is a very abundant plant in the Alps, especially in dry places. The healthy shoots are much branched, and bear numerous large umbels of complicated inflorescences which resemble flowers, the golden-yellow bracts of the inflorescence simulating a corolla. Frequently among the clumps of this plant we shall find small unbranched shoots, bearing pale leaves, sometimes slightly larger than the leaves of the healthy plant, and often rust coloured on the lower surface. These shoots never bear flowers. A dense, little rosette of leaves is often found at the apex. These are shoots specialised to a parasitic Fungus (*Uromyces pisi*), allied to the Rusts of wheat, which lives within them, and thus the parasite is for the most part localised to such shoots, and does not spread indiscriminately through the whole plant.

A familiar instance of response to disease is the production of galls. These may be caused either by plant invaders or by parasitic animals, chiefly insects. The tissues of the part of the host plant attacked by the parasite, be it a leaf or be it a branch, are profoundly modified by the presence of the invader, and stimulated to renewed, and often excessive, growth, and the formation of new tissues or organs of unusual shape and size, which are called galls. The well-known "Robin's Pin-cushions" on Rose leaves, and the "Oak Apples" on Oak twigs, are two common examples out of many thousands of varieties of galls, due to insect attacks. Galls of various forms

frequently occur on the leaves of Alpenroses, the Alpine Currant, and many other plants.

In other cases galls are produced by the stimulus of parasitic fungi. Galls of this nature may often be observed on the leaves of the Alpenroses. A large spongy body, spherical or oval or somewhat irregular in shape, arises from a portion of the leaf, and may grow almost to the size of an apple, though it is frequently much smaller. This gall is of a pale yellow colour, often tinted with rose on the side turned towards the sunlight. These galls have been called Alpenrose Apples. The Fungus which stimulates these new formations is known as *Exobasidium rhododendri*.

THE LICHENS.

It is often imagined that the large Lichens, especially the greyish-green Beard Lichen (*Usnea barbata*) (Plate XLIV., Fig. 2), which festoon the branches of the Spruce and other Conifers in Alpine Switzerland, are parasitic upon these trees. This is not, however, correct. The Lichens simply attach themselves to the trees, to which they do little or no harm. Many plants, especially in the tropics, though much more rarely in temperate climates such as that of Western Europe, are what is called epiphytic. That is to say, while they attach themselves to other plants, they do not live parasitically at their expense. They neither penetrate nor destroy their tissues, nor rob them of their food-supply. The attached plant remains entirely self-supporting.

The Lichens are exceedingly abundant plants in the Alps, and very interesting organisms from many points of view. Though in this volume we are only concerned with the higher members (in the botanical sense) of the vegetable kingdom, occurring within the Alpine zone, we may, however, here make an exception and add a few remarks on the subject of the Lichens.

In addition to the Bearded Lichens, another, a very different type, may be observed on almost any large boulder. It will be frequently noticed that yellow, green, or brown patches are to be seen firmly encrusted on bare rocks, forming what might almost be described as films, adhering closely to the surface, and without any definite outline. These patches are the Crustaceous Lichens.

The Lichens are composite organisms; that is to say, the body of the Lichen is built up of two plants living together, closely intertwined. One of these plants is a member of the Algæ, the group to which the Seaweeds, etc., belong. The other is a Fungus. The Alga, which is green, and the Fungus, which is colourless, are so closely interwoven together that the resulting structure, or Lichen, is quite dissimilar from any single Alga or Fungus. The constituents of the Lichen are not individually visible to the naked eye, and it requires careful microscopic examination to detect them.

The life history of a Lichen is too complicated to be entered into here. It may, however, be added

that the two constituents of the Lichen have come, as
it were, to an agreement as to the part which each
is to play.   The Alga, by means of its green chlorophyll,
undertakes the manufacture of the food-supply, while
the Fungus looks after the reproduction of the species.
This extraordinary mutual benefit society of two quite
different plants—a condition which the botanist calls
symbiosis—is not confined to the Lichens, though they
form by far the largest group of symbiotic plants.

CHAPTER XII

THE GEOGRAPHICAL DISTRIBUTION, AFFINITIES, AND ORIGIN OF THE SWISS ALPINE FLORA

In this, the concluding chapter, we will briefly review some points of interest in regard to the geographical distribution of Swiss Alpines, and the theories advanced to account for the origin of the Alpine flora of Europe.

Inequalities of Distribution.

It has been already pointed out that some districts of Alpine Switzerland are much richer in species, and especially in the rarer plants, than others. Also the converse—that certain Swiss Alpines are confined to particular districts. It was stated nearly forty years ago, by a great authority, that whereas the Bernese Oberland only offers a single species not found elsewhere in Switzerland, the chain of Alps of the Valais, lying to the south of the Rhone valley, contains sixty-three species peculiar to it. Whether these figures would be accepted as accurate or not to-day is really immaterial to the argument. The Alps of the

Cantons Valais and Grisons (Graubunden) are certainly much richer in Alpine species than any other district on the north side of the main Alpine chain.

Among the rarities confined to the Valais are :—

Anemone halleri, All.
Silene vallesia, Linn.
Oxytropis fœtida, D. C.
Potentilla multifida, Linn.
Trifolium saxatile, All.

Saxifraga diapensioides, Bell.
Valeriana celtica, Linn.
Senecio uniflorus, All.

In the Engadine, and elsewhere in the Grisons, the following species are found :—

Papaver nudicaule, var. *rhæticum*, Leresche.
Dianthus glacialis, Hänke.
Sempervivum wulfeni, Hopp.

Senecio carniolicus, Will.
Valeriana supina, Linn.
Pedicularis jacquini, Koch.

which are either unknown elsewhere in Switzerland or only occur in the southern Canton of Tessin.

Rare species, common to both the Valais and Grisons, but practically confined to these Cantons, are, among others :—

Arabis halleri, Linn.
Sempervivum funckii, Braun.
Pedicularis incarnata, Jacq.

Potentilla nivea, Linn.
Phyteuma humile, Schleich.

Primula longiflora, All., and *Phyteuma pauci-florum*, Linn., are rare plants found in the Valais, Grisons, and Tessin.

How can these inequalities of distribution be explained? Some of the older observers attributed the facts to the effect of soil or climate alone. There is, however, little doubt that this explanation is insufficient. A celebrated Swiss botanist, the late Alphonse de Candolle of Geneva, has left us a more plausible theory.

It can scarcely be doubted, even by the most sceptical, that the Alps were at one time more heavily glaciated than they are at present. The retreat of the glaciers, with certain exceptions, has been marked even within the last few decades. The amount of glaciation appears, however, to have been as unequal in the past as it is at present, and it is to this fact that De Candolle attributes the observed inequalities of distribution among Alpine plants. The southern chain of the Valais and the eastern Rhætian Alps appear to have been less glaciated than the central Oberland region and northern Switzerland generally; and further, the glaciers there began to retreat earlier than in the Oberland. The consequence has been, on this theory, that the Valais and Grisons were being colonised by Alpines, while the Bernese Alps remained a vast waste of ice or snow.[1]

[1] According to Prof. Jaccard, the number of species to be found in any locality is directly proportional to the diversity of its ecological formations.

The question, however, is naturally bound up with the greater problem of the origin of the Alpine flora of Switzerland, and its relation to the vegetation on the north and south of the Alps. To this question we will now turn. Before we attempt to summarise the theories which have been advanced, we may first set out the facts which such theories should explain.

THE AFFINITIES OF THE SWISS ALPINE FLORA.

The mountain ranges of Central Europe form an incomplete chain, stretching roughly west and east, beginning with the Pyrenees, then the Swiss and Austrian Alps, and finally the Carpathians. The widest gaps in the chain are between the Pyrenees and the Swiss Alps, and between the Austrian Alps and the Carpathians. The Alpine floras of these mountain regions are essentially similar, many species being common to them all. Although, in the Swiss Alpine region, there is probably no species which is not found elsewhere, there are, on the other hand, many plants in the Austrian Alps and the other ranges, which do not occur in Switzerland. At the same time, there is a distinct unity in type and marked relationship between the floras of all these Alpine chains.

Further, many Swiss Alpine species occur so far afield as the mountains of Central Asia, such as the Himalayas and the Altai. The Edelweiss (p. 15), for instance, is found in the Pyrenees, the Swiss Alps, the Tyrol, the Carpathians, and the Himalayas.

Schroeter states that 275 Swiss Alpines occur in the Pyrenees, 399 in the Austrian Alps, 231 in the Carpathians, 129 in the Altai, and 72 in the Himalayas. We see, therefore, that many Alpines are very widely distributed, though confined to Alpine regions, and for the most part unknown in the plains between the various links in the chain of mountains in Southern Europe. We may picture these plants as occupying islands surrounded on all sides by a sea of Lowland vegetation.

We now pass on to compare the Swiss Alpine flora with those of the plains to the north and south of the Alps.

One of the most striking features of the vegetation of Alpine Switzerland is its close affinity with that of the Lowlands of temperate Western and Central Europe, north of the Alps, especially with the floras of Britain, France, and Germany.

We have seen (p. 205) that many British plants are abundant in the Swiss Alpine region. Further, the great majority of the species which there occur, and which are not found in the plains to the north of the Alps, belong to genera or families highly characteristic of the latter region. This affinity is, if anything, somewhat closer than that of the floras of the Pyrenees and Tyrol to the same Western European flora.

When, however, we compare the Swiss Alpine flora with the subtropical Mediterranean flora to the south of the Alps, the difference is exceedingly

striking. Comparatively few representatives of the southern flora which is in its general aspect quite distinct, are found in the Swiss Alpine region. Among the few Mediterranean types in the Alps are the Crocus (p. 153), the Globularias (p. 110), *Biscutella lævigata*, Linn. (a very common Cruciferous plant, especially abundant on dry banks), the Mediterranean Heath (*Erica carnea*, Linn.), and species of *Hutchinsia*. Others occur in Tessin (Ticino), which is the only one of the Swiss Cantons which lies wholly on the south side of the Alps. Here Mediterranean types are naturally more abundant, the climate, race, language, and flora being, as we should expect, thoroughly Italian.

The Swiss Alpine flora must next be compared with that of the Arctic regions of Northern Europe. It is a very remarkable fact that at least 30 per cent., or nearly one-third, of the Swiss Alpine species flourish in the far northern frigid zone. Such plants as *Dryas octopetala*, Linn. (p. 106), *Ranunculus glacialis*, Linn. (p. 193), and *Saxifraga oppositifolia*, Linn. (p. 186), are nearly as abundant in the Arctic regions as in Switzerland, and no fewer than 130 other species are common to both the floras. On the other hand, several important Swiss genera, such as the Gentians, are either absent or very poorly represented in Arctic Europe.

The flora of temperate North America (United States) is quite unlike that of Western Europe, yet in the Rockies and other ranges we find a number of

plants common in Alpine Switzerland, such as *Caltha palustris*, Linn. (p. 205), *Dryas octopetala*, Linn. (p. 106), *Androsace chamæjasme*, Jacq. (p. 74), *Pyrola uniflora*, Linn. (p. 261), *Primula farinosa*, Linn. (p. 69), *Saxifraga oppositifolia*, Linn. (p. 186), *Juniperus communis*, var. *nana*, Willd. (p. 233), and *Empetrum nigrum*, Linn. (p. 231). These are associated with a large number of plants unknown to Europe either generically or specifically, such as *Claytonia* and *Gaillardia*.

Thus we see that the distribution of the Swiss Alpines beyond the Alps affords an exceedingly interesting study.

The Origin of the Swiss Alpine Flora.

Any theory, which is to account adequately for the origin of the Swiss Alpine flora, must explain the facts of the present-day distribution and affinities of these plants, which we have just passed under review.

The study of this problem has thus naturally two sides : the historical and the geographical. We now pass to consider the historical or geological facts.

The Alps, like the other mountain regions of Europe, Asia, and North America, began to come into existence as a mountain range during the Oligocene period, and the uplifting of these and other "massifs" continued during Miocene times. They are thus quite modern structures in a geological sense. The elevation of these vast areas was probably comparatively rapid at some epochs, while

slow and gradual at others, and has possibly not yet entirely ceased. During the next geological period, the Pliocene, the mean temperature of Europe and North America became gradually lowered by the setting in of new climatic conditions, which eventually culminated in the Great Ice Age.

The epoch during which this great event took place is known as the Pleistocene or Glacial Period, and according to one very probable view, we are at present living in the latter part of this very period.

The Glacial Period no doubt did not set in suddenly. The foci, so to speak, of the wave of long-continued cold appear to have been located at the Poles, both at the beginning, during the period of maximum intensity, and during the last lingering phase. The cold increased in intensity slowly and gradually. As the temperature fell at the North Pole, a wave of cold began to creep further and further southward over the greater part of Central Europe and North America. When the Ice Age reached its maximum, a very large portion of the British Isles, Central and Southern Europe, Canada and the United States, became highly glaciated—that is to say, these areas resembled Greenland, as it is to-day. The Alps, and all the other mountain regions of the Northern hemisphere, were almost entirely clothed in a mantle of snow and ice extending to the foothills or almost to the plains.

In all probability the advance of the wave of low temperature was exceedingly gradual, and several

thousands of years may have elapsed between the period when the temperature first began to fall at the Pole and the glaciation of the British Isles.

There was also probably more than one period of maximum low temperature. Cycles of severe cold, each of considerable length, seem to have alternated with more genial, Interglacial Periods, when the ice retreated for a time from Britain and the plains of Central Europe. Finally, the climate became permanently temperate, the ice retreated to the polar circle, and to the higher peaks of the European and American mountains, and thus was ushered in the era of to-day.

The Glacial Period then was a long-continued epoch, the changes of temperature being extremely slow and gradual. Periods of cold alternated with more genial epochs. As the tides ebb and flow, so the wide-spread glaciation appears to have now advanced, now retreated.

We will not attempt to discuss here the arguments which have been put forward to account for the occurrence of such glacial periods. These remain the province of the mathematician, physicist, and astronomer. We may, however, add that the late Tertiary Glacial Period is not the only ice age of which geological evidence exists. Nor will we concern ourselves with the proofs of the general glaciation of Europe and North America. As Darwin, in the "*Origin of Species*" (p. 310), remarks: "The ruins of a house burnt by fire do not tell their

tale more plainly than do the mountains of Scotland and Wales, with their scored flanks, polished surfaces, and perched boulders, of the icy streams with which their valleys were lately filled."

There is little doubt that some members of the floras of Europe and North America, both of the plains and the mountains, date back to a period prior to the Ice Age. The history of both these floras begins in the Miocene period.

We now turn to the explanation of the origin of the Alpine flora of Europe, which is most generally accepted, and examine how far it will explain the present geographical distribution of Alpine plants, and the historical facts as above outlined. This theory was elaborated many years ago by Forbes, Charles Darwin, Sir Joseph Hooker, Asa Gray, and others. Briefly, it is as follows :—It is believed that in Miocene and Pliocene times a flora existed in Europe and North America, which was essentially similar in both these regions. The Alps no doubt also then possessed their Alpine flora. In the Far North, however, there was another flora, which we may speak of as the ancient Arctic flora. This, then, was the state of affairs prior to the Ice Age.

With the setting in of glacial conditions at the Pole, these floras were driven, each in their turn, further and further southward. The ancient Arctic flora retreated before the growing ice cap of the Arctic regions, and migrated into North America (Canada, and the United States) and into Europe. The

temperate Miocene flora of North America was driven, in its turn, towards the south, and there being no mountain ranges stretched across the continent to bar its way, it found a haven in what are now the tropics, and in some cases, it is believed, even migrated into the Southern hemisphere. In Europe, however, the retreat of the Miocene flora was barred by the Alps and other links in the incomplete chain of mountains, which stretches from the west to the east across the continent. The flora, brought up sharp against the highly-glaciated Alps, became almost entirely extinct. A few survivals, however, preserved by some good fortune, still lingered.

With the advancing wave of cold, the Alps and the Rockies became gradually more and more glaciated, and the ancient Alpines were driven downwards to the Lowlands, and there mingled with the ancient Arctic plants from the Far North.

At the periods of maximum intensity of cold, the plains of Europe and North America were populated by Arctic and Alpine species.

When, however, the ice again retreated northward, many of the ancient Arctic plants returned to the polar region and the old temperate, Miocene types to North America, and there mingled with some Arctic species which finally made their homes in the Lowlands.

In Europe, as we have seen, the Miocene flora had been practically exterminated, and the present Western European flora would seem to have originated

from some of the ancient Arctic plants, which became established in the plains. Both in Europe and North America, as the glaciation decreased, some of the ancient Arctic, as well as the ancient Alpine species, ascended the mountains, and gave rise eventually to the modern Alpine floras of these continents.

Such is the bare outline of the theory which has been advanced to account for the origin of the Alpine flora. It is quite impossible to discuss the evidence for, or against, it here. At any rate, it will explain the facts of the present-day distribution of Swiss Alpine plants, which we have already enumerated. It will explain why some of the Alpines of Europe and North America are identical, while the Lowland floras of these regions are very dissimilar. It will explain the isolated seclusion of Alpines on the various detached mountain chains of Europe and elsewhere without any appeal to the theory of multiple centres of origin of species. It furnishes a reasonable historic connection between the facts of the past and the present.

At the same time, it must be pointed out that difficulties exist, either as to the theory as a whole, or as to some of its essential components, which have led such authorities as Dr Christ and the late John Ball to dissent from it. The relationship between the present Alpine and Arctic floras is the chief stumbling block. A large number, in fact the majority, of Swiss Alpines do not occur in the Arctic. It has been urged that Central Asia was the original home

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of the Alpine flora. It has been pointed out that, even if the Alpine flora has been derived from an Arctic flora, which, according to the theory, existed in the Far North before the incoming of the Glacial Period, we have still to explain the origin of this ancient flora, and above all, why at that time it possessed an *Arctic* character!

The recent experimental work of Prof. Bonnier, to which we have more than once alluded, has a profound significance for those who are inclined, in part at any rate, to distrust the theory. Bonnier has shown that the conditions which prevail in the Arctic regions are by no means identical with those in the High Alps, and, what is even more important, that a plant grown in the Arctic region differs from one grown in the Alps. It is thus clear that the effect of physical conditions alone is greater than was formerly supposed.

Until, however, we know not only how one species is derived from another, but which particular genera and species have given rise to other genera and species, it is not probable that we shall be able to settle the matter finally. Was *Eritrichium nanum* derived from a species of *Myosotis?* Did *Anemone alpina* originate from *Anemone pulsatilla*, or perhaps *A. vernalis?* These are questions to which at present there is no answer; and until we can decide such matters, we shall not see clearly on the subject of the origin of the Alpine flora of Switzerland.

APPENDIX I

GLOSSARY OF BOTANICAL TERMS

Absorption, the act of imbibing a liquid or a gas (see p. 10).

Achene, a dry, one-seeded, indehiscent fruit—*e.g.*, the individual fruits, commonly miscalled "seeds," of a Strawberry or Buttercup (p. 285).

Actinomorphic, the term used to describe a flower which can be divided into two symmetrical halves by two or more planes of symmetry, as opposed to Zygomorphic (*q.v.*).

Acyclic, a term used to describe a flower whose parts are arranged spirally instead of in whorls; *cf.* Cyclic.

Adhesion, the union of dissimilar parts of the flower, such as the petals and sepals; *cf.* Cohesion.

Adventitious Roots, those which arise as outgrowths from the stem or leaves, and are not branches of the main root.

Alkaloid, a general term applied to organic bases, which occur in many plants; *cf.* Aconitine (p. 130).

Alternate, applied to leaves which are arranged spirally on the stem, and are not opposite to one another. Also known as scattered.

Analogous, having the same function, but not necessarily the same structure; *cf.* Homologous.

Androecium, the male organs or stamens of a flower, considered as a whole.

Anemophilous, a term applied to flowers which are cross-pollinated by the agency of wind; *cf.* Entomophilous.

Angiosperm, a Flowering Plant whose ovules are enclosed in ovaries. The term is used in opposition to Gymnosperm (*q.v.*).

Annual, a term used to describe plants which pass through their whole life-history in one year, and then die.

Anther, the upper portion of the stamen consisting of the pollen-sacs and the tissue between them.

Apetalous, without petals, or with very small rudimentary petals—*e.g.*, the flowers of the Willow.

Apocarpous, applied to the gynæceum of a flower in which all the carpels are free from one another—*e.g.*, the Marsh Marigold (*Caltha*).

Aquatic, living in water.

Asexual, a term applied to reproduction by means of organs other than the stamens and carpels—*e.g.*, Bulbils of *Polygonum viviparum* (p. 156).

Assimilation, the process by which the plant converts raw food material into its own substance. The term is used especially in reference to **Carbon Assimilation**—that is to say, the formation of organic substance from carbon dioxide and water by green plants in sunlight (p. 10).

Association, a community of plants living together (p. 32).

Awn, a prolongation of an organ, usually thread-like; *cf.* the awned fruits of *Anemone alpina* (p. 39).

Axil, the angle formed, on the upper side, at the point of attachment of a lateral organ to the main organ—*e.g.*, the angle above the attachment of a leaf to the stem.

Axis, a term generally used to imply the stem. The root may also be termed an axis. Such organs as leaves are appendages of the axis.

Berry, an indehiscent fruit, containing several seeds surrounded by a juicy or fleshy pulp—*e.g.*, the Bilberry and Gooseberry.

Biennial, a plant which requires two years to complete its life-history. In the second year it produces flowers and fruit, and then dies.

Bisexual = **Hermaphrodite** (*q.v.*).

Bract, the leaf or modified leaf on the axis of an inflorescence, in the axil of which the flower arises. (The bracts are often entirely suppressed, as in the Crucifer family.)

Bracteole, the leaf, or one of the leaves, borne on the axis of the flower itself, above the bract and below the flower. (Bracteoles are often entirely absent) (p. 225).

Bud, a short stem axis, crowded with overlapping, young, undeveloped leaves, arising close to one another.

Bulb, a modified stem, often subterranean and disc-like in form, bearing a number of succulent leaves, containing reserve materials—*e.g.*, an Onion or a Lily bulb.

Bulbil, a deciduous bud, capable of reproducing the species, and often containing reserve materials (p. 156).

Calcicole, applied to plants which flourish best on calcareous (limestone) soils (p. 117).

Calcifuge, applied to plants which will not grow on calcareous (limestone) soils (p. 117).

Calyx, the sepals of a flower considered as a whole; the outer series of a differentiated floral envelope (generally green).

Capitulum, or **Head**, a type of inflorescence in which all the flowers are stalkless, and arranged on a terminal expansion of the axis—*e.g.*, the inflorescence of the Compositæ.

Capsule, a many-seeded dry fruit, composed of two or more carpels, which open in various ways to allow the seeds to escape (p. 88).

Carpel, the modified leaf, bearing and enclosing the ovules. The pistil consists of one or several carpels, which may be free or united together.

Catkin, a close spike of unisexual apetalous flowers, which may be shed as a whole—*e.g.*, Willow Catkins (p. 189).

Cells, the ultimate units of which plant tissues are built up (p. 8).

Cell Sap, the watery contents of the cell.

Chalk-gland, a glandular tissue secreting water and calcium carbonate (p. 76).

Chlorophyll, the green colouring matter of plants. It is generally localised in special granules within the cells, known as chlorophyll corpuscles or **Chloroplasts** (p. 10).

Chromoplasts, special portions of the protoplasm containing colouring matter (p. 45).

Claw, the narrowed base of the petal.

Cleistogamous, flowers which never open, and which are self-fertilised (p. 278).

Cohesion, the union of similar parts of the flower, such as the union of all the petals; *cf.* Adhesion.

Cone, as applied to the Coniferæ, the fertile shoots, bearing spirally arranged scales subtending carpels or bearing the pollen sacs (p. 235).

Coniferæ, the group of plants, including the Pines and Firs, which bear fertile shoots or cones (*q.v.*) of a special type.

Connective, the part of the stalk or filament of the stamen connecting the two pairs of pollen sacs.

Contractile Roots, special roots which pull the stem down into the soil (p. 122).

Corm, or solid bulb, is a modified swollen underground stem which serves as a storehouse for reserve food material. It is often covered externally with scale-leaves (pp. 153, 166).

Corolla, the petals of a flower considered as a whole; the inner series of a differentiated floral envelope, usually white or coloured.

Corona, an outgrowth from the corolla or perianth—*e.g.*, the " trumpet " of a Daffodil.

Cotyledon, the first or one of the first pair of seed-leaves produced by a young seedling plant (p. 83).

Cross-fertilisation, the act of impregnation of the egg or ovum of one flower by the male gamete (*q.v.*) of another flower (pp. 52, 268).

Cross-pollination, the dusting of the stigma of one flower by the pollen brought from another (p. 268).

Crustaceous, forming a crust, closely adherent to the substratum—*e.g.,* Crustaceous Lichens (p. 292).

Cyclic, a term applied to leaves or parts of a flower arranged in whorls; *cf.* Acyclic.

Cyme, a form of inflorescence in which the main axis ends in a flower, and the succeeding flowers are produced on successive, lateral axes. A cyme is also called a centrifugal inflorescence, because the oldest flower is placed centrally —*e.g., Lychnis* (p. 225).

Deciduous, applied to those plants whose leaves do not persist from year to year (*cf.* Evergreen), but are shed each autumn.

Decurrent, applied to leaves which are prolonged downwards on the axis—*e.g.,* leaves of Thistles.

Dehiscent, opening at one or more points so as to allow the contents to escape. Applied to fruits and pollen sacs.

Dichasium, a form of cyme, in which two lateral branches of nearly equal strength arise below the flower which terminates the main axis. These lateral branches may each again give rise to two branches, and so on.

Dichogamous, a term applied to flowers in which the stamens and carpels ripen at different times, and thus self-pollination is prevented.

Dicotyledon, a plant having two seed-leaves. The Dicotyledons form the majority of the flowering plants; *cf.* Monocotyledon.

Dioecious, unisexual male and female flowers borne on different plants (p. 189).

Dimorphism = Heterostylism, flowers of two or more forms

differing in the relative lengths of the stamens and styles —*e.g.*, *Primula*, *Lythrum* (p. 68).

Disc-florets, the flowers occurring in the central portion of the capitulum of the Compositæ; *cf.* Ray Florets.

Drupe, a fleshy, indehiscent fruit, containing one or more seeds. The outer fruit-coat is fleshy or pulpy, the inner is hard and stony—*e.g.*, a Cherry and a Peach (pp. 231-2).

Ebracteate, without bracts (*q.v.*).

Ecology, or **Œcology,** the study of plant life in relation to its environment.

Emergence, an outgrowth from the surface tissues of a plant organ, such as a prickle on a rose stem.

Endosperm, the store of food material laid up in certain seeds outside the embryo. The embryo absorbs it during its germination—*e.g.*, the horny part of a grain of maize.

Entire, applied to leaves the margins of which are not toothed.

Entomophilous, a term applied to flowers which are cross-pollinated by the agency of insects; *cf.* Anemophilous.

Epicalyx, the outer series of a double calyx—*e.g.*, in *Potentilla, Dryas, Fragaria* (pp. 128, 158).

Epigynous, applied to flowers in which the calyx tube completely encloses the ovary, and the corolla and stamens appear to be placed on the top of the ovary.

Epipetalous, applied to stamens borne upon petals (p. 64).

Epiphyte, a plant which grows upon another plant, but is not a parasite (p. 291).

Etiolation, the condition of a plant which has been grown in absence of sunlight. The stems are long and weak, the leaves small, and the colour is yellowish-white instead of green.

Evergreen, a term applied to leaves which last for more than one season, and to plants bearing green foliage all the year (p. 25).

Exalbuminous, applied to seeds which have no endosperm, and in which the embryo occupies the whole cavity of the seed.

Exstipulate, possessing no stipules.

Extra-floral, outside the flower.; a term applied to some nectaries which are situated on leaf-stalks, etc., instead of in their usual position within the flower (p. 276).

Extrorse, applied to anthers which are so turned that they open outwards, away from the centre of the flower.

Family = Natural Order (*q.v.*).

Ferment, a substance in the plant which produces chemical changes, without itself contributing to the resulting products (p. 214).

Filament, the stalk of a stamen.

Flaccid, limp, flabby, as opposed to turgid (*q.v.*).

Floral envelope, the modified leaves surrounding the stamens or carpels, or both, in a flower, and placed below them. It may be undifferentiated (a perianth) or differentiated into calyx and corolla.

Floral leaf, a leaf modified to form one of the parts of a flower —*e.g.*, a sepal, a petal, a stamen, or a carpel.

Flower, a shoot bearing modified leaves devoted to sexual reproduction. The flower may consist of stamens or carpels alone, or both, with or without a floral envelope. In a hermaphrodite flower the stamens are always placed below the carpels.

Follicle, a dehiscent fruit, composed of a single carpel containing several seeds.

Fruit, the ripened carpel or carpels of a single flower, enclosing one or more seeds.

Function, the part or rôle performed by any organ—*e.g.*, reproduction is the function of the flower.

Gall, an abnormal growth, caused by an insect or a fungus (p. 290).

Gamete, the sexual unit, male or female, consisting of a naked mass of protoplasm, motile or non-motile.

Gamopetalous, applied to flowers in which the petals are all united together; *cf.* Polypetalous.

Genus (plural **Genera**), a group or collection of nearly related species, possessing certain characters in common by which they are distinguished from other groups or genera (pp. 15, 249).

Geophilous; see **Geophyte.**

Geophyte, a plant which develops its aërial organs more or less completely beneath the surface of the soil (see p. 125).

Germination, the first act of growth of a seed.

Glabrous, without hairs.

Gland, a definite secreting organ, usually superficial (p. 212).

Glandular Hair, a hair with an enlarged apex, containing a secretion (pp. 72, 99).

Globose, spherical.

Gymnosperm, a flowering plant whose ovules are not enclosed in carpels; *cf.* Angiosperm. The Gymnosperms include the Coniferæ (*q.v.*).

Gynæceum, the carpels or female organs of a flower, considered as a whole.

Habit, the external form of the plant, its shape or build.

Habitat, the particular kind of locality in which a plant flourishes—*e.g.*, a marsh, a forest.

Head of Flowers = **Capitulum** (*q.v.*).

Herbaceous, not woody.

Hermaphrodite, applied to flowers which possess both male and female organs.

Heterostylism; see **Dimorphism.**

Holophyte, a plant which obtains all its own nourishment itself, and does not live parasitically or saprophytically.

Homologous, having the same type of structure, but not necessarily the same function; *cf.* Analogous.

Honey, or **Nectar,** the substance secreted by many flowers to attract insects.

Honey-glands, the organs which secrete honey.

Humus, decomposing organic matter in the soil (pp. 119, 143).

Hybrid, a cross between two species or races (p. 70).

Hypogynous, applied to flowers in which the calyx and corolla arise directly from the receptacle and in which the ovary is superior.

Imbricated, overlapping, like the tiles on a roof.

Indehiscent, applied to fruits which do not open to allow the seeds to escape; *cf.* Dehiscent.

Inferior, applied to the ovaries of those flowers in which the calyx tube encloses the ovary, as in epigynous and some perigynous flowers; *cf.* Superior.

Inflorescence, the mode of branching of the floral axis; the manner in which the flowers are arranged on the primary and lateral shoots.

Insectivorous, applied to plants which capture insects and absorb nutriment from them.

Internode, the portion of the axis between the insertion of two successive leaves (p. 191).

Introrse, applied to stamens in which the anthers open inwards, towards the centre of the flower.

Involucre, the whorl or rosette of bracts below an inflorescence or a single flower (see pp. 35, 111).

Irregular = **Zygomorphic** (*q.v.*).

Keel, a term applied to the two lower, united petals of the flowers of members of the Leguminosæ.

Labellum, or **Lower Lip,** applied to the enlarged and irregularly shaped member of the inner whorl of perianth members in the Orchids (p. 137), and to a similarly placed petal in other flowers.

Lamina, the blade of a leaf.

Lichens, a group of thalloid plants, consisting of Algæ associated with Fungi (see p. 291).

Loculus, the cavity of an ovary or anther.

Monocotyledon, a plant having only one seed-leaf. Lilies, Crocuses, and many other bulbous and tuberous plants, with the Grasses and Rushes, come under this heading; *cf.* Dicotyledon.

Monœcious, applied to plants which bear unisexual male and female flowers on the same plant.

Natural Order, or **Family,** a collection or group of nearly related genera, possessing certain characters in common, whereby they can be distinguished from other groups. Sometimes the order contains only one genus.

Nectar = Honey (*q.v.*).

Nectary, an organ secreting honey or nectar (pp. 272, 273).

Nitrogenous, containing nitrogen.

Node, the point of insertion of a leaf on an axis (p. 191).

Nut, a dry, indehiscent fruit with a woody pericarp—*e.g.,* Hazelnut.

Offset, the bud formed at the end of a runner or stolon (p. 100).

Opposite, applied to leaves which are arranged in pairs at the same level on the stem; *cf.* Alternate.

Organ, a part of a plant which serves a definite function—*e.g.,* a leaf, a stamen.

Ovary, the female portion of the flower, consisting of one or more closed carpels, enclosing one or more ovules.

Ovule, the female organ enclosed in the ovary, which when fertilised becomes a seed.

Panicle, a branched raceme (*q.v.*).

Pappus, the hairs or scales developed at the summit of the fruits of many Compositæ. Derived originally from the calyx—*e.g.,* Dandelion fruits.

Parasite, a plant living in or on another plant (the host), from which it derives part or all of its food-supply (p. 287).

Parthenogenesis, the development of an embryo from an ovule without fertilisation (p. 279).

Pedicel, the stalk of a single flower of an inflorescence.

Peduncle, the stalk of an inflorescence or of a solitary flower.

Perennial, a plant which lives for more than two years and does not perish after producing flowers and fruit, but flowers again the succeeding season; *cf.* Biennial and Annual.

Perianth, a floral envelope, not differentiated into two distinct series, calyx and corolla.

Pericarp, the wall of the ovary as developed in the fruit.

Perigynous, applied to flowers where the calyx tube surrounds, but does not enclose, the ovary.

Petal, a unit of the corolla, or inner series of a differentiated floral envelope.

Petiole, a leaf stalk.

Phanerogam, a Flowering Plant; a wide term, including the Gymnosperms and Angiosperms.

Phyllotaxis, the plan of arrangement of the leaves on the stem.

Pistil = **Gynæceum** (*q.v.*).

Pollen, the yellow dust formed in the anthers of the stamens; the male spores which produce the male gametes.

Pollen-grains = **Pollen.**

Pollen sac, the sporangium or sac in which the pollen-grains are formed in the anther.

Pollination, the act of dusting the stigmatic surface of the pistil with pollen.

Pollinium, the pollen mass of an Orchid (p. 138).

Polygamous, bearing hermaphrodite and unisexual flowers on the same or different individuals of the same species.

Polypetalous, applied to flowers in which the petals are free from one another; *cf.* Gamopetalous.

Prickle, a pointed Emergence (*q.v.*).

Protandry, the form of dichogamy, in which the male organs (andrœcium) mature before the female (gynæceum).

Protogyny, the form of dichogamy in which the female organs (gynæceum) mature before the male (andrœcium).

Protoplasm, the viscous or jelly-like substance, which forms the essential part of the "cells" or individual units of which all living creatures, both plants and animals, are built up (p. 9).

Raceme, a simple inflorescence in which stalked flowers are borne laterally on a central axis, the oldest flowers being at the base.

Rachis, the axis of a compound leaf.

Ray Florets, the outer flowers of the capitulum of the Compositæ, which often differ from the Disc Florets (*q.v.*).

Receptacle, the portion of the axis of the flower which bears the floral envelope, and the male and female organs; the axis bearing the florets in the Compositæ (p. 18).

Regular = Actinomorphic (*q.v.*).

Reserves, food material stored in the plant for future use (p. 11).

Respiration, the gaseous exchange between a plant and the atmosphere, corresponding to the breathing of animals. Oxygen is absorbed and carbon dioxide given out (p. 11).

Rhizome, a creeping or prostrate, subterranean stem, bearing erect, leafy shoots.

Root-stock = Rhizome (*q.v.*).

Rosette, applied to a group of leaves, arranged in a very close spiral, the internodes between them being very short (p. 75).

Runner, a slender, prostrate stem-branch, usually rooting (p. 100).

Saprophyte, a plant deriving its nourishment from decaying organic matter (p. 287).

Scale, a disc-like outgrowth, usually of superficial origin, especially on leaves (p. 26).

Scale-leaves, reduced leaves which have generally only a protective (p. 167) or storage function.

Scape, a floral axis arising from the ground, and terminating in a single flower—*e.g.*, Daffodil.

Schizocarp, a splitting fruit, in which the pericarp divides into two or more one-seeded portions.

Seed, a fertilised ovule.

Seed-coat, a covering of the seed, derived from one or more integuments of the ovule (pp. 265, 266).

Selective Capacity, the power possessed by roots of selecting certain special substances from among those in solution in the soil (p. 77).

Self-pollination, the act of placing the pollen of one flower on the stigma of the same flower. This results in self-fertilisation (pp. 52, 278).

Semiparasite, a plant deriving part of its nutriment from the tissues of another plant; *cf.* Parasite (p. 218).

Sepal, a unit of the calyx, or outer series of a differentiated floral envelope.

Sessile, stalkless.

Shade-leaves, leaves growing under conditions of poor illumination (pp. 84, 247, 253).

Shrub, a woody perennial, without an erect or main trunk.

Spadix, a fleshy spike.

Spathe, a sheath-like leaf, enveloping an inflorescence.

Species (plural **Species**), a classificatory unit; a unit of a genus; one sort or kind of plant (pp. 15, 249).

Sperms = male gametes (*q.v.*).

Spike, a simple inflorescence, in which the flowers are stalkless and attached directly to a central axis; a sessile raceme.

Spiral = Acyclic (*q.v.*).

Sporangium, a sac containing spores.

Spur, a prolongation of a perianth member, usually tubular.

Stamen, an individual member of the andrœcium ; the male leaf of a flower.

Staminode, a modified stamen, no longer pollen producing ; a reduced stamen (p. 217).

Standard, a term applied to the large, upper petal of a Leguminous flower.

Stigma, the receptive portion of the pistil, on which the pollen is deposited.

Stipulate, possessing stipules.

Stipules, the paired appendages (often leaf-like) occurring at the base of some leaves.

Stolon = Runner (*q.v.*).

Stoma (plural **Stomata**), a pore or minute opening in the outer layer (epidermis) of a leaf (p. 10).

Style, the upper portion or portions of the pistil, bearing the stigma or stigmas.

Sun-leaves, leaves growing under conditions of strong illumination (p. 84).

Superior, a term applied to an ovary which is free from, or not enclosed by, the floral envelope ; *cf.* Inferior.

Symbiosis, the living together of two *dissimilar* organisms : either two plants or animals, or a plant and an animal (p. 293).

Sympetalous = Gamopetalous (*q.v.*).

Syncarpous, applied to the gynæceum of a flower, in which the carpels are united together to form a single ovary.

Teeth, minute, pointed lobes on the margins of leaves.

Tendril, a special organ, usually thread-like, adapted for climbing.

Thallus, a vegetative body without differentiation into stem and leaf.

Transpiration, the act of giving off water from the leaves of a plant. The water passes off in the form of vapour, through the pores or stomata (p. 12).

Tuber, a short, thick, underground stem, stored with food material.

Turgid, distended with sap.

Umbel, an inflorescence in which the flowers are stalked, the stalks all radiating from a common point on the axis (p. 42).

Unisexual, applied to flowers which contain either male or female organs, but not both (p. 39).

Variation, a departure from type (p. 47).

Versatile, applied to anthers which are balanced on the filament, and so swing freely.

Viviparous, germinating while attached to the parent plant (p. 157).

Water-stomata, special pores on the leaves of some plants which exude water (p. 76).

Whorled, applied to foliar and floral leaves, which are arranged in a circle, at one level on the axis.

Wing, a prolongation of a seed or fruit; the lateral petal of a Leguminous flower.

Zygomorphic, applied to flowers, which are not divisible into two similar halves in more than one plane of symmetry.

APPENDIX II

THE STRUCTURE OF THE FLOWER

THE botanist's idea of what constitutes a flower is not exactly the same as that implied in our common speech. Even small, green, inconspicuous objects, such as the little structures which go to make up a Willow catkin, come under the botanical category of flowers, though they do not possess the brightly-coloured, expanded petals which are ordinarily associated with the word. The definition of a flower, from a botanical standpoint, is that it is a shoot, bearing leaves specialised for purposes of reproduction. The shoot is, as it were, telescoped, so that the floral leaves, instead of being separated from one another, like the leaves on an ordinary branch, are closely crowded together. This is not peculiar to flowers alone. The same thing happens in the crowded leaf rosettes of *Sempervivum* (Plate XXIV., Fig. 1) and other plants. The floral leaves are, however, not merely crowded on the shortened axis or receptacle, but they are also usually arranged in successive circles, known as whorls, instead of being in a continuous, spiral series.

Let us now examine the floral leaves, and notice how they are modified for the ultimate purpose of setting seed, which will reproduce the plant. Starting from the outside of the flower—in other words, from the base of the floral shoot—we first meet with a group of leaves, the *perianth*, which have

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nothing directly to do with reproduction, but at the same time are of great indirect value in connection with it. The perianth leaves may be all alike (*cf.* Crocus, Text-fig. XXX.), or they may be differentiated into two series: an outer, known as the *calyx*, and an inner, the *corolla* (*cf.* Buttercup, Text-fig. XXVI.).

The individual members of the calyx are called *sepals*. They are commonly green, and more nearly resemble ordinary foliage leaves than do any other of the parts of the flower. In some cases, as in the Rose, they may be remarkably leaf-like. The purpose which they serve in the economy of the flower is that of protection. In the bud, they commonly enclose all the other floral parts. The corolla consists of *petals*, which usually differ from the sepals in being larger and more delicate in texture, and either white or gaily coloured, instead of green. Like the sepals, they enclose and protect the rest of the flower, but in a very large number of cases they have another and more special function—namely, that of attracting insects to visit the flower, for a purpose to which we will return later.

Immediately within the petals, we meet with the first of the "essential organs" of the flower—namely, the group of *stamens* constituting the *andrœcium*. Each stamen consists of a slender stalk or *filament*, terminating in a head or *anther* of four little sacs, two on each side of the *connective*, as the top of the filament is called. The stamen, like the other parts of the flower, may be regarded as a metamorphosed leaf. In some flowers, such as that of the White Waterlily, the leafy nature of the stamens is particularly obvious. The object of the stamen's existence is the production of the yellow dust, known as *pollen*, with which the anther sacs are filled. When the stamens are ripe, the anthers open in various ways, and the pollen escapes. The stamens are the *male organs*, and the pollen gives rise to the *male gametes* or *sperms*, without whose aid no seeds can be set. We will return to the subject of the fate of the pollen after considering the pistil.

The central structure of the flower is the female organ, which is known as the *pistil* or *gynœceum*. As the andrœcium is made up of stamens, so the gynæceum is made up of one or more *carpels*, either free or more often fused together. Each carpel may be regarded as essentially a leaf, bearing immature seeds, or *ovules* as they are called, along its margin. Its nature is, however, obscured by the fact that the edges of the leaf are fused together, so as to enclose the ovules. The structure of a pistil, consisting of a single carpel, can be best understood by splitting open a pea-pod, down the edge along which the peas are attached. The pod, when opened out, is seen to be only slightly changed from a leaf folded along its midrib.

The part of the carpel which contains the ovules is called the *ovary*. It is prolonged upwards, as a columnar or thread-like outgrowth, called the *style*, which terminates in a special portion intended for the reception of the pollen grains, and known as the *stigma*. The stigma is frequently hairy or sticky, so as more easily to catch and retain the pollen grains.

A better crop of seeds is usually produced when pollen from another flower is deposited on the stigma—or in other words, when *cross-fertilisation*, and not *self-fertilisation*, takes place. Cross-pollination is brought about either by the arrival of pollen blown by the wind, or brought by insect visitors which, attracted by the coloured perianth or by a sweet scent and a prospect of honey, fly from flower to flower, and thus unintentionally convey the pollen of one flower to the stigma of another.

When the pollen-grain reaches the receptive surface of the stigma, it grows out into a long slender tube (only visible under the microscope), which travels down the tissues of the style into the cavity of the ovary, and, advancing towards one of the ovules, enters it by a tiny aperture in its outer coat. The male fertilising element, or *sperm*, passes down the tube, enters the ovule, and fuses with a cell within it known as the

egg-cell. The next generation may be said to begin with the fertilised egg-cell, which develops into a plant embryo.

The form of the embryo, at the stage when it is ready to begin independent life, may be seen by examining a ripe pea. Within the seed-coat we find two thick, whitish bodies, which occupy nearly the whole of the interior and are known as the *cotyledons.* Between them we can see a tiny root (*the radicle*), and a bud which will form the leafy shoot (*the plumule*). The cotyledons are really the two first leaves of the young plant, which have given up the usual form and appearance of leaves in order to act as storehouses of food material for the young plant to draw upon before it has expanded its green leaves and can nourish itself independently.

In other cases, such as the wheat and the coffee-bean, the embryo does not occupy the whole interior of the seed, but lies more or less embedded in a store of food material which is known as the *endosperm.* The cotyledons do not in these cases store the food themselves, but they have the power of sucking it out of the endosperm.

The Flowering Plants are divided into two main groups, the *Dicotyledons* and *Monocotyledons*, according as their seedlings have two seed leaves, or only one. These two groups also differ in floral characters. For instance, the dicotyledonous flower has, as a rule, four or five parts in each whorl, and the perianth is often differentiated into calyx and corolla, while the monocotyledonous flower has its parts in threes, and the perianth is undifferentiated.

We must now return to our description of flower structure, and consider some of the chief modifications which the general type may undergo. A typical flower contains both gynæceum and andrœcium, and is called *hermaphrodite.* But it is possible to have *unisexual* flowers, which may be either wholly male, or wholly female. This is brought about by the suppression either of the gynæceum or andrœcium

(cf. *Veratrum*, p. 123, and *Dianthus*, p. 113). Sometimes both male and female flowers occur on the same plant, which is then termed *monœcious*. In other cases, specialisation is carried still further, one plant bearing only male, and another only female, flowers. Such plants are described as *diœcious*.

Apart from the actual loss of one or other of the " essential organs," there are several other directions in which flowers have become modified. One of these is the *union* of *similar* members. For instance, when the sepals or the petals are free from one another, the flowers are called *polysepalous* or *polypetalous*, but these members may unite among themselves, and then the flowers are termed *gamosepalous* or *gamopetalous*. The stamens, again, may unite by their filaments into a single group, when they are called *monadelphous*, or into several groups, *di-*, *tri-*, or *polyadelphous*. If they unite by their anthers, they are spoken of as *syngenesious*.

In describing the gynæceum, we took a pea-pod as a typical illustration of a carpel. Many gynæcea, however, consist of more than one carpel. These carpels may either be free, as in the Buttercup (Text-fig. XXVI.), or fused together more or less completely. In the Saxifrage (Text-fig. XXVIII.), the two carpels are united in the ovary region, but the styles and stigmas are free; in the Crocus (Text-fig. XXX.), the fusion has gone further, and only the three stigmas are free; while in the Primula (Text-fig. V.), in which there are five carpels, they are completely fused throughout. A gynæceum consisting of fused carpels is spoken of as *syncarpous*.

Another way in which the flower may become modified is through the *union* of *dissimilar* members. For instance, the stamens, instead of growing freely from the receptacle, are sometimes united for the greater part of their length with the corolla (*cf.* Primula, Text-fig. V.). A more profound modification is brought about by the hollowing out of the top of the receptacle, and its union with the lower part of the

calyx. This produces the calyx cup, which is very well seen in the Rose. The gynæceum is enclosed in the *calyx cup*, or, as it is sometimes called, the *receptacular cup*, and the stamens, petals, and free parts of the sepals arise from the edge of it. This kind of flower is called *perigynous*, while the simpler type, in which the receptacle is more or less conical, is called *hypogynous* (*cf.* Buttercup, Text-fig. XXVI.).

As a further development, the gynæceum may fuse completely with the calyx tube, so that all the floral parts appear to grow on the top of the ovary (*cf.* Crocus, Text-fig. XXX., and Groundsel, Text-fig. XXIX). The flower is then said to be *epigynous*, and the ovary *inferior*.

Besides the floral parts which we have mentioned, special structures called *nectaries* occur in some flowers. These take various forms, but agree in one essential feature—namely, that they secrete *honey*. In many flowers the nectaries are modified stamens, as in the Globe-flower (p. 207), where they are horn-shaped structures. In this case the modified stamen both secretes the honey, and forms a receptacle to hold it. In the Pansy, on the other hand (Text-fig. XV.), processes from two of the stamens secrete the honey, which drops into a spur-like receptacle, hollowed out of the base of the front petal. In the Lesser Butterfly Orchid (Text-fig. XI., 1), one of the perianth members is spurred like the Pansy; but here it is the tissue of the spur itself which secretes the honey. In the Buttercup (Text-fig. XXVI., 2), honey oozes out from a patch of glandular tissue concealed behind a little scale at the base of the petal.

Starting from such a flower as the Buttercup, there seem to be several lines along which evolution may proceed. One of the most important steps involves the union of the petals—that is to say, polypetaly is replaced by gamopetaly. On the other hand, the plant, instead of becoming more highly evolved in regard to the corolla, which aims at the attraction of insects, may decide to dispense with it altogether, or to reduce it to

a merely protective structure.   In so doing, it must give up the idea of insect-pollination in favour of self-pollination or wind-pollination.

These distinctions are made use of in classification.   The *Dicotyledons* fall into three classes, known as the *Polypetalæ*, *Gamopetalæ* and *Apetalæ*, according to whether their petals are free, united, or absent.   Within each of these groups we find another tendency operating—namely, to proceed from a *hypogynous* form of flower to a *perigynous*, and eventually to an *epigynous* type.

We may illustrate some of the chief varieties of floral
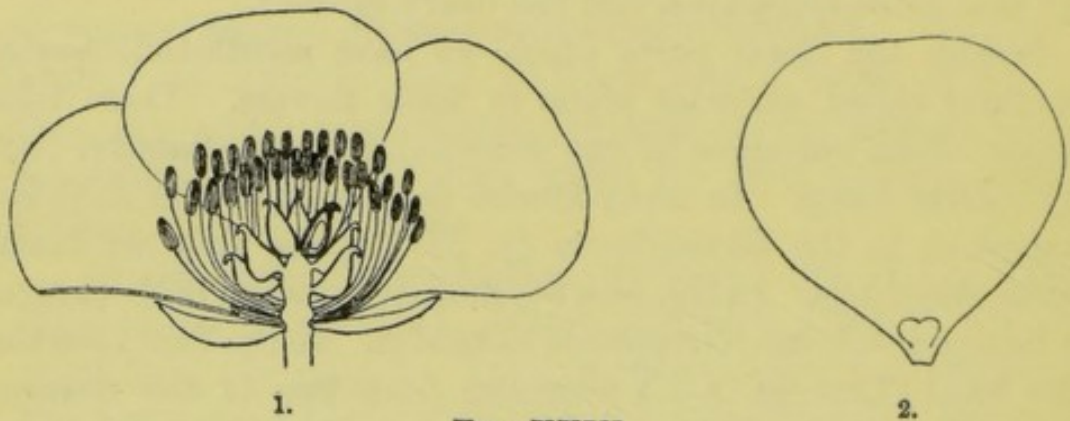
Fig. XXVI.

1. The Flower of a Buttercup (natural order Ranunculaceæ).
2. Petal of a Buttercup, showing the Honey-gland at the base.

structure by reference to five flowers, of which text-figures are given here.   Each diagram represents the flower cut in half longitudinally.   The Buttercup (Text-fig. XXVI.) is a *hypogynous* flower, *polysepalous* and *polypetalous*.   Both the stamens and carpels are numerous, and free from one another. Each carpel contains a single seed.   The Buttercup is called a regular flower, because all the parts of each whorl are alike in shape and size.

The next text-figure (XXVII.) represents a Pea flower, in which the five petals differ amongst themselves in size and

shape, giving an *irregular* flower, which is symmetrical about one plane only—namely, that seen in the figure. There are ten stamens, nine of which are united, while one remains free, and
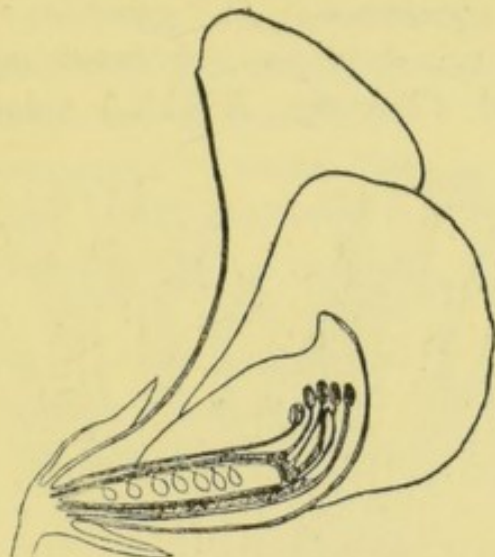
FIG. XXVII.—The Flower of a Pea (natural order Leguminosæ).

thus the andrœcium is *di-adelphous*. The result of one stamen being free is to leave a slit in the tube formed by the filaments, through which the insect visitor can pass its proboscis when
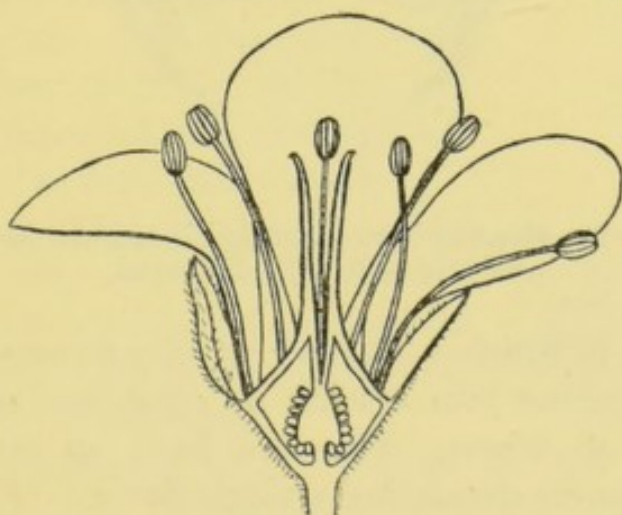
FIG. XXVIII.—The Flower of a Saxifrage (natural order Saxifragaceæ).

seeking for honey. The *gynœceum*, as we have already mentioned, is *monocarpellary* (see also p. 252).

In the Saxifrage (Text-fig. XXVIII.) we have an example of an incompletely *epigynous* flower. The petals and stamens grow from the edge of the *calyx tube*, which is fused with the lower part of the *gynæceum*. The *gynæceum* consists of two carpels, not unlike two short pea-pods fused together.

The Groundsel (Text-fig. XXIX.) belongs to a more
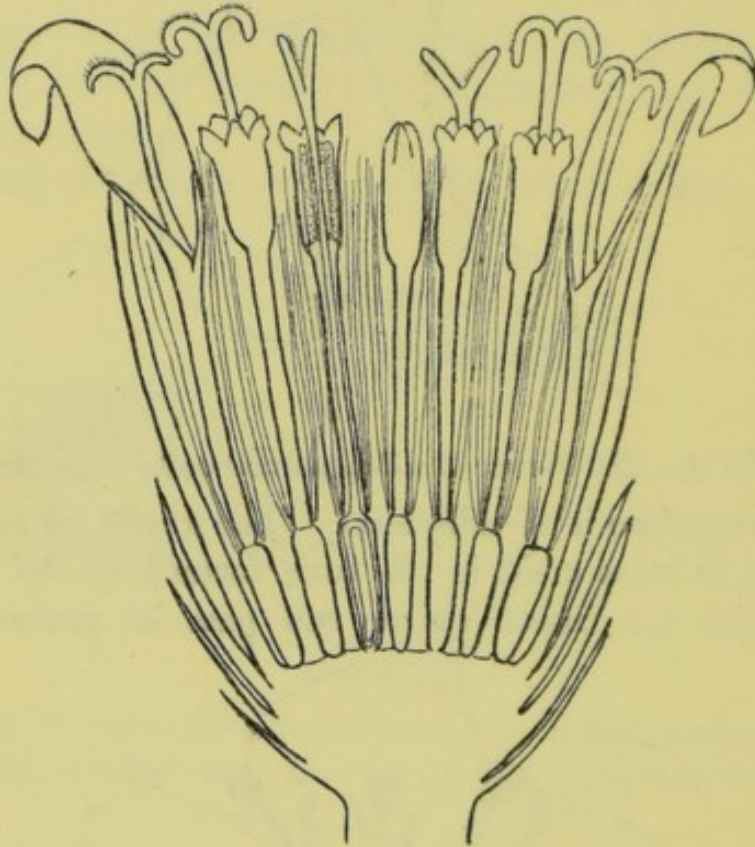
FIG. XXIX.—The Head of Flowers of the Groundsel, *Senecio* (natural order Compositæ). Enlarged.

advanced type, in which a number of tiny flowers or *florets* are all crowded together into a head or *capitulum*, surrounded by an *involucre* of bracts. Thus we have an *inflorescence* or collection of flowers simulating a single flower. The Groundsel is an example of the natural order Compositæ, to which the Edelweiss (Plate I., Fig. 1) also belongs. The flowers are all *epigynous*. The *calyx* is represented by hairs, which, later on,

make it easy for the wind to waft the fruits along and so distribute them in new situations. There are two types of floret, the outer or ray florets, which have strap-shaped *corollas* and no stamens, and the hermaphrodite disc florets, which have a symmetrical corolla of five united petals and five *epipetalous* stamens. The latter are *syngenesious*, and form a hollow cylinder round the style. The ovary, which contains a single ovule, is prolonged into a slender style, divided at the top into a bifid stigma. One disc floret is represented cut in half to show the stamens.

The Buttercup, Pea, Saxifrage, and Groundsel are all Dicotyledons. Text-fig. **XXX.** shows the flower of the Crocus, a *Monocotyledon*. Here the perianth, which is *epigynous*, is not differentiated into calyx and corolla, but the segments are all alike and coloured. The stamens are attached to the perianth tube. The three carpels are united and form the ovary and style, but the curious funnel-shaped and toothed stigmas are free from one another.

Among the Monocotyledons we find a great variety of flowers, showing *polypetaly*, *gamopetaly*, and *apetaly*, and also *hypogyny* and *epigyny*, precisely as among the Dicotyledons.

Fig. XXX.—The Flower of a *Crocus*. A typical Monocotyledonous Flower. (natural order Iridaceæ). Reduced.

The arrangement of the flowers on the plant is by no means haphazard. Sometimes the flowers arise singly, just as leafy branches may occur, in the axils of the leaves. This happens, for instance, in the Violets, but the fact is not obvious at first sight, because the stem and the leaf bases are hidden away

underground. In the Violets also, a pair of small, scale-like leaves occur part of the way up the flower-stalk or *peduncle*. Such simplified leaves are known as *bracteoles*.

In a very large number of plants the flowers occur in special groups, and then, instead of arising in the axils of ordinary foliage leaves, they commonly arise in the axils of simplified leaves, called *bracts*. Such aggregations or groups of flowers are known as *inflorescences*. Inflorescences fall under two heads: *indefinite* or *racemose*, and *cymose*. In the *racemose inflorescence*, the main axis does not end in a flower, and thus its growth can continue indefinitely. The older flowers are at the base, and the younger near the apex. A simple inflorescence of this type is called a *raceme* if each flower has a special *stalk* or *pedicel* (*cf.* Plate XLVII., fig. 1), and a *spike*, if each flower is *stalkless* or *sessile*, as in the Lesser Butterfly Orchid (Plate XXXI., fig. 2). If the *raceme* is complicated by branching, we have the form of inflorescence called a *panicle.* If the main axis of the inflorescence is suppressed altogether, so that all the pedicels start from one point, we get an *umbel* (*cf.* Plate XIII.); and if the pedicels also are suppressed, and the flowers are crowded together on a flattened expansion of the apex of the peduncle, we have a *head* or *capitulum* (Text-fig. XXIX.).

In the other type of inflorescence, the main axis terminates in a flower, and the younger flowers appear below it as lateral outgrowths. Such an inflorescence is known as a *cyme*. If two lateral flowering branches grow out below the first flower, we have a *dichasium*; if there is only one, a *monochasium*. When all the branches of a *monochasium* are developed on the same side, a *scorpioid* cyme is produced. Of this type of inflorescence the Forget-me-not is a good example.

APPENDIX III

BOOKS ON THE SWISS ALPINE FLORA

FLORAS

The best flora in *English* is

A. GREMLI'S *The Flora of Switzerland: For the Use of Tourists and Field-Botanists* (Translated from the Fifth German Edition by Leonard W. Paitson. David Nutt, 1889),

which is now, unfortunately, out of print. A useful book, however, is

K. W. v. DALLA-TORRE'S *The Tourist's Guide to the Flora of the Alps* (Translated and Edited by Alfred W. Bennett. Swan Sonnenschein, Le Bas & Lowrey, 1886. 5s.).

Both these works are handy for the pocket and for use in the field, the latter especially. Neither of them are, however, really suited to the lay reader, nor are they illustrated. Gremli's *Flora* is a standard work, written in technical botanical language, often severely contracted. The artificial system of Linnæus is made use of as a key to the genera, and this, while now an archaic contrivance, has its advantages. Gremli's flora includes not only the Alpine plants, but the whole vegetation of Lowland Switzerland.

Dalla-Torre's *Tourist Guide* is written, so far as possible, in non-technical language, which is not contracted. It is not confined to the Swiss Alpine flora, but treats of the Alpine

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floras of all the Western and Central European Mountains. The Lowland plants are not included.

Another useful work which may be recommended is

J. Hoffmann's *Alpine Flora: For Tourists and Amateur Botanists* (Translated by E. S. Barton (Mrs A. Gepp). Longmans, Green & Co., 1903. 7s. 6d. net).

This book deals only with Alpine plants, but is not confined to the Swiss Alps. The language is made as simple as possible. The book is illustrated by 40 coloured plates, containing 250 figures of typical Alpines, in execution of more than average merit. It is, however, rather large for the pocket, though not unwieldy.

The following works, in the absence of any satisfactory descriptive flora in English, couched in language intelligible to the layman, will be found very useful in Switzerland :—

Bentham & Hooker's *Handbook of the British Flora* (Reeve & Co. 7th Edition, 1908. 9s. net),

and the corresponding volume of plates by

Fitch & Smith—*Illustrations of the British Flora* (Reeve & Co. 7th Edition, 1908. 9s. net).

It contains descriptions of many Swiss Alpines which are also British plants, but of course a large number of Swiss species are not discussed. It is especially useful, however, for determining the families and genera.

The following work, consisting of coloured plates of Swiss Alpines,

C. & L. Schroeter's *Taschenflora des Alpen-Wandereres* (A. Raustein, Zurich. 7 fr. 50 c.),

enjoys a wide popularity in Switzerland, and is a very useful possession.

The photographs in

Somerville Hastings' *Alpine Plants at Home* (First Series. Gowans' Nature Books, No. 20. 6d. net),

afford excellent illustrations of many typical Swiss Alpines.

LARGER WORKS ON THE ALPINE FLORA

A large work in two volumes, with many coloured plates,

A. W. BENNETT's *The Flora of the Alps* (J. C. Nimmo, 1897.   15s. net),

may be consulted. It is written on much the same lines as Dalla-Torre's *Tourist Guide*, above mentioned, and also includes the Alpine floras of the various mountain ranges in Central and Western Europe.

Of the many recent works in German or French, the following may be mentioned :—

The latest Swiss flora (in German) is by

H. SCHINZ and R. KELLER : *Flora der Schweiz, zum Gebrauche auf Exkursionen, in Schulen, und beim Selbstunterricht* (A. Raustein, Zurich.   2nd Edition, 1905 ; 3rd Edition, 1909.   6 fr. 80 c.).

The work is in the highest degree technical, and the language contracted.   It is, however, a very complete account.

G. BONNIER and G. DE LAYENS' *Flore complète de la France et de la Suisse* (Paris, Librairie générale de l'Enseignement, 1908.   11 frs.),

is written with as few technical words as possible, and is well illustrated by over 5,000 figures.

WORKS ON THE NATURAL HISTORY, ECOLOGY, AND DISTRIBUTION OF SWISS ALPINE PLANTS

KERNER's *The Natural History of Plants* (Translated from the German by Prof. F. W. Oliver, in 2 or 4 large 4to volumes.   Cassell & Co. 1st Edition, 1894 ; 2nd Edition, 1905).

This great work, a most fascinating book, especially useful to the layman, contains in simple language a full account of plant life in the Alps, among much other information on plants generally.

C. SCHROETER's *Das Pflanzenleben der Alpen.   Eine Schilderung der Hochgebirgsflora* (A. Raustein, Zurich, 1908),

a thick volume, containing many illustrations, is of the highest value, especially from the ecological standpoint. It is to be hoped that it will one day be translated into French, if not into English. It is hardly suited, however, to the layman.

H. CHRIST's *Der Flora der Schweitz* (Translated into French by Tièche under the title *La Flore de la Suisse et ses Origines.* H. Georg: Bale, Geneva, Lyons. 2nd Edition, with Supplement, 1907),

is a standard work, especially on the distribution and origin of the Swiss Alpines.

For a summary of recent literature, especially by the Zurich School of Botany, on the ecology of the Swiss flora, see T. W. Woodhead, in the *Naturalist* for May and June 1908.

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(*For references to the technical terms mentioned in the text,*
see APPENDIX I., p. 307.)

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SOME IMPORTANT WORKS ON AGRICULTURE AND GARDENING

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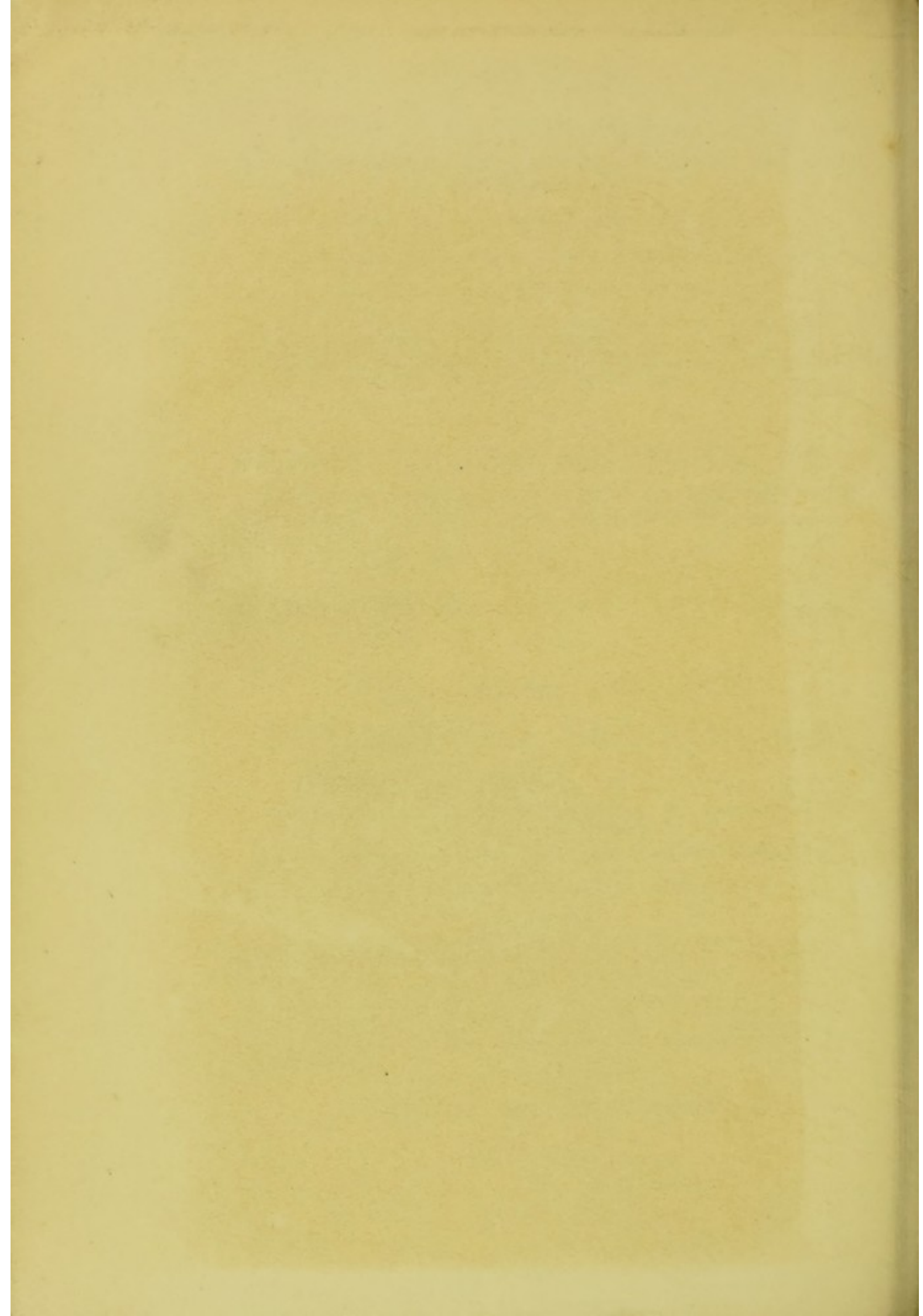DRAINAGE WATERS — THE FEEDING EXPERIMENTS — MISCELLANEOUS ENQUIRIES—
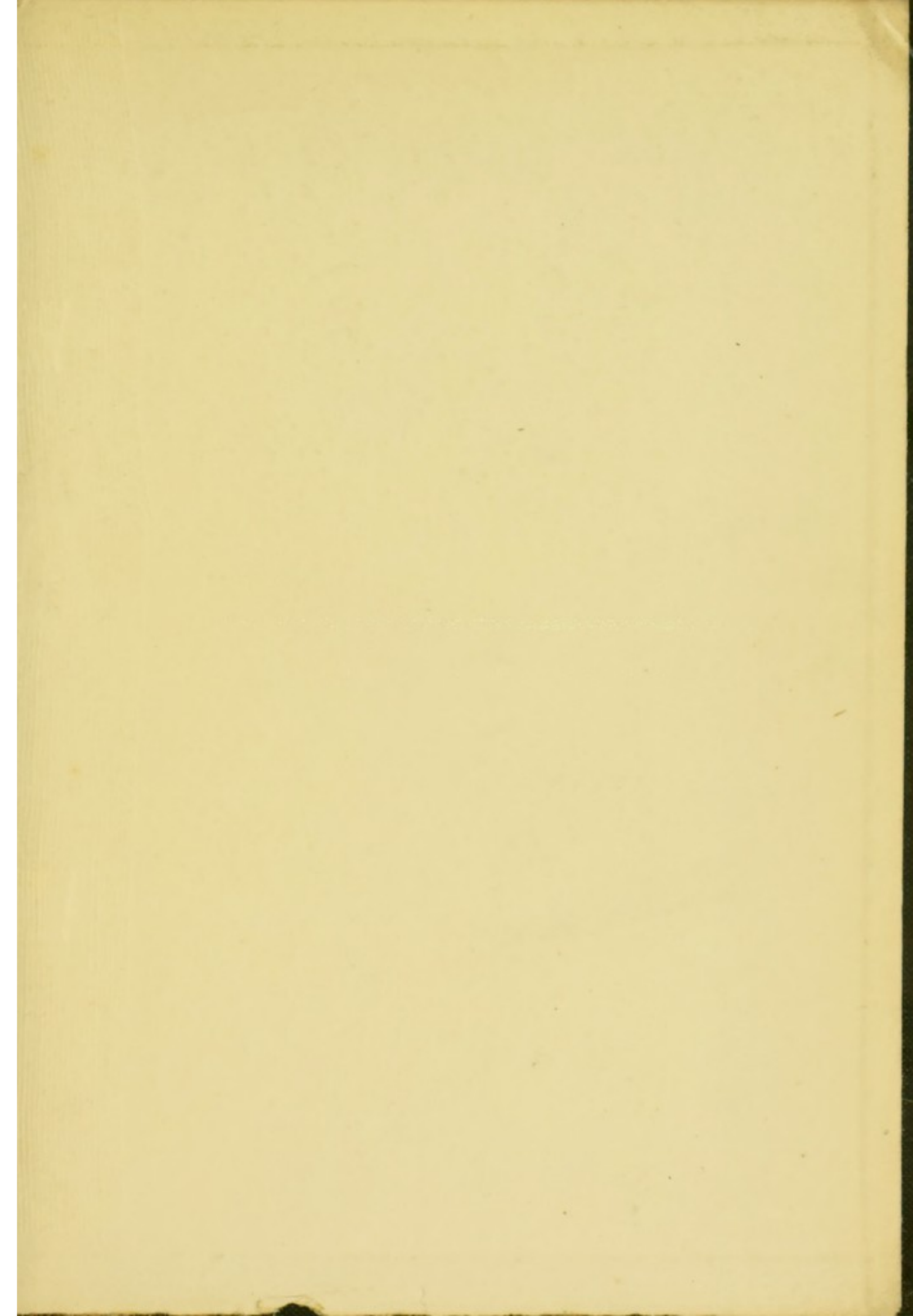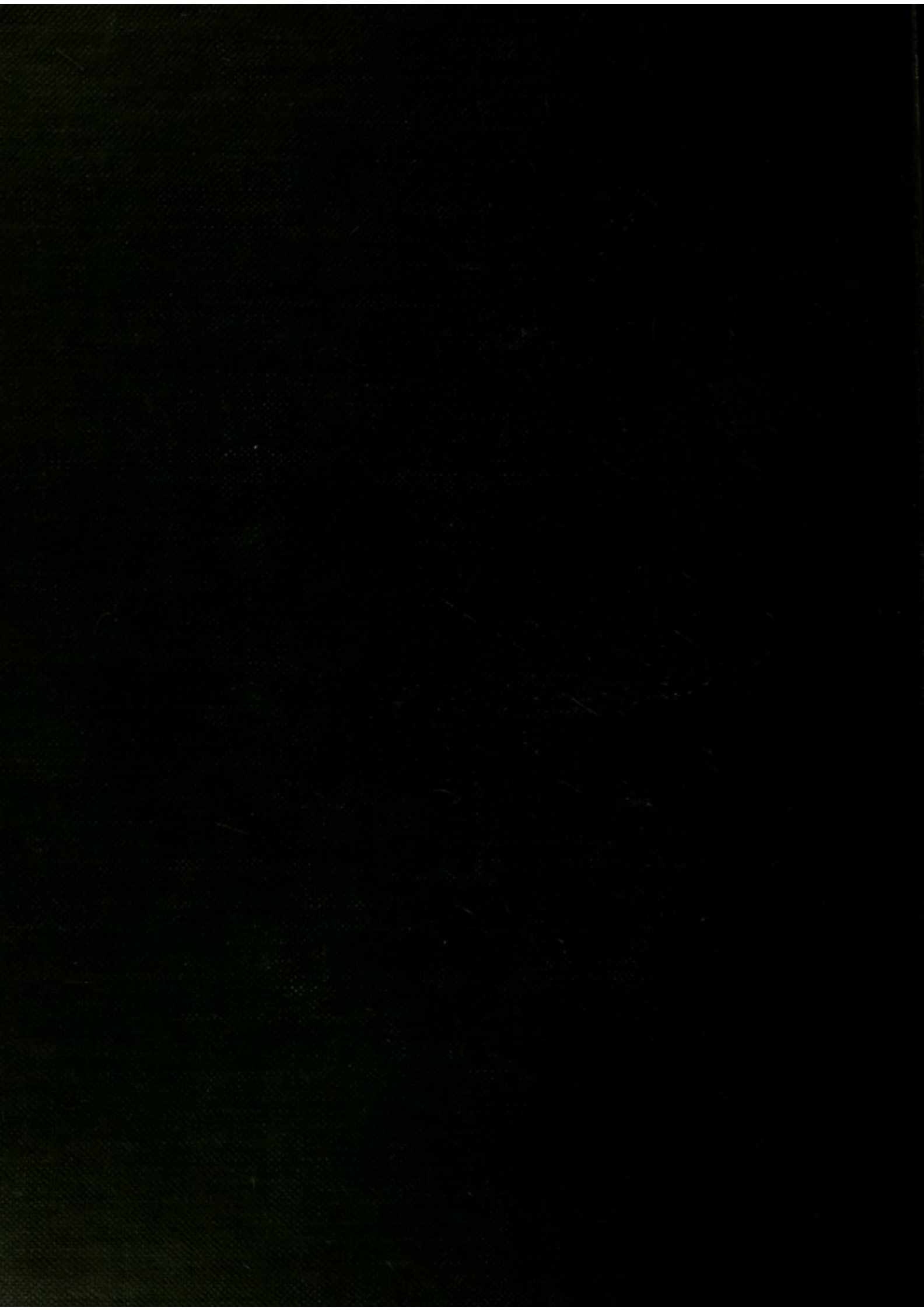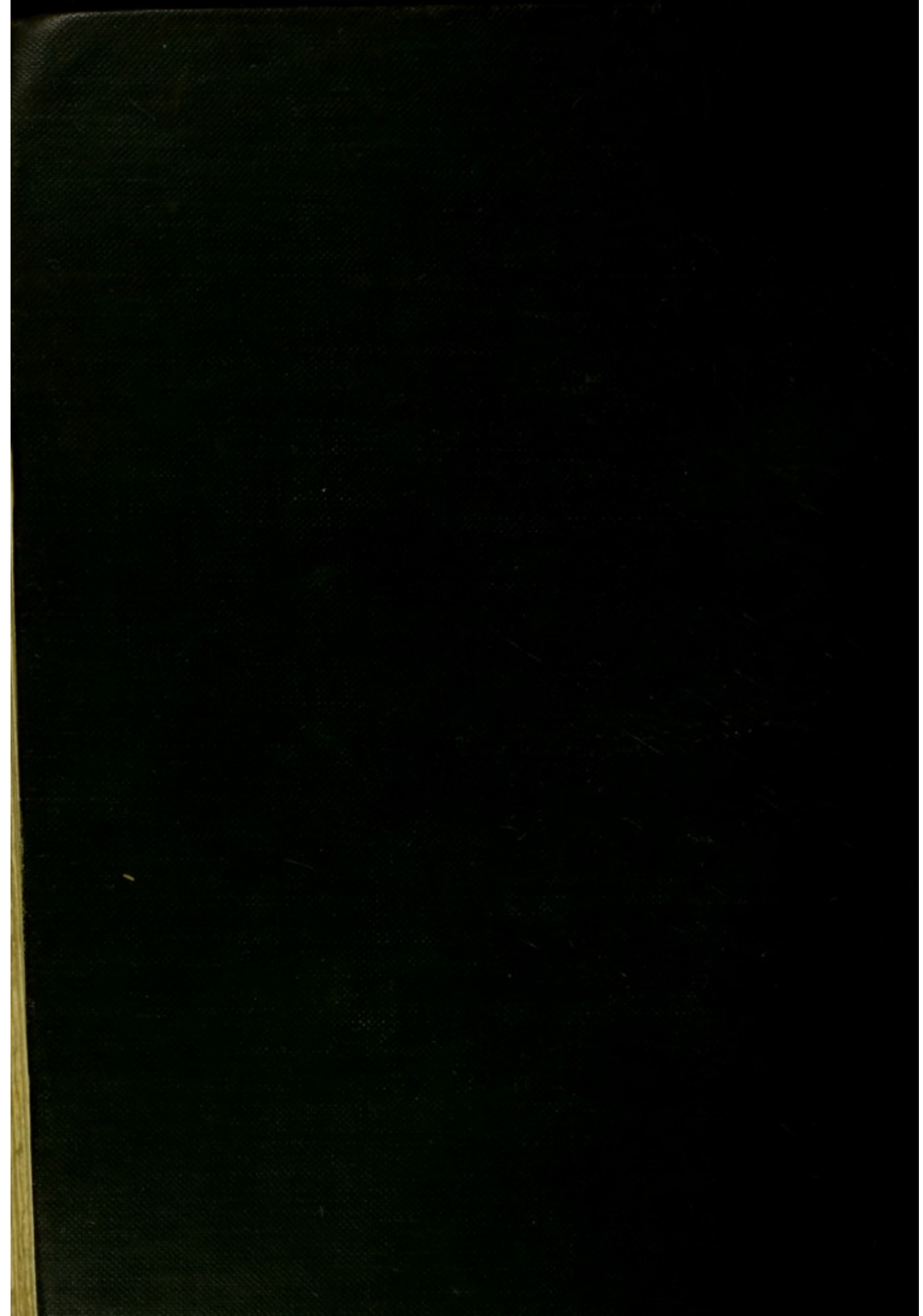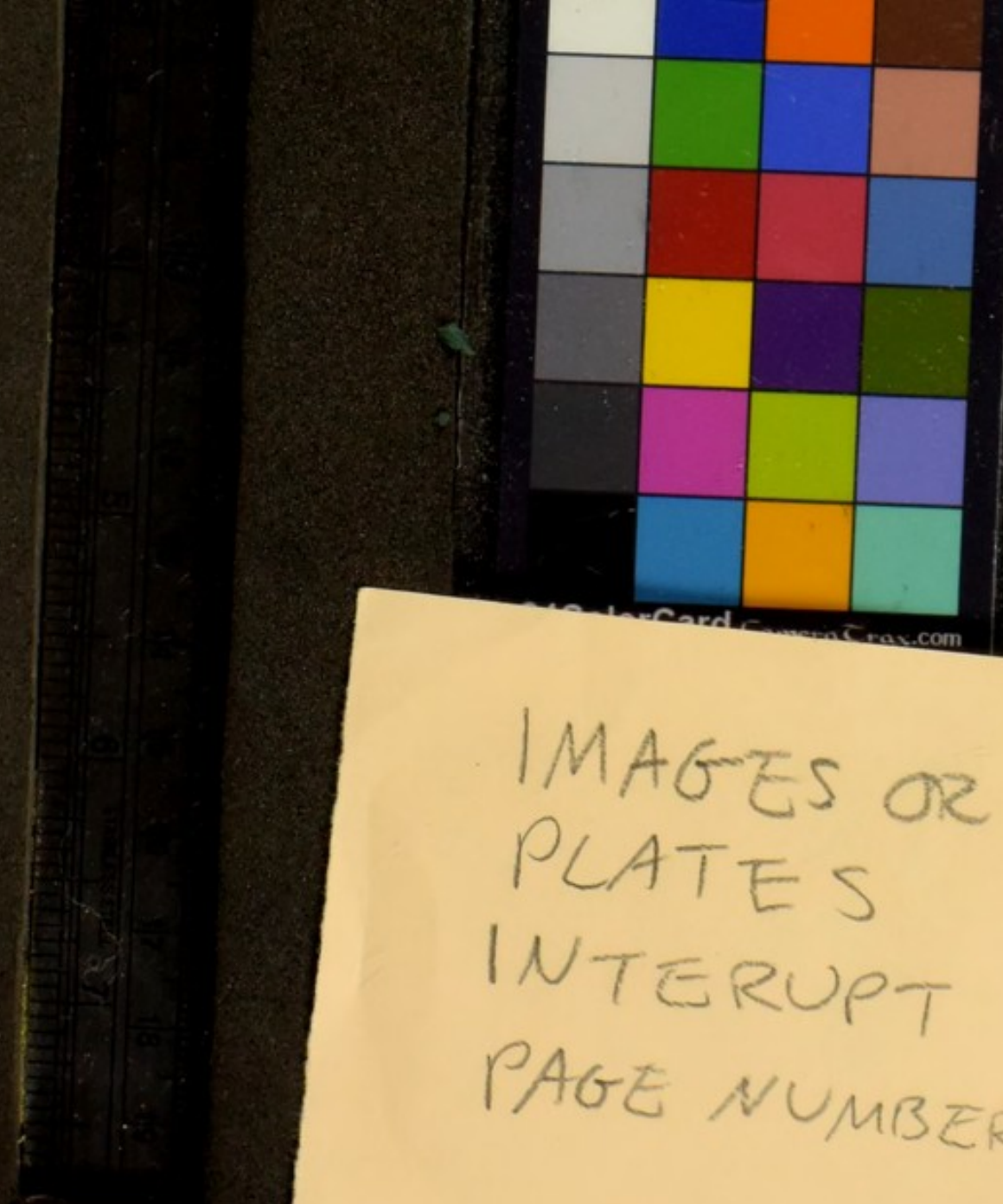*Appendix*—INDEX.

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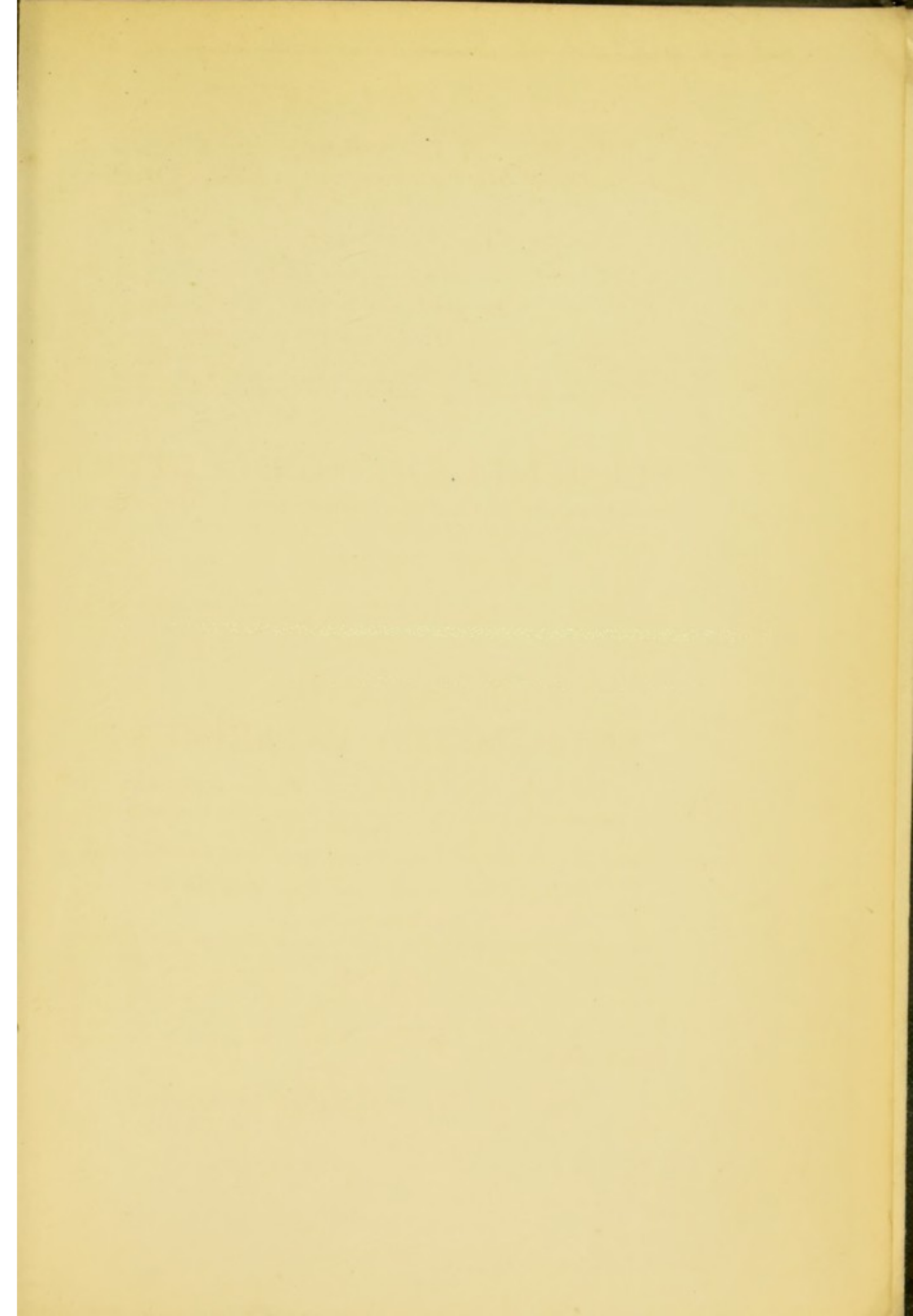
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