THE USES AND WONDERS OF PLANT-HAIRS.

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KATE E. STYAN,

AUTHOR OF

"*The Wonders of Fruit and Seed Dispersion,*"
"*The Beauties and Wonders of Floral Pollen-grains,*" *etc.*

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[189–?]

CONTENTS.

LIST OF ILLUSTRATIONS.

"NATURE IS LOVED BY WHAT IS BEST IN US."

Emerson.

CHAPTER I.

INTRODUCTORY REMARKS—THE USES OF HAIRS, WITH EXAMPLES.

IN the world in which we dwell, every created living structure has some definite purpose to achieve, is formed for some particular use, and is destined for some special end, whether or no that purpose and use, that final aim, be strikingly great or otherwise. Between all living things, however, there must be both co-operation and dependence, for so great is the ceaseless struggle for existence that, were it not so, neither animal nor vegetable would ever be able to carry out this essential natural law. No animal or plant, from the smallest to the greatest, can well exist *alone*, but each must to a certain extent depend and act in union with the other—plant with plant or animal; animal with animal or plant—so that the true and legitimate functions of each may be properly performed. Life must be lived, its dangers and difficulties met and contended with even by the humblest weed that grows; it must arm itself against the burning heat of day, the cold and damp, the draught, the visits of unwelcome insect visitors, birds, browsing animals, and even man; whilst, at the same time, it must so deck itself as to appear in some way attractive to certain insect species, or be so organised that other natural elements may assist it in its important work of fertilization, propagation, and dissemination.

The more plant-life is carefully studied, the more marvellous does it appear, for nature is so lavish in the beauty and wondrous care of structural detail of her children that we stand amazed at the wonder of it all, and at the almost human sense of sagacity that rules the ordering of their silent lives. Every root, stem, and leaf, every blossom, fruit, and seed, is necessary and exquisitely made; whilst of these individual organs, every tiny cell, every appendage, whether of root, foliage, or bloom, is of the most essential and untold value.

Looked into carefully, the subject of plant hairs—those minute out-growths found so plentifully on the separate organs of a vast number of varied species—appears a very great one, one upon which, from time to time, many different theories have been brought forward by the most leading botanists of the age. Taking these theories as a whole, and coupling with them all the proofs that have so far been collected, it would seem that a great amount of *certainty* has now been arrived at, and conclusively we may say that the presence of hairs on plants is arranged for some definite purpose, and that the positions in which they are found, together with the great variety of individual forms they assume, are only so many more special adaptions by means of which the particular functions may be the more readily carried out.

Thus the simple form of hairs that spring from the epidermis, or skin, of true roots, as well as stems that creep below the surface of the soil, are extremely useful in so far as they are able to collect moisture from the soil, to absorb the necessary food materials in a liquid form, and so nourish the plant. During this process they return to the soil certain gases that are no longer of any use to them. In the same way, a great many of the hairs found on stems and leaves are able to absorb, to a certain extent, the moisture from the surrounding atmosphere, in which case they not only help to feed the plant, but at the same time assist in keeping it cool and fresh by their powerful radiation of heat, which causes condensation of moisture and a very considerable deposition of dew. Such hairs may really be regarded as a cooling apparatus. One interesting case may be stated in proof of the assertion that hairs are absorptive organs. Amongst a field crop, whose plants possessed smooth leaves, grew a vast quantity of wild charlock weed. To eradicate the latter, a spray was used that contained a preparation of sulphate of copper, the result being that the bristly hairs of the charlock absorbed the poisonous solution, and the plants died, whereas the actual farm crop remained uninjured. We frequently find, too, that habitually water-dwelling plants are totally destitute of all hairy outgrowths, but develop them if accidentally forced to grow in dry places, as in the case of the Amphibious Persecaria (Polygonum amphibium) and other species. Whether this arises from the fact that, dwelling in water, their absorptive properties are no longer needed, or that being cut off from the visits of insects that would necessarily cause irritation to be set up—such being considered the probable origin of many hairy growths—their development is not produced, is at present somewhat of a disputed point, though authorities all more or less agree that, under certain conditions, hairs may and do disappear, of which a watery growth is undoubtedly one.

It is equally clear, too, that hairs aid largely in protecting a plant from cold and excessive damp. Many readers may have noticed that very frequently indeed young leaves and buds, when first opening, are covered with densely-growing, fine, delicate hairs that can be rubbed off, or wither away and finally drop off as the organs mature. On leaves, this growth may be seen either on both surfaces or only on one, the upper or lower, as the case may be, but *specially* on the latter; also on the margins and veins. In the Rhododendron and Horse-chestnut, for example, the leaves are clothed with a thick "felt" that falls off when the young structures expand; in the Beech, the leaves, when young, have long silky hairs the whole way round their margins, but these, when the leaves mature, almost entirely disappear. The same thing occurs in the case of numerous buds: they are hairy whilst young, but smooth when the organs have expanded.

Again, many of the spring catkins—those of Poplar, Willow, etc.—show beautiful growths of hairs, very soft and silky; these, no doubt, protect the stamens that lie within from cold as well as other influences. We find, also, that very many young ovaries are protected in the same way, being hairy until maturity, or at any rate advanced age is reached; many good instances of this may be seen amongst the Leguminoseæ.

Just as hairs, then, are protective against cold, so are they important factors in guarding various organs against any excess of rain, damp, mist, and fog, and it is really very essential that this should be so, for the stomata, or breathing pores of leaves are so delicate that they might very easily get clogged and injured were it not for the presence of protective hairs. Since stomata lie chiefly on the under surface of leaves, it is there that the greater number of hairs is *usually* met with, though sometimes equally dense on both surfaces, as well as on the stems and flowers. Perhaps one of the best and loveliest examples of this is that of the mountain Edelweiss, with its dense white, woolly growth of hairs that presents such a beautiful appearance to the eye. Clothed in its webby, felted coat, it can safely withstand the mountain rains and mists, as well as the piercing cold of passing storms. The common Colt's-foot (Tussilago farfara) and Sweet-scented winter Heliotrope (Petasites fragrans), the Mouse-ear Hawkweed (Hieracium pilosella), and a great many other species, show thick woolly growths on their leaves; the Marsh Cud-weed (Gnaphalium uliginosum) being particularly conspicuous on account of the white cottony, hairy growths on its stems and leaves. Hooded petals are frequently fringed with delicate hairs for a similar purpose, as, for instance, those of the white Dead-nettle (Lamium album).

Similar woolly coats are extremely useful also in protecting plants from excess of draught and from the too fierce burning of the rays of the sun. In very dry localities, or those in which the sun beats down in such a way as to cause a rapid evaporation of the moisture absorbed by the roots, it may often be noted that the plant dwellers are clothed with a thick, felt-like dress in order to check this process, and so preserve their lives. Amongst foreign species so provided by nature may be mentioned the Mountain Edelweiss (whose hairs, before quoted, doubtless serve as a protection against heat as well as cold and damp), and the plants that inhabit the steppes of Russia; whilst amongst English species there are notably some curious and beautiful examples amongst the Compositæ, namely, the Cud-weeds, the Filagos, Fleawort (Senecio campestris), and others. The Cud-weeds (Gnaphalium) derive their very name from the Greek word "gnapheus," a fuller, on account of their coats resembling the soft and woolly-like nap of cloth, the hairs, according to some authorities, actually being used to stuff mattresses and couches. Very many species of Cud-weed grow in dry, gravelly and hot regions in England, and one (the Dwarf Cud-weed) on the summits of the Scotch mountains. For the greater part, these plants possess extremely soft, downy, cottony leaves and stems, the hairs in some cases being very yellow in colour. The Filagos closely resemble the Cud-weeds, being very woolly, and growing, more or less, in similar localities, and their name is derived from "filum," a thread; the white covering of the stems and leaves being beautifully downy, with myriads of tiny hairy threads.

There are several developments of hairy growths by means of which plants can guard themselves against the attacks of browsing animals and many insects, notably in the case of stinging hairs (as in the true Nettles), and in those which form so dense a woolly covering as to cause a choking sensation to anything attempting to eat them, much in the same way as would a piece of flannel. This is well seen in the Mulleins. In the former case, that of stinging hairs, very few animals or insects ever attempt to eat plants possessing such formidable appendages. Nettles are attacked by certain species of caterpillars, and donkeys, but by very little else; they grow freely and luxuriantly in almost any uncultivated spot, owing their immunity entirely to the presence on their surfaces of the curious glandular hairs, that secrete a burning, acrid fluid, which causes the unpleasant stinging sensation when a drop is forced into one's skin by the breaking off of a hair's tip. Guarding themselves thus as nettles do, they also act as protectors to many other plants of quite different species, such as the Dead Nettles (Lamium), Hedge Woundwort (Stachys sylvatica), and others. We find the latter growing very frequently quite close to beds of nettles, assuming at the same time a very similar external hairy appearance, so that whilst aiding themselves with protective means, they also depend upon the stinging hairs of their neighbours for all further assistance, their own hairs being non-secretive, and non-stinging.

Plants whose leaves and stems are hairy are far less frequently attacked by aphides or plant-lice than those that are smooth-surfaced. Cultivation, which tends to abortion in many different ways—the suppression of hairs being one of them—causes plants to become the prey of aphis pests far more frequently than those habitually wild—a fact commonly known and experienced by most gardeners. The appearance of aphides is extremely common amongst garden and greenhouse plants, but far more rare amongst the wild haunts of nature, which is a fact that forms a conclusive proof to the assertion that hairs may protect from the attacks of various forms of "blight."

Again, we find that in many instances hairs are of great use in helping a plant to climb up and grapple on to some foreign support. Plants so adapted are, for the most part, roughish to the touch. One very good example may be seen in the Hop (Humulus lupulus), a plant that, in its wild condition, straggles hither and thither, twining round any suitable support it may touch against in the course of growth, and clinging to that support, whatever it may be, by means of its hooked hairs. The latter are very strong, particularly so in damp weather, when the hairs become increasingly stiff; this is well known by all hop-pickers, for in wet weather they experience a great deal of real discomfort from the way in which the skin of their hands and arms gets cut and roughened by the action of the stiff, hooked hairs that cover the surface of bind and leaves. The hairs are conspicuous to the naked eye, but it is only when viewed under a microscope that their curious structure becomes at once apparent. *Some* of the hairs consist merely of one very sharp-pointed horn springing from a somewhat swollen base; these are not specially interesting to look at. *Some*, however, consist of a large, bulbous base that divides at the top into two equal-sized, sharp-pointed horns, the whole structure closely resembling a bullock's head that is extremely curious in appearance, and really a very lovely object. In this case it is easy to realise that Nature could scarcely have provided any means more suitable for the use of climbing plants than these delicate, though strong-hooked, appendages. The climbing garden Runner Bean is rough to the touch; this is owing to the presence on the leaves and stems of countless myriads of long, slender, much-curved (or hooked) hairs, and is a very analogous case to that of the Hop, though none of the hairs resemble an animal's head with its two horns. Then the wild Cleavers (Galium aparine)—whose name points to its habit of adhering—a weak, straggling, uninteresting-looking wayside weed, is covered all over with small, stiff, reflexed, hooked hairs that grapple on to anything with which they may come into contact, whether it be vegetable or animal. By this means the weak plant can easily straggle over and adhere to surrounding herbage, and this accounts for the way in which it is found rankly luxuriating in most hedgeways, roadsides, and copses. Its ally, the Mugwort (Galium cruciatum), is also covered with small, closely-packed, saw-like hairs, and straggles over surrounding herbage in the same way as the Cleavers, though perhaps not quite so rampantly. The stiffened hairs, known as "prickles," on the stems of rose, bramble, etc., are another form of hooked appendages for the same purpose.

In the dissemination of fruits and seeds there is little doubt that hairs play a very important part; in fact, they may be said to be almost indispensable in the act that is one of the greatest in plant-life. This necessary work is being carried on daily all over the world by various natural means or agencies, of which the wind is one of the leading. We find many wonderful contrivances adapted by plants to ensure their fruits being wind-wafted, and one of these contrivances is that of hairy outgrowths. The forms of these vary very much. They may be merely tufts, springing from the base or apex of the fruit or seed, stalked or sessile, as the case may be, forming what are called "pappuses"; they may be true coverings to the seed, or they may elongate into long, silky, feathery awns. Pappuses are extremely lovely structures formed in many species of plants from the calyx, after-growths, as it were, when the blossoms fade and the fruits ripen for dispersion. They are extremely light, formed of the most delicate hairs of which it is possible to conceive, and even if stalked the stems are so slender that the whole structure can get wafted easily by the wind to a very considerable distance. An individual pappus may be composed simply of a tuft of slender, unbranched (pilose), stemless hairs that crown the fruit, as in Senecio; it may have its tuft built up of stemless (sessile), but branched (plumose), hairs; it may, as in the Dandelion, consist of a long, slender stem springing from the top of the fruit, crowned at the tip by a mass of pilose hairs; or it may be plumose stipitate, that is, formed of branched hairs springing from the top of a long or short stem. The largest and most beautiful example we have in England is seen in the Wild Goat's-beard (Tragopogon patensis), one of the Compositæ, in which each fruit in the head is formed of a mass of branched hairs, and so numerous the fruits, so closely interlaced the hairs on each, that the whole pappus head forms one large, silvery ball of the choicest, most exquisitely slender, filmy hairs. The merest touch, the faintest puff of wind, is sufficient to disperse the ball and carry away, over meadow and hedge, the ripened fruits that form the handles, as it were, to each of the tiny umbrella-like pappus growths. The "clocks" of the Dandelion are familiar to all, so, too, the Thistle "down"; but there are a number of other pappuses just as lovely, only overlooked because they are smaller or perhaps less frequently met with. Of all the natural orders, the Compositæ can boast of forming the most pappus heads; they abound amongst the many species, notably in the Goat's-beard, Dandelion, Ragwort, Filago, Cud-weed, Groundsel, Hawkweed, Hawkbit, Burdock, Fleawort, Colt's-foot, Hawk's-beard, Cat's-ear, Lettuce, Golden Samphire, Cornflower, Sow-thistle, Knapweed, and Fleabane. Similar pappuses are found amongst the Teasels, many Sedges, the Bulrush, Tamarix, the Willow-herbs, Valerians, and numerous other plants. That of the Red Valerian (Centranthus ruber) is very elaborately branched, and so delicately feathery and soft that it forms a very beautiful object; that of the wild Cotton Sedge (Eriophorum augustifolium), a dweller in bog-lands, has each seed embedded in a dense tuft of long, soft, very slender white hairs. In itself, each pappus of this plant is extremely lovely, but the massing together of myriads of such structures and the waving of them in the wind is a picture never to be forgotten by those who have ever seen it. As the wind drifts over the bog, and sways these countless heads of snow-white pappuses, the effect produced at a distance is that of a large lake of water rippling with small breaking wavelets, each of which shines as its crest catches a glint of fleeting sunlight. The seeds of Black Poplar also lie in a catkin form, each seed embedded in a mass of satiny, white, extremely fine hairs. Each mass is a perfect pappus attached to a very tiny seed. The union of all these separate pappuses forms the long white silky "tail" one picks up in the summer time beneath the trees, each tail looking like that of a very young lamb, and, for this reason alone, being very striking to look at. In the Cotton plant of commerce the seeds are entirely covered with long fibrous, uni-cellular, woolly hairs that, when dry, become filled with air, flattened and twisted, and easily catch the wind. So firm are they that they can also readily be manufactured into the articles so needful to the use of man. A story is told that upon the first discovery of America, the explorers are reputed to have found a "short, shrubby plant bearing little lambs"; these were nothing more nor less than the hairy coverings of the cotton seeds. Stiff bristles are found on the seeds of Asclepias syriaca, and these serve as organs of flight.

Awns are delicate hairy prolongations found on a number of fruits and seeds. In the wild Clematis (Clematis vitalba), or Traveller's Joy, each small achene has a slender silky, thread-like appendage at its apex that gets caught by the wind in the autumn time, enabling the fruit to be easily disseminated. The pretty clusters of these silvery "beards" on the hedges are well known to all country dwellers, and much used by them for decorative purposes indoors. Some species of Avens (Geum palustris) show short silky awns, something like the Clematis. There is also a beautiful example seen in the grass, Stipa pinnata —one much sought after for decorative uses. The fruit of this grass is a very sharp-pointed achene, covered with short, soft, reflexed hairs; from its upper ends proceeds a slender, strong stem, spirally twisted like a cork-screw for part of its length, then becoming straight. The straight portion gives rise to a long, extremely delicate hairy awn a foot or more in length, the latter is so light that any wind catching it can waft the fruit far away, in fact, in its native haunts abroad the fruit is borne for miles over arid land until a damp spot is reached, where, amid surrounding herbage, the awn becomes arrested, and by the untwisting of the corkscrewed stem, the fruit is forced into the soil for future development to take place.

As a rule, the hairs found on seeds and fruits are very numerous, but instances occur in which they are present in very limited numbers, notably in the case of Aeschynanthus, which bears only three hairs altogether, two on one side and one on the other. Owing, however, to the remarkable flexibility of the three hairs, they are able to adhere to or curl round the fur or wool of animals, and thus the fruits become disseminated by animal conveyance as well as by the agency of the wind, and the loss of the use of many hairs is well compensated for by the peculiar adaption of the few. Numbers and numbers of other examples might be mentioned in support of the fact of the usefulness of hairs in the dispersion of fruits and individual seeds, but a few are sufficient to show that they are most important factors in the carrying out of this great work, and that not only has Nature provided her plant-children with very wonderful means by which they may so work, but that the instruments themselves are structures of very real beauty and unsurpassed delicacy.

CHAPTER II.

The Uses of Hairs (*continued*). Uses Classified.

Another very interesting point to notice is that there are a great many plants that cover their stems and leaves with glandular hairs, or those that secrete a fluid of some kind, which secretion may be agreeably or unpleasantly odoriferous, sticky, very bitter or sweet to the taste. When pleasant both in scent and taste, such hairs no doubt aid in the fertilization of flowers, acting as means of attraction to welcome insect-visitors when they come in search of honey; on the other hand, when nauseous in odour, acrid or glutinous, they form a preventive means by warding off or entrapping insects as they approach the actual flower. The stickiness of so many glandular hairs found on stems, leaves, and even calices acts as a kind of "lime" to creeping insects that greedily endeavour to clamber upwards to the nectar-glands, and effectually prevents them from so doing; in some cases it not only entraps them, but is able to decompose them and make use of the nitrogenous matters digested as food for the plants. So largely is this method of entrapping carried out by some species of plants that we may gather them and find their stems covered with decayed insect carcases as well as those freshly caught, and one species of the Caryophyllaceæ has received its name of "Catchfly" for this very reason. Amongst this large Natural Order, a great many of the members show the propensity of catching insects by means of their glandular hairs, but the Catch-flies (Silenes) are specially favoured in that way; they are extremely sticky to the touch, the exuded fluid being particularly adhesive. These plants, also the Campions, the Petunias, some of the Dwarf Phloxes, and the London Pride, are excellent examples. The great authority, Kerner, gives an instance in which on a single inflorescence of the Red German Catchfly (Lychnis viscaria) he counted no less than 64 small entrapped insects, and on the sticky flower stems of the Nottingham Catchfly (Silene nutans) over 60 distinct species of insects, chiefly ants. In the London Pride (Saxifraga umbrosa), the tall flower-stems, bearing delicate, pearly pink flowers, are covered with myriads of very sticky, ruby-coloured glandular hairs; these entrap a vast number of creeping and very small flying insects; the stems of Petunia and Phlox Drummondii may also be seen so covered, and both are extremely glutinous to the touch. Again, in Henbane (Hyoscyanus niger), the stem, leaves, and several of the floral organs are densely covered with hairs of two kinds, glandular and non-glandular. If the hand be lightly rubbed up the plant, it comes away feeling most unpleasantly sticky owing to the fluid exuded by the secreting hairs, and this, in addition to the presence of numbers of dead insects fixed amongst the hairs, clearly shows how impossible it would be for any small insect to reach the flower and rob it of its nectar. Larger flying insects, whose agency in bringing about cross fertilization is much desired, can reach the flower in safety, but all dangerous visitors are effectually and cleverly kept at bay or caught and killed. The amphibious Persecaria (Polygonum amphibium), when growing on land, develops glandular hairs for a like purpose; but when growing in its natural habitat, water, no hairs are formed on the stem or any other part, water being doubtless a sufficient natural protection from insect depredators. In a small way, plants like these, that entrap unwelcomed insect visitors by means of a " lime," and absorb to a certain degree some of their nitrogenous matters, approach very closely to the true insectivorous species—such as Sundew (Drosera) and Butterwort (Pinguicula)—but act in a more simple way. In the Sundew and Butterwort, the process of entrapping, digesting, and absorbing insect-matters is very elaborate, and most wonderfully carried out by means of the large glandular hairs (tentacular hairs) that cover the upper leaf-surfaces. As most readers know, the plant is an inhabitant of boggy lands, soils destitute in those special chemicals, nitrogen and sulphur, absolutely essential to the formation of protoplasm—the life-giving element of plant-life —and possessing few of the other chemicals most needed for the same purpose. To compensate for this, we find that nature has formed the plant so as to be able to catch, kill, and digest insects as a means of nourishment, and for this purpose she has clothed the Sundew's leaves with masses of red-hued, bulbous-shaped hairs, capable of movement, and filled with sticky, acrid, digestive fluid that is odoriferous, hence attractive to insects. No sooner does an insect alight on a leaf than its hairs begin gradually to bend over, one by one at a time, until at last the insect is completely trapped, the hairs continuing to exude more and more of their gummy juice. In a few hours the insect juices are absorbed and digested, and the plant builds up for itself new protoplasmic, life-giving substances.

The fluid secreted in these glandular hairs is so extremely viscid that it can be pulled out into long thin threads; apparently, it is colourless, and yet will stain white paper pale pink. If a small amount of carbonate of ammonia be applied, the glands instantaneously become very dark in colour, which is interesting to note in so far as it *proves* that the hairs are really absorptive.

So we find that in numerous instances plant hairs are of great use in helping to nourish the structure, partly or entirely, as well as in repelling the visits of unwelcomed insect visitors at the same time, such as in Silene, Primula Sinensis, Sundew, etc. When we come to consider the strange and wonderful growths that appear in close union with the flower-heads of so many plants, very often it is easy to see that such barriers of hairs are so situated, and rendered impenetrable, solely in order to form a last wall or hindrance to any unwelcomed guest that may, in spite of difficulties on stems and leaves, have clambered thus far up the plant. Having crept so far, the visitor must be allowed to go no farther; an effectual check must be put upon its movements, and that check must take the form of hairs.

Such growths are found largely on bracts, that is, on those leaf-like structures situated at the base of secondary floral pedicels or close to the base of terminal flowers or *head* of sessile flowers, as, for instance, in the overlapping involucral bracts of the Compositæ. The large leafy bracts of the Pasque-flower (Anemone pulsatilla) are clothed with thick silky hairs; in the Carline thistle, the lower part of the stem and leaves appear quite glabrous (smooth), but close to the flower-head lies a dense mass of prickly, recurved, very hairy teeth or outer involucral bracts that prevent an insect from even reaching the true involucres. In Knautia dipsacifolia the hairs are reflexed—a fact that shows how well-nigh impossible it must be for any insect to creep upwards; those forming the involucre of the Garden Hawkweed and Mouse-ear Hawkweed (Hieracium pilosella) are densely covered with two forms of hairs; those that are stellate or star-like, and those possessing glandular, secreting tips; similar appendages abound amongst the various species of Compositæ and in a large number of other plants, their use being undoubtedly to ward off insects from reaching the flower. As on leaf buds, so on floral we find them present in considerable numbers, and even on the bud-scales that drop off as the flower develops, as in the Maple, where each hair found on the margins and surfaces of the scales is long and very slender; these appendages probably protect the growing flower bud from cold and damp. Very lovely examples of hairy calices are found in wild Basil, Dead-nettle, Thyme, Mint, Comfrey; in the dense, woolly-covered ones of Henbane and Mullein; the sticky, glandular-haired ones of London Pride; the silky-looking and also yellow glandular-tipped ones of White Campion; the slender, sharp-pointed, rough-coated ones in the Gorse; the hooked, hairy ones of wild Cleavers, Garden Poppy, etc. Since insects come in such numbers in search of honey, it is absolutely necessary that *only* those should be allowed to reach it that can and do aid the plant in producing cross-fertilization, and so it comes about that most wonderful growths of hairs appear either on or immediately in connection with the floral organs, appendages so formed as to create every impediment to insects *not* desired, but no hindrance to those that are of use. This being the case, a large number of plants introduce into their blossoms varieties of lattice-work, "chevaux de frise," and "weels" of hairs to protect their honey-glands or nectaries. When coloured, as in Iris, etc., such hairs are termed "Corolline."

The term "weel" is adapted from the technical name for the wicker baskets, broad at one end, with a small terminal opening, used by eel-catchers and other fishermen, and is employed in reference to the arrangement of hairs that partakes of a similar form, and renders all access to some flowers impossible to certain kinds of insects, whilst others, by reason of their long, thin proboscides and strength, are able to push aside the latticed hairs, and so reach the nectar. For the most part, such structures are very flexible, straight, and elastic, and lie in a more or less complete circle round the inner surface of the floral tube, or else are given off on one side only; in the latter case, their great length is sufficient to cover the whole space of the corolla tube, and so prove as useful as when they grow in a perfect circle and are shorter in length. As an example of a half circle of hairs in the corolla, we have the common Germander Speedwell (Veronica chamœdrys); and as good examples of perfect "weels" there are Lamium, Stachys, Ballota, Pholonis, Prunella, Phlox paniculata, Gentiana, Verbena officinalis (in which the floral tube is so short that the "weel" of hairs lies just above the nectar and safely protects it), and many others, brief mention of which is interesting. Thus, in the Malvaceæ, the petals are united, but at the base of each may be seen a small depression in which the nectar is secreted, each hollow being guarded by a weel of small hairs; the effect of these sets of small weels is that they make it impossible for any small insect to penetrate to the bottom of the corolla. In Swertia, the honey lies in hollow depressions on special growths of the corolla (or secondary petals), growths called by some "nectariferous petals"; round the margins of each of these depressions springs a fringe of hair-like appendages, whose tips bend, interlace, and form a net-work over the true nectary. One point in connection with this flower is worth study, and that is that large flying insects, in approaching the flower, come from above, and, whilst pushing their proboscides downwards through the cage of hairs in order to procure the honey beneath, rub both stamens and pistil in so doing. They assist in this way to bring about cross-fertilization. On the other hand, small creeping insects that approach from below, or small flying ones that come laterally, would not strike the pistil and stamens, so we find that the hairs entirely prevent their entrance, as their visits would do harm, and not good.

Many petals are so fibrillated that they may be looked upon as hairy ones, as, for instance, in the Soldanella alpina and Gentiana ciliata; these hairy growths take the form of weels either in one, two, or three rings. In the Passion Flower, the whole corona (termed a subsidiary organ of the flower) is made up of three weels; single ones are found in some species of Lilium, but specially in the Gentianaceæ. In the true Gentians, a horizontal row of very beautiful, delicate hairs or fimbriations surrounds the opening of each corolla tube, forming a "guard" to the flower. Then, again, the lovely Buck-bean (Menyanthes trifoliata) owes its rich beauty to its frised or hairy petals, each of which is covered with a mass of tiny, pearly-pink, fimbriations, so closely packed that no creeping insect can easily cross its surface, and the appearance of the whole blossom, with its five pale pink petals, is one of very great charm. Sometimes the hairs forming these barriers, weels, etc., are pure white, but they very often partake of the same tone as the organ from whence they spring, as, for instance, lilac in the Gentian and pink in the Buck-bean. At the base of the corolla tube, and contiguous with the bases of the epipetalous stamens of the Deadly Nightshade (Atropa belladonna), lies a circle of very soft, delicate greenish-white hairs, which protect the nectaries that are seated immediately beneath the hairy ring. In the Garden Pansy, a thick tuft of hairs stands at the base of each anterior petal, preventing the ingress of small insects as well as rain, and, in addition to proving useful, add a charm to the appearance of the bloom.

It may, perhaps, sound strange to say so, but nevertheless is true, that in a few rare cases hairs may be regarded as instruments of imprisonment, as, for instance, in the Arum maculatum and Aristolochia clematitis. In the former, the fleshy spadix, upon which the pistils and stamens are borne, lies within an enveloping bract called the spathe, which becomes constricted a short way from its base. Just where this contraction takes place, and on the spadix, grows a circle of pale brownish or cream-coloured hairs, each of which is long, stiff, and reflexed, that is, pointing away from the top of the infloresc ense, or, as it may be more easily understood, backwards. In this arrangement there is a remarkable purpose. We find that the hairs grow thus so that any insect can creep down the interior of the leafy spathe in search of the honey that lies at the very base, but that they cannot climb back again until the pollen has become ripened in the stamens, shed, and dusted on their bodies as they creep about. As soon as ever this has taken place, the hairs shrivel up, and the insect can readily wander away, carrying with it pollen that may, in all probability, fertilise the pistils of another Arum flower growing close at hand. In the Birthwort (Aristolochia) a similar weel or circle of hairs grows on the interior of the corolla tube, and acts exactly in the same way as that of the Arum, also for the same great purpose.

On petals, hairs are of very great use indeed in the way of forming "bridges" or footholds to large (usually flying) insects. Careful observation soon makes it apparent that the hairs are produced in the very spots most required, just where the insect alights and needs something to which to cling whilst in search of nectar—some support that will render its visit a safe one.

Some flowers really seem to lay themselves out to please guests; they adapt themselves to the needs of the latter, hold out to them various attractions, and, whilst doing all they can to attract and render safe such visits, derive a lasting benefit to themselves in the way of ensuring safe cross-fertilization and consequent healthy perpetuation of their kind. The hairy bridges or footholds may consist of many or few, promiscuously or evenly-arranged growths of appendages, clumps, or fringes of hairs, individually long, silky, short, or rough. In the Canterbury Bell they line the interior of the corolla; in other species of Campanula they not only do this, but also add a matted fringe to each segmented petal tip in the united corolla; whilst in the pendulous bell of Foxglove they deck the edges of the petals, and also form a tuft on the interior of the lower petal, adding very greatly to its beauty.

Stamens are frequently hairy on their filaments and anthers, whilst their pollen-grains develop hair-like excrescences on their surfaces for the sole purpose of enabling them to be easily carried about by the agency of insects; indeed, such processes are almost entirely confined to what are called entomophilous plants, or those that are cross-fertilized by insects. The pollen-grains that fall from the anthers in the Mallows (Malvaceæ), in Doronicum, Althoea, the Marigolds, Common Daisy, Cineraria, Ox-eye Daisy, and Dandelion all show beautiful little spinous hair-like growths, invisible to the naked eye, but clearly visible under a microscope. When seated on the filaments, hairs may be useful in protecting the nectar from the visits of non-desired guests, as well as from cold, damp, etc.; in a few rare instances, as in some species of Eyebright (Euphrasia), they assist in holding the stamens in one definite, fixed position for a given time whilst they mature. The Black Mullein (Verbascum nigrum) has the loveliness of its flowers greatly intensified owing to the presence on its stamens of a row of rich violet-coloured hairs; in the Geraniums, each stamen filament, on the side opposed to the perianth, shows a hollow depression full of nectar; above the hollow, so seated on the filament that the nectary is perfectly protected, stands a bunch of hairs, but the interesting point about these is that no insect can ever reach the nectary until it has literally *forced* its way beneath them, thus slightly lifting up the stamen in so doing, causing a discharge of pollen. This is really a very wonderful contrivance of Nature, being so extremely neat and effective. The stamen filaments of Deadly Nightshade are decked with a number of long, very sharp-pointed hairs; those on the filament of Henbane are short and very delicate; other very hairy ones are found in Stachys, Lamium, the Verbascums, in Physalis atriplicifolia—where the nectariferous disk is protected—and in a great many other plant species.

There is a great use attached to the hairs that grow on the anthers of stamens, namely, that of *directing* the way in which the pollen should fall, causing it to disperse in given lines, and not to spread about and get wasted, as might, and so very often does, easily happen. Not being essential to every flower, only a comparatively few species adopt this use to which hairs may readily be put; but it is seen to take place in the Orobanches, Lamiums, Louseworts, and many others.

Passing from the stamens to the pistils of flowers, it is astonishing to find how many of them are the possessors of hairy dresses of one or another form, and of what inestimable use such clothing may be. As everyone knows, stamens and pistils are the "*essential*" organs of a blossom from the fact that they, and they alone, are the instruments of fecundity and propagation by seeds; this being the case, it is easy to understand that such delicate and important organs really need special protection and special adaptations to ensure fertilization, whether self or cross. So hairs are produced on many of these parts for particular purposes, a few of which may be interesting to notice.

In the Laburnum, for instance, a circle or weel of hairs runs round the base of the pistil, and thus prevents it from becoming fertilized by the pollen from its own stamens that lie very close around; in the White Campion, the sides of the styles are clothed with curious club-shaped hairy excrescences, doubtless protective; in a number of the Papilionaceæ, such as Vetch and Garden Scarlet Runner Bean, the style ends in a strange hairy portion that hits against the body of any insect that enters the peel of the corolla, and rubs off from the former any pollen that may be adhering to it when it first visits the blossom. This is a very clever contrivance to bring about cross-fertilization, though not, perhaps, *quite* so wonderful as that very often met with amongst the Compositæ, as, for example, in the Common Daisy, Ox-eye Daisy, Chamomile, Knapweed, Feverfew (in which the pistil ends in two branches, each terminating in a brush of hairs that sweep the pollen out of the stamen-tube, so that it can be borne away by insects; whilst, when the pistil itself becomes fully developed, the hairy brushes open out and curve downwards, so that an insect alighting on the flower-head, having on its body pollen from another blossom of the same species, would dust off the pollen on to the stigmatic surfaces by means of the fringes of hairs), and many others. These wonderful little hairy stigmas are often called "pollen brushes," because they sweep off pollen dust from the bodies of bees and small flies, as well as from the stamen tubes.

Then, again, hairy stigmas *retain* pollen-grains, whilst those destitute of such outgrowths are obliged to resort to some other means, such as the development of a viscid fluid or rough excrescences, etc. Hairs, however, are extremely useful to many floral pistils, and very lovely examples of feathery and penicillate stigmas are met with, as, for instance, in Deadly Nightshade, Wall-pellitory, and Bromus.

In the Orchidaceæ, the stigma terminates in a glandular out-growth of the upper margin (rostellum), and is lined with a loose tissue that is built up of tiny jointed, ascending hairs; whilst the interiors of styles and ovaries frequently show hairy linings. Young ovaries (as in Lupin, Broom, Sweet Pea, Gorse, etc.) show a thick covering of short, soft, white silky hairs. In these latter cases the outgrowths doubtless protect the organs from cold and wet.

To the naked eye it is rarely apparent that many stigmas are covered with hairs, but the use of a microscope soon shows that this is not so; in fact, the greater number show growths that are soft, white, woolly, club-shaped or straight, loosely packed or crowded, that afford safe harborage for falling pollen grains, and a secure resting-place ere the great work of pollination once commences.

In treating of flowers, it certainly appears that hairs and nectar are most intimately connected; in fact, *so* closely that where nectar is wanting, the hairs themselves sometimes secrete it in order that the flower in question may obtain cross-fertilization by attracting insects just as surely as were the nectaries on the usual floral organs. Taking flowering plants as a whole, too, the greater number of honey-bearing ones show hairs on some part or other, whereas the non-honey-bearing species are, as a rule, hairless or smooth (glabrous). Examples might be quoted in great numbers, but if we take only one of the natural orders—the Malvaceæ, or Mallows—that one alone furnishes good proof for the above statement, for amongst these plants, *all* the nectar-bearing are hairy, and all the non-nectar-bearing glabrous.

Having, step by step, traced the presence of hairy growths on plants from roots to the innermost organs of flowers, it may be interesting to sum up the various uses of such hairs under the following large groups, sub-dividing each again into several smaller classes. The three large groups may be classified as—(1) *Protective*, (2) *Defensive*, (3) *Assistive*.

Under the first large group the uses may be ranged into the following sub-classes:—(1) To keep off superfluous cold and damp; (2) To guard against excessive heat and drought; (3) To prevent too rapid evaporation; (4) To guard against excessive glaring sunlight; (5) To aid in the dispersion of seeds and fruits.

Under the second large group there would be the following sub-classes:—(1) To ward off the visits of injurious insect-visitors, browsing animals, and man; (2) To guard against the attacks of "blights," specially of aphides.

Under the third large group there would be the sub-classes:—(1) To aid in the climbing or clinging of the plant; (2) To help in pushing out the pollen from certain stamen tubes; (3) To catch and retain pollen grains for the purpose of cross-fertilization; (4) To attract insects by offering safe "footholds," by the secretion of nectar, by sweet odours, etc.; (5) To partially or entirely nourish the plant, by absorbing food materials from the soil, or by catching and digesting nitrogenous substances from insect-bodies; (6) To aid in cross-fertilization by the process of imprisoning small insects whilst the stamens mature.

From time to time *new* uses may be brought forward, or the reader of these pages may at once sum up fresh ones in his own mind; however this may be, the few that are here quoted are extremely interesting, and the mere fact of reviewing them will go far in bringing before one's mind the important truth that, in the matter of detail, Nature is never found wanting. She it is who feeds, aids, and guards her plant-structures; she it is who builds their lovely forms, their beauteous colours, and bestows their many odours; every tiny part of them is dear to her; no organ is too humble for her most loving scrutiny; she glories in their luxuriance, and takes such infinite care of them that we may well say of them that which has been said of us, that "the very hairs of their heads are all numbered."

CHAPTER III.

The Meaning of the Word "Hair" (Trichome). "Emergences." Structure of a Typical Hair. Weight of Hairs, compared with that of the Organs from whence they arise. How a Hair may probably originate. The Textures, Colours, Odours, Flavours, and Uses of Hair-secretions.

To become conversant with the true life-history of plant-hairs, it is necessary, at the very outset of the study, to clearly understand what we mean when we speak of a *hair*, and then note the different parts of which it may be composed. The term "hair," or "trichome," is one that is given to those outgrowths in plants that are usually developed from a cell (or cells) of the epidermis, that is, the membrane that covers the whole of the exterior surface, and remains the outermost in leaves, stems, and roots of plants. In the course of growth, an epidermal cell, as it is called, which is usually thin, very delicate, and closely packed amongst others, begins to expand or extend itself. This expansion may arise in the form of a simple tubular prolongation; rows or plates of cells; a wart-like protuberance; shield-like, outspread scale; a glandular outgrowth; prickly elongation; or as a woolly envelope (on young leaves); sporangium or spore-case (ferns); of a root-like, absorbing organ (mosses); or an adventitious bud (Begonia). By some leading authorities, such as Ranter and Warming, certain of these epidermal outgrowths are classified as "Emergences," and are so placed by them because, although the structures, morphologically and physiologically, are closely allied to many forms of hairs, they differ from them in not originating from a simple epidermal cell, but from the tissue found beneath that membrane. The tentacles (or glandular hairs that are endowed with the power of movement) on the leaves of Sundew; the prickles on the rose, etc.; the so-called "beards" on the delicate petals of Menyanthes (Buck-bean); the sharp hairs found just below the calyx in Agrimonia Eupatorium (Common Agrimony); the wonderful "pappuses" of the Compositæ, Valerianaceæ, etc.; and the sporangia of ferns, are so placed by these botanists; but others—amongst them the learned Sachs—dispute the right of making such a nice distinction between "Emergences" and "hairs." Thus, if we take the case of the tentacular, glandular structures from the leaf of Sundew, there are some scientists that maintain them to be true trichomes, whilst others consider this to be wrong, and look upon them merely as leaf-prolongations; so that, to a certain extent, since there are good arguments on both sides, the question must remain somewhat of an open one at present. It is now a well-known fact that certain vessels do, in a few rare instances (as in some prickles, etc.), enter the hairs from the structures from whence they spring, so that when Nitsche showed that the tentacles of Sundew contained some of the vascular tissue peculiar to the leaf-blade, as well as certain other special elements, it seemed a conclusive proof that they might be considered true hairs. On the other hand, Darwin maintained that whilst the upper portion might be considered a trichome, or true prolongation of the leaf's epidermal cells, the lower portion must be regarded as a leaf-*prolongation*, since that portion, and that alone, possesses the power of movement. Again, when in some Algæ and Fungi—plants that are considered to possess *no* true epidermis—long outgrowths appear which may be regarded as hairs, but which are prolongations developed from the surface of the flat masses of tissue composing the plant (as in the alga, Coleochocte scutata), or from the tip of a cellular filament, then we may once more be led into confusion; however, without entering too deeply here into arguments, if we take the broad line and consider that a true hair has its origin from one or more cells of a plant's epidermis, then, in a simple way, we can understand what a trichome really is. In the young condition, hairs are simple cells, portions of cells, or aggregates of cells, with their surfaces covered by a membrane composed of cellulose (Carbon, Hydrogen, and Oxygen); they are usually thin-walled, and contain protoplasm as well as cell-sap. Sometimes in the course of growth the sap and protoplasm dry up and entirely disappear, their place being filled instead with air; this is found to be the case in hairs found on seeds and tiny fruits of a large number of flowering plants, as, for instance, in the Cotton seeds, in which every hair becomes soft, twisted, woolly, and full of air; and also in the seeds of Asclepias syriaca, which are extremely bristly and stiff, and serve as a means of dispersion. Or it may happen that instead of drying up, the hair protoplasm becomes so richly nourished that it becomes marked with a strange and wonderful power of circulatory movements and other important peculiarities, as, for example, in the jointed hairs of Tradescantia, the lovely stellate hairs of Althœa, and the stinging hairs of Nettle. The actual cell-wall, too, does not always remain the same. Sometimes it keeps thin and delicate for the whole of its life, being very pliant and soft, but (as in the Gourd plant) it may become very much thickened, even stony, or filled with large deposits of lime and silica, when it is said to be silicified (Nettle); in some cases, some of the cell-wall layers become extremely mucilaginous, or peculiar oils become deposited somewhere within its cells. Very frequently a hair remains the same thickness for its entire length, merely tapering to a sharp point just at the very tip, or swelling out into a club-shaped or oval swelling; or it may assume many other marked forms that will be treated separately on a further page. The base may be, and often is, much swollen, conical, and very bulb-like (as in so many glandular hairs, such as the stinging, etc.), and this is really an interesting fact to notice. The bulbous base of the hair is caused by an extremely luxuriant growth of the cells that lie just beneath the epidermis from whence it springs (cells that form what is called the parenchyma), and also by a further increase of active growth in the epidermal cells themselves. It is not easy to say exactly *why* some hairs should have such swollen bases, whilst others are destitute of them, but it generally appears that the swelling is found on glandular-hair bases, and may in some way be intimately connected with the process of secretion that goes on in these structures.

Hairs never assume the same form as that of the leaves and lateral shoots of the plant from whence they spring, and, put together, the whole of the mass that grows from the root, stem, leaf, or flower is infinitely less in weight than the individual organ itself; it may be composed of myriads upon myriads of hairs, but each member of the vast mass is so delicate that the weight of the entire collection is extremely slight.

The next important point to notice is the origin of a hair, or that condition or circumstance that actually calls it into being. The study of this matter opens out a field full of difficulties, theories, and arguments; we may sift them as we will, yet many doubts remain; we may collect proofs in favour of both sides of the same question, and yet, at the best, be able to draw more or less unsatisfactory conclusions in the end. Many definite facts may be brought forward, but many must yet be dismissed as not sufficiently proven to be accepted; we know that hairs are produced in special positions on a plant, and that they are formed under certain conditions, but the origin of them *in all cases* is by no means yet fully understood. They may be structures produced in the ordinary, legitimate course of perfect development from the epidermal cells, just in the same way as those formed on human beings, as they follow up the true law of life; they may be hereditary outgrowths, brought about by no peculiar external agencies, but simply and purely naturally. There is little doubt but that heredity may play an important part in hair production, for when we come to consider, further, another probable origin of hairs, namely, that of *irritation*, there is every reason to believe that, in a great number of cases, the primal instance of irritation—which set up the hairy growth—has been handed down, so to speak, from generation to generation of plant species, and is now an accepted fact, even if no fresh cause of friction is actually brought to bear upon the species in question.

The subject of *irritation* being the probable origin of many hairy growths is a very interesting one, for so many instances may be found in support of it, and we can really believe that hairs *do* frequently arise as the immediate result of a plant being in some way irritated externally, as, for instance, by the coming into contact with some foreign body, which sets up some peculiar mechanical process, or by the friction caused by insects when in search of honey or even when visiting a plant for no special, definite purpose. For example, in the Ivy, what do we find there? Nothing more nor less than that the aërial roots—developed from the stems above ground—send out from their epidermal cells, directly contact with a support, etc., takes place, certain peculiar prolongations, which finally resolve themselves into clasping or adhesive *hairs.** It appears that actual contact (perhaps with the addition of moisture and slight decrease of light) is the probable origin of these trichomes. Again, in the case of root-hairs (those formed behind the growing points of young roots), we find that they are produced immediately the tip of the root is brought into touch with moist soil, and at once proceed to glue themselves to the particles of earth with which they come into contact. According to Dr. Masters, it would seem as though contact,

* Rev. G. Henslow's "Origin of Floral Structures."

without the addition of moisture, is useless, and he has given a good proof of this in investigations he carried on with some roots of Mustard seed. The latter he found could grow through a heavy clay soil, but were unable to produce *any* root-hairs until they touched the sides of the pot in which they grew, and that "wherever there was a film of water investing a stone, the sides of a porous flower-pot or plate of glass, *there* the root-hairs abounded."* Chatin has also noted the fact that directly roots become in any way irritated by reason of contact with a foreign body, root-hairs are at once developed.

There is a particularly interesting point connected with irritation set up by insect-agency which may be seen in the case of certain "galls" (as on Willow, Sycamore, Oak, etc.) that grow on leaves, owing to punctures made by various species of insects. If one of these galls (that found on the oak leaf is a beautiful example) be examined, it will be found to be covered with clusters of what are called stellate-hairs; in a gall taken from the leaf of Willow the cavity within may be seen to be filled with a number of large, strong hairs that project inwards, *some* of which very closely resemble in form those that develop on climbing roots when they come into contact with a support. A Sycamore gall is also lined with clubbed hairs, and a great many other similar instances might be quoted that, in addition to being hairy *externally*, a large number of "galls" are also papillose *internally*. As a rule, compared with the hairs found on the surfaces of leaves, etc., those found on galls are more numerous and of a finer texture. They vary greatly in form, being

* Mem. Soc. Nat. Sci. Cherbourg, p. 5. 1856.

clubbed, hooked, stellate, swollen, or glandular at their tips, curved, straight, and, like other plant hairs, are full of protoplasm, the living matter of all cell-life. Galls, we know, are the result of punctures caused by insects, and they act as nests for the insects' eggs. The mere act of puncturing, together with the presence of one or more eggs, must set up irritation; of this there is no doubt, consequently, we may look upon such friction as being the origin of the gall-hairs as well as the galls themselves. A similar origin may be ascribed to the hairy growths found within so many ovaries, and in the styles or stalks of many a flower's pistil (Poplar, Vanilla, etc.). In a number of cases, these hairs also resemble those of roots, which is another proof that they very probably originate owing to some irritation that has been set up, of which, no doubt, that caused by the passage of pollen-tubes down the pistil's style to the ovary, for the purpose of fertilization, is one.* Externally, many an ovary is hairy (Lupin, Sweet Pea, Broom, etc.), and probably the growth arises, just as it does in other parts of a flower, from the irritation set up either by an insect's proboscis as it probes the blossom for nectar, or by its feet, body, head, or tongue.†

Clusters of, or scattered, hairs are found seated in various positions on the calices, petals, corolla-tubes, stamen filaments, nectaries, stigmas, styles, and ovaries of flowers, and careful observation has shown that in a vast number of instances the hairy growth occurs in the very spot where the insect

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* M. L. Guignard. Ann. des. Sci. Nat. tom 4, p. 202. 1886.
† Rev. G. Henslow's "Origin of Floral Structures."

visitor sets up irritation. The feet may clutch a petal or filament; they may scramble to find a foot-hold near the centre of the blossom; or the insect's tongue even may lick other parts than those in which honey is actually secreted (as on the stamens and pistils, etc.), in any case, a friction is caused in those certain positions, and it is there that we invariably find the hairy processes.

The very beautiful whorl of hairs on the corolla tube of Gentian; on the stamens of Verbascum phœniceum and Centaurea; on the corolla of Honeysuckle, Amaryllis belladonna; on the styles of White Campion and filaments and stigmas of Deadly Nightshade; in the corolla of Canterbury Bell and Foxglove, and the floral tube of Germander Speedwell, etc., probably owe their origin to this process of irritation.

Whilst there seems much positive proof for this origin of hairy structures, and eager as we may be to accept such a theory, it is well to bear in mind that a vast number of plants are found which possess papillose growths on their blossoms and elsewhere, where, apparently, *no* contact—consequently no irritation—ever takes place. These may be exceptions to a general rule—we cannot say; but whilst upholding the theory, it is right not to be forgetful of this fact, since it may even be that some other origin for hairs may yet be found, of which at present we are ignorant. To a certain extent—though exactly how or why is not yet fully understood—environment appears in certain cases to regulate hair development. Thus many water plants growing in their natural habitats are perfectly destitute of hairs, but, if forced by circumstances to grow in a dry spot (as on the edge of a lake, pond, or river, whose waters dry up in summer and leave a dry mud bank, etc.) can and do produce a hairy covering. An example of this can be well seen in the Amphibious persecaria. And again, roots that grow in a heavy soil produce very, very few hairs, whilst an enormous quantity are formed when they grow in sandy, loose earth. Such things happen, we cannot quite say how; but of one thing we may be certain, and that is, that Nature, in bringing about wondrous growths, acts in that way for some special purpose, and carries out her own wonderful designs, many of which are, and for ever may be, "past man's understanding."

A very large number of hairs produce peculiar secretions that differ greatly in many ways, such as in colour, texture (appearance), odour, taste, and are useful in various important ways. Thus the secretion may take the form of an ethereal or volatile oil, gum, resin, a meally "dust," pulverulent substance, etc. The "colleters" found on the buds of many shrubs, trees, and a few herbs (Red Salvia, White Campion, etc.) exude a substance particularly gummy (viscid), containing drops of resin and balsam. When balsam is secreted, it either appears on the exterior of the cell-wall of the hair in small drops mixed with the mucilage, or forms the larger portion of the whole deposited material. Very viscid fluid is found in the glandular hairs of Primula Sinensis, Phlox Drummondii, many of the Caryophyllaceæ, Pinguicula, Dionœa (Venus' Fly-trap), Drosera (Sundew), etc. In the three latter species the secretion assumes the property of an acrid, peptonising, digestive ferment, which serves to digest nitrogenous matter and assist in the nourishment of the plant. Other plants—notably, Primula

Auricula and the "Gold and Silver" Ferns (Gymnogramma), which are much sought after for the beauty of the undersides of their fronds—show special glandular hairs covered with waxy threads that secrete a white, grey, and coloured meally, dust-like substance that gives much beauty to the foliage. In Primula Auricula this meal exudes from the oval tips of the hairs in the form of long thin threads of a resinous material, which can be dissolved in ether, acetic acid, and alkalies, and can also (so some authorities maintain) be again crystallised out of the solutions.*

Curious glandular hairs, with short stalks and cup-shaped plates of tissue, that secrete a very peculiar and strong-scented, pulverulent substance called "lupulin," are met with in the female inflorescence of the Hop when ripe; this secretion is useful for flavouring purposes, and is extracted by a drying process; it is known amongst hop-pickers and country folk as the "development," and the fruit is not supposed to be ready for gathering until the "development" is ripe. A similar secretion—known as "hashish"—is formed in the long, multi-cellular, glandular hairs on the female plant of Indian Hemp, Pelargonium, Aspidium Fern, etc.; this secretion appears as an odoriferous, acrid gum-resin, and is used medicinally.

Very oily secretions are met with in the Rose and Dittany (Dictamnus albus), the latter receiving the name of "Burning bush," owing to the fact that its stems are covered with a strong, resinous, oily exudation, which, when lit, will burn extremely fiercely.

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* Sach's "Physiology and Morphology of Plants."

It is very interesting to note some of the different colours presented by many secreting hairs. Thus, in the London Pride, the substance formed in the glandular hairs is of an opaque, rich ruby or carmine hue; in Sundew, purple; in Pine-apple Sage, reddish yellow; in Hop and White Campion, rich yellow; in Mouse-ear Hawkweed, yellowish brown; in Dittany, green; in the bud-scales on the leaves of Poplar, greenish white; whilst in a large number of other species it verges paler and paler, till we find it cream, then colourless and white, transparent or opaque, as the case may be.

Just as it varies in colour, so, too, does it in odour. Very often the exudation is extremely agreeable, being sweet and generally *pleasant*, or, on the other hand, pungent, nauseous, and disagreeable. In the Scented Geranium, Pelargonium, Thyme, Hop, Red Pine-apple Salvia (in which it exactly resembles the fruit from which the plant receives its name), Sundew, Sweet-briar Rose, the secretion is considered by most people very delicious and sweet; in Hound's-tongue, Henbane, etc., very unpleasant; whilst every degree of nicety or nastiness may be met with amongst the vast number of glandular and other secreting hairs found on wild and cultivated plants.

The flavour, or, perhaps, correctly speaking, *property*, of the secretion may be very bitter, acrid, or burning, as in the stinging hairs of the Nettle, etc., the glandular outgrowths of Venus' Fly-trap, Drosera, etc.; bitter and spicy, as in Primula Sinensis; lemony, as in Diplacus; saltish, in Tobacco; or it may be very saccharine, and pleasant to the taste; in fact, a great variety of flavours are present amongst hair secretions generally.

If we sum up the uses of these exudations, with their contrasts of colour, odour, and flavour, they may be considered in the main as so many natural provisions for the general protection and welfare of the plant, as well as for attracting or warding off the visits of insects. There is no doubt that they both attract and repel, and act in the same way and for the same purpose as do the beauteous forms, the sweet or repellent scents, the agreeable or nauseous flavours adapted and emitted by so many other plant organs.

CHAPTER IV.

CLASSIFICATION OF THE DIFFERENT KINDS OF HAIRS. DESCRIPTION OF THE LEADING FORMS.

NATURE never shows monotony; she never forms any two structures *exactly* in the same mould, though true it is they may so closely resemble one another by reason of certain characteristic features that we can instantly place them into special groups marked by a common brotherhood, so to speak. Just as no two human beings and no animals, whether as a whole or in part, are ever *facsimiles* the one of the other, so no two plants, or parts of them, are ever so perfectly similar as to be absolutely indistinguishable. Every minute plant *hair*, even, differs from its fellow in some wee point, though a common likeness may prevail over many, and make it feasible for us to classify them into special classes, according to their varying forms.

It is possible, and, indeed, very easy to notice with the naked eye whether or no a plant's surface is smooth or covered with a growth of hairs that is woolly, webbed, silky, rough, or of any other peculiar texture; whether or no any of the floral organs, in their turn, present anything special in the way of lax or dense hairy weels, etc.; but it is impossible, without the aid of a magnifying glass or microscope, to realise, even in the smallest degree, the intrinsic beauty, the strangeness, and the wonderment of the many curious forms of individual hair structures that deck even the commonest of cultivated or wild wayside plants. For some of the strange forms we *must* go farther afield, but it would not be going very wrong were we to say that if a dozen common garden or hedgerow plants were gathered and examined, probably at least nine of them would show hairs so lovely and so quaint in appearance, that a short half-hour's study with a magnifying glass would open out before our eyes pages of a book that had till then been closed, interests of which we had before never even dreamed.

In the first place, it would very soon be seen that whilst most of the hairs were long, slender, more or less the same thickness for their entire length, perhaps sharp-pointed, *some* were quite different in that they possessed, either at the apex or base, special cells that formed peculiar secretions, such hairs being known as *glandular*, whilst the former, on account of their having no connection in any way with secretions, are called *lymphatic*. Lymphatic hairs are much more commonly met with on a whole than glandular, but yet the latter abound in many species, and present many interests, of which mention will be made in due course.

All hairs may be ranged into certain leading types, each of which possesses special characteristics; but each type shows varieties that deviate so much that they stand prominently forward, presenting features distinctive and readily apparent. Broadly speaking, plant hairs may be classified into four large groups :—(1) *Uni-cellular*, containing those that are composed of one single cell *only*, as in

Wild Chervil (Chaerophyllum temulentum); (2) *Multi-cellular*, those whose structure is built up of two or more cells, the number in some cases being extremely numerous, as in Groundsel; (3) *Simple*, containing those which show no lateral or apical branchings of any kind, as in Gorse; (4) *Compound*, in which group are placed those that present few or many branchings, terminal or lateral, as in Ribes.

These four groups intermingle. Thus, for instance, a simple (unbranched) hair may be either uni- or multi-cellular, whilst one that is compound, or branched, may be also either of the two. In the Mouse-ear Hawkweed some of the hairs are compound and multi-cellular; in the Purple Dead-nettle (Lamium purpureum) they are simple, multi-cellular. In Milfoil (Achillea millefolium) they are simple, uni-cellular; and in the Stock (Matthiola), compound, uni-cellular. From these main types the following distinctive forms may be recognised:—

(1) *The jointed.*—Hairs of this kind exhibit, at varying distances up their length, swollen joints or knuckle-like thickenings, which seem to rest in sockets, the latter being much more clearly developed in some instances than in others. On the whole, compared with other forms, this kind of hair is by no means so common, but amongst wild plants they are met with in a considerable number of instances, and may be well seen in those found on the stem and leaves of Hedge Woundwort and many of the Labiatæ; in the simple, multi-cellular hairs on the stem of the Common Fleabane (Pulicaria dysenterica); in the simple hairs found on the corolla of Bugle (Ajuga reptans); in the very beautiful simple hairs on the stem of Mouse-ear Chickweed (Cerastium vicosum); on the stems of

Mossy Saxifrage; on the leaves of Foxglove (Digitalis); on the leaves of Germander Speedwell, etc.; and on the loose, hairy tissue that lines the upper margin of the stigmatic surface in many of the Orchidaceæ.

(2) *The hooked, curved, saw-like, or uncinate.*—As a rule, the bases of these structures consist of a mass of small, closely-packed cells, forming a bulbous-shaped, swollen, and more or less highly-raised portion, from whence springs the curved or hook-like apex. The hook is usually very sharp-pointed, and composed of one or more cells. On some plants (the Mugwort), the leaf margins are covered with large, simple, saw-like hairs alternating with those of smaller dimensions; the hooked hairs that abound on all parts of wild Cleavers are small in size, simple, and very sharp-pointed; in Scarlet Runner Bean each hair on the leaf is tall, bulbous at the base, then slender, and ends in a short, beautifully-curved tip; those found on the top are very hispid, that is, rough-coated, and much curved, the stem and apex being uni-cellular. Many found in the interior of Willow-galls are long and curved. Under a microscope these uncinate hairs are really very lovely and curious objects.

(3) *The Stellate, star-like, or rayed.*—These are very lovely structures, commonly met with, usually appearing in such large masses that they form a complicated net-work, "down," or "felt," which presents in a great number of cases a woven, silvery-white appearance, as on the under surfaces of the leaves in many of the Compositæ, etc. If a stellate hair be taken and examined carefully, individually, it will be found to possess, as a rule, a short or somewhat elongated pedicel, broader at the base

than at the apex, and, springing from the tip of the pedicel, a number of arms or rays which are sometimes quite short, sometimes very long, quite simple—as in those found forming the "felt" on the stem, leaf-edges, and surfaces, as well as the involucral bracts in Mouse-ear Hawkweed—or else branched at the sides (Stock), or forked at the tip (Lavender). The number of rays varies in different species, but ranges between three and fifteen; in Lavender some of the hairs possess four, others five to ten rays; in Mouse-ear Hawkweed there are from six to twelve; in Stock we find from three to six, each much branched; in the Ivy each hair has from three to nine rays. Each ray is usually slender and uni-cellular. In many cases, these hairs greatly add to the external beauty of the plant, giving the appearance of a delicate bloom (Lavender and Stock leaves), or exquisite white "felt"—as in the Hawkweeds, Hawkbits, and others of the Compositæ. They abound on the leaves and stems of Hollyhock, where each ray is very long, slender, and unbranched; also in the curious growths known as "Oak spangles" or "galls"; amongst the Malvaceæ generally, and many other plant species.

(4) *The branched, or compound.*—This term is applied to hairs that give off *lateral* branches, in distinction to those given off at the apex, which characterise the *forked* hair. Good examples of branched hairs may be seen (1) in the leaf-sheath of Garden Ribes, where two forms may be found—(*a*) those that are simple, swollen at the base, and glandular-tipped; (*b*) those swollen at the base, glandular-tipped, but branched laterally up the pedicels. The branched forms are long and multi-

cellular. (2) In the Deadly Nightshade. Nearly every part of this plant—the stem, leaf-surfaces, veins, floral pedicels, outer calyx and corolla surfaces, corolla tube, stamen filaments, and stigmatic surface—shows hairs so much branched that, in a miniature way, each resembles a short thick piece of coral. Under the microscope such a hair is a curious object, and the way in which each of the many cells fits into the other is really beautiful. (3) In a great number of the Compositæ. (4) Amongst the stellate hairs of Stock. (5) In the Mulleins.

(5) *The forked, barbed, or glochidiate.*—The distinctive feature of these structures is the barb or fork that terminates the hair pedicel. The fork usually consists of only two or three sharp-pointed prongs—as in Rough Hawkbit (Leontodon hispidus) and many of its allied species, such as the Hawkweeds, etc.; in the Whitlow grass (Draba verna); in those hairs of Wild Hop in which each divides at the apex into two sharp-pointed, but not very much curved, prongs; in Aubretia, where the prongs are three or four in number, each very slender, and sharp at the tip.

(6) *The rough or scabrous.*—Such hairs are characterised by a peculiar growth on their membranes of small excrescences or rounded projections that give a rough appearance and also a scabrous feeling to the whole organ upon which the hairs grow. The excrescences may be very dense, as on the hairs on the petal margins of Larkspur and the stems of Harpalium, or they may appear in lax formation, *i.e.*, scattered loosely and irregularly. Good examples may be seen in Bugle, Chervil, Green Procumbent Speedwell, Gorse,

Scarlet Runner Bean, Forget-me-not, Heliotrope, Meadow Crane's-bill, etc.

(7) *The clavate or club-shaped.*—A hair of this kind usually stands on a distinctly swollen base, begins to expand at its lowest extremity, and continues to increase in size until its apex becomes extremely large, the whole form at last being that of a club. Examples—White Campion, Pansy, the interior of Willow-galls, in Avens, Scented Geranium (in which each is uni-cellular, simple, thick-coated, bulbous at the base), etc.

(8) *The ramentaceous.*—These are large, usually flatly expanded leaf-like hairs, light or dark brown in colour, multi-cellular, which very soon after their full formation become destitute of cell-sap, consequently dry. They abound in very large quantities on the leaf-stalk and leaf-ribs of many ferns—Polypodium, Acrostichum crinitum, etc., especially when young; in fact, the young leaves are often quite hidden by them. In Acrostichum crinitum, the laminæ or leaf-blades show ramentaceous hairs in the form of long, strong bristles, and, mixed with them, delicate, articulated hairs as well.

(9) *The glandular.*—This group includes a very vast number of structures, many of them of marvellous form and unsurpassed interest. They receive their name owing to the fact that they possess *glands*, either at the base or tip of the hair, that secrete various kinds of fluids, destined for certain specific important purposes, such as for attracting or warding off welcome or unwelcome insect visitors, catching and digesting them, and thus aiding in the nutrition of the plant, protecting developing buds, etc.

A typical glandular hair is one that is often known by the name of *capitate;* that is to say, it is one whose base is generally more or less swollen like a cushion, whose pedicel or stem is either long or short, uni- or multi-cellular, simple or branched, and whose head is distinctly round (London Pride), oval (White Campion), triangular (Speedwell), or broadly expanded. In this head, balsamic matters, oils, irritant juices (as in Primula obconica and Primula sinensis), which affect some people in a peculiar way, but are not felt at all by others, as well as resins, gums, and peptonising, digestive fluids are secreted, and it is owing to the presence of these various materials that the odour, flavour, and colour of such hairs varies very considerably, some being agreeably odoriferous, others nauseous; some sweet, others bitter; some ugly, others really very lovely in tone of colouring. Very beautiful examples of capitate glandular hairs may be seen in the London Pride, whose stem surfaces and floral pedicels are covered with myriads upon myriads of them. Taken individually, each hair resembles a small goblet filled with wine: the slightly enlarged base of the hair might represent the goblet stand; the slender multicellular pedicel would form the stem; and the oval gland at the tip, containing an opaque, rich ruby-coloured fluid, would be the wine within the glass; these hairs are extremely sticky. In Groundsel and White Bryony, quaint and interesting capitate hairs may be seen. In the former, each consists of a long pedicel built up of a large number of oval or brick-like cells, and an oval or circular gland at the tip; in the latter plant, the pedicel is multicellular, of varying breadth, and a gland at the top made up of two or three (rarely one) large, broad, shallow cells in some cases, or of circular ones in others. Mention must be made of the small capitate hairs found amongst the masses of long simple ones composing the feathery awn on the tiny achene (fruit) of Marsh Avens (Geum palustris), from the fact that it is an interesting case of a fruit having two different forms of hairs to aid in its dispersion. Whilst the long slender ones may easily catch the wind, it may be equally certain that the sticky glandular hairs assist in enabling the wee fruit to *adhere* to anything with which it may come into contact. Each glandular hair consists of three or four small pedicel cells and a circular gland at the tip that is dark brown in colour.

A great many herbaceous plants, shrubs, and trees show peculiar glandular hairs on their leaf-buds that are known by the name of *colleters.* These hairs are multi-cellular, short-stalked, spring from the cells of the epidermis, and assume different forms in different species; thus, in Dock and Sorrel (Rumex) they expand at their apices in a strap-shaped manner; in Coffea and Cunonia the cells are borne on a kind of mid-rib, on which they are arranged in a fan-like way; in Syringa and Ribes sanguinea they take the form of club-shaped or spherical knobs. Colleters very soon mature, and usually disappear directly the bud begins to open, their function doubtless being to protect the delicate developing structure they surround; for this purpose, they secrete watery gum-mucilage and drops of balsam or resin, which become deposited over the surface of the bud. Gum in colleters is seen well in Ribes, Salvia, Helianthus, Corylus, Lonicera; on the scales on the young leaf-buds of Æsculus; on the stipules which arise previous to the development of the leaves in Viola and Prunus; on the ochreæ of Polygonum; and on a vast number of young leaves of numerous other species of plants. This gummy secretion is called the *blastocolla.*

Perhaps the most wonderful of all glandular hairs are those of Sundew (Drosera), Butterwort (Pinguicula), and Venus' Fly-trap (Dionea), for on each plant the leaves are covered with those that secrete an acid, peptonising juice, capable also (in Drosera) of mechanical movement. If a single hair (tentacle) be taken from the leaf of Sundew, and carefully examined under a microscope, it will be found to consist of a thin, somewhat flattened, hair-like pedicel, composed of several rows of elongated cells, filled with a purplish, granular fluid (said to consist, according to Mr. Sorby, of the commonest species of erythrophyll, a substance often found "in leaves with low vitality and in other parts (like petioles), which carry on leaf functions in a very imperfect manner"), and, at the apex of this, a large capitate gland. Simple vascular tissue with spiral vessels pass upwards from the blade of the leaf, through the pedicel, to the gland at the top. The form of the glandular tip is generally oval, about four-five-hundredths of an inch in length, and it appears to be composed of an outer layer of cells filled with a purplish granular matter, together with an inner layer of cells differing both in colour and shape, but filled with the same fluid as the outer cells. In the centre of the gland lies a cylindrical mass of cells, closely packed, elongated into different lengths, truncated or rounded at their bases, and blunt at their apices; these cells are surrounded by a spiral line or fibre that is easily detachable. The central cells contain a limpid fluid which, if hot water or certain acids be applied, becomes white and opaque, whilst if a similar treatment be practised on that contained by the pedicel cells, the latter becomes very bright red, with the exception of that contained in the cells that lie immediately below the gland; these become much less red and *more* distinctly green. If a small amount of carbonate of ammonia be applied to the gland, it at once becomes *dark;* if other fluids be applied, it becomes very pale; this shows that the gland is undoubtedly absorptive.* When in a state of quiescence (non-irritation), each glandular hair on the Sundew's leaf is covered with a *shiny* secretion that forms a brilliant drop, and the effect of a mass of these leaves on an area of bog-land, with the reddish hairs glistening and sparkling like myriads of diamonds as they catch the sunlight, is one of infinite charm. The glandular hairs on the leaves of the Butterwort and Venus' Fly-trap behave in very much the same way as those of Sundew; each secretes a viscid, digestive fluid, but those on the latter plant are quite dry when in a state of non-irritation, though directly the leaf catches and closes over any insect they begin to excrete their fluid. This vigorous excretion is caused by the irritation set up as soon as the nitrogenous substance is brought into contact with the glands, and lasts so long as the irritation continues, again drying up when it is removed.

Capitate glandular hairs abound, so much so that it is impossible to quote them all, or nearly all; but enough has been said about them generally to show what a vast field of interest lies in the

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* Darwin's "Insectivorous Plants," pp. 1-8.

study of them, their structural forms, colourations, odours, and secretions.

Hairs known as "*stinging*" also come under the category of glandular, because they secrete a peculiarly acrid, burning fluid. Good examples may be seen (i.) in the Urticaceæ (Nettles), plants that receive their name from the burning property they possess, "urtica" being derived from "uro," to burn. In the Loasa, or Chili Nettle, much annoyance and real danger is caused owing to the presence of the stinging hairs; in the foreign species, U. Baccifera and U. Balerica, the stinging hairs are so numerous that the plants are almost too formidable to touch; in some of the East Indian species they are specially dangerous, for, whilst in some the prickling feeling which is immediately caused is often followed by so burning a heat that it would seem as though a hot iron were pressed on the flesh, causing the pain to increase for hours and even days, till the patient shows symptoms like those that follow lock-jaw and influenza, in other cases, as in one species from Java, the effects prove still more severe, death even being sometimes the final result. On our own wild stinging Nettles are good examples of similar hairs, though, in spite of causing pain, the effects of their *stings* are never dangerous, as in the case of the foreign species. An individual hair of Urtica dioica shows an enlarged bulbous base composed of a large number of elastic cells, a long pedicel, and an oval, sharp-pointed, slightly-enlarged cap at the tip. The walls of the hair are strongly silicified. In the cells near the hair base lies the gland that secretes the acrid fluid, and this passes up the pedicel to the apex by means of a duct. If the cap be broken (a very easy thing to happen, owing to its extreme delicacy), the sharp point of the latter pierces the skin, thus injecting the secreted fluid into the flesh, causing immediately the disagreeable sensation of a sting. If, however, the hair be broken *below* the tip, no stinging feeling arises, as in this case the fluid merely exudes on to the exterior of the skin, and is in no way injected. (ii.) In Malpighia urens, in which the hairs cause both annoyance and danger. (iii.) In some species of Rhus.

(10) *The peltate or shield-like.*—These are, perhaps, the most strange-looking of all the different forms of hairs with which we may meet, being attached to the epidermis, from whence they spring by their centres, and projecting on either side in a horizontal manner, forming thus a kind of much-flattened plate or shield, which is very membraneous in texture, multi-cellular, and either more or less even round the margin, or else cut up into delicate teeth of equal or much-varying length. From the fact that their presence on a plant often causes it to appear extremely scaly or scurfy, the term "lepidote" has been given to such hairs, "lepis" being another name for "scurf."

The Bomeliaceæ are characterised by the extreme scurfiness of their leaves, caused by their covering of scaly, peltate hairs; the Sea Buckthorn (Hippophæ rhamnoides) is also clothed with them; also Malpighia urens, the paleæ of many young ferns, a good many of the cruciferous plants, Eleagnus, etc. In Eleagnus, the under surface of each leaf is white, silvery, and very scaly; the scales can be rubbed off, and, if examined under a microscope, are seen to be the very loveliest little peltate hairs, each of which is flatly-expanded, multi-cellular, much indented round the margin by being cut into fine teeth of differing lengths, thickened towards the centre of the hair, and appearing ribbed by reason of the radiating cell-walls from the centre to the outer edge of the hair.

(11) *The radical or root-hairs.*—Useful as are the hairs found on all the other parts of plants, those known as *radical* are perhaps in many ways the most useful of all in so far as they are the proper organs of a plant for the absorption of food, and carry on such an important work in that way throughout their lives. If a young root be carefully removed from the earth, and cleaned, it presents to the naked eye, near its growing point, a soft, silky appearance; this is due to the presence of the root-hairs. If any root that has grown in a moist air be examined, it will be seen to be clothed with a shining white velvety surface or pile, which is composed entirely of masses of root-hairs closely crowded together. They live but a short time, usually dying off after a few days or weeks, and this is the reason why the older parts of roots, those even of annuals, are totally destitute of living hairs. So great, however, is the number of active root-hairs found even on the most minute plant, as the root continues to grow forwards, that millions of new ones are for ever being formed to take the place of those that are withering, and actually dead, farther back on the root surface. Their very existence is closely connected with the life and activity of the plant-roots within the soil. In structure, they appear as extremely delicate, cylindrical, uni-cellular, long, thin-walled filaments or tubes, though sometimes showing peculiar and irregular thickenings (Viola tricolor); for the most

part they are simple, but in a few cases (as sometimes in Turnip) branched, and spring from the epidermal cells of the root. In the higher plants they abound on all the subterranean roots; in others (as in Anthurium, some Aroids, tropical Orchids, Ivy, etc.), on the aërial roots; in some Cryptogams—non-flowering plants (Mosses)—they spring from the stems, and are noted for their extremely long, apical growth, and also for the repeated branchings they often exhibit; they are also interesting, because they possess a curious generative power as a means of propagation, being capable of producing gemmæ or buds, which, under the influence of light, develop into leafy stems. If by any chance the root-hairs appear on the surface of the ground by upheaving the soil, they are able to develop rows of cells filled with chlorophyll (the green colouring matter of leaves, etc.), upon which other similar gemmæ are produced.*

The way in which root-hairs take in nourishment for a plant from the soil in which it grows is extremely interesting and truly marvellous. The surface of each hair is covered with a thin layer of water, and the same fluid fills the hair-walls. This water, which is absorbed, passes either directly through the skin (membrane) into the interior of the hair, or else passes along through the walls, and thus the water from the soil is sucked up into the plant by the power of what is known as "*osmosis*." In addition to the water, the root-hair absorbs other indispensable nutritive materials, viz., sulphate of lime, magnesia, and certain salts

* Sach's "Text Book of Botany," p. 139.

which lie dissolved in the water contained in the soil. But there are other materials necessary to plant-life, which are so combined that they cannot be rendered soluble only by water, but have to be acted upon in a peculiar way before their solution and absorption can take place; such materials are silica, potash, ammonia, phosphoric acid, etc. Now, we find that this action is brought about by the presence in the membrane of the hair of an *acid* fluid, which, when it comes into contact with certain soil particles, renders them soluble, so that, by the law of diffusion, they are enabled to pass from the hair into the stream of sap flowing up the root, and so reach the assimilative organs of the plant, namely, its leaves.

Owing, thus, to the work of the root-hairs, all the phosphates and potash salts that are so extremely necessary to energetic vegetable growth, are obtained by the plant, and even crystallized and *solid* minerals are dissolved by the acid fluid in the hair-walls, and the absorbed materials dispersed as further articles of food. In the course of growth it often happens that the hairs come into contact with tiny bits of stone (containing compounds of phosphoric acid, carbonate of lime, dolomite, and magnesite); these they dissolve by the above means, and small quantities of the salts are carried into the plant.*

(12) *Prickles.*—Though so very different in outward appearance to any other trichomes, these structures, since they are true epidermal outgrowths, are undoubtedly hairs, and must be classified as such. They are hairs with very hard, thick,

* Sach's "Physiology and Morphology of Plants," pp. 257-263.

lignified, silicified walls, generally short in length, very sharp-pointed, sometimes straight, but more often than not curved. They serve as a means of protection against the attacks of animals and also as climbing organs. Examples—the prickles on the stem of rose, blackberry, raspberry, etc.

It will thus be seen that the forms of individual hairs are extremely varied, and often as beautiful as they are different. One plant will often bear various kinds, as will also the many members of one large natural order, but special forms appear to be constant and peculiar to nearly every species in some of the great families of plants. Thus the Malvaceæ (Mallows) are characterised by their tufted hairs; the Boraginaceæ by those that are curiously bristly; the Cruciferæ by many that are stellate and peltate; the Compositæ for their stellate and forked; the Filices (Ferns) for hairs that are ramentaceous; the Bromeliaceæ for many curiously peltate. Why this specialisation should occur it is impossible to say; the fact must be accepted as it is stated, and we must be content to leave it thus for the present, unsolved.

CHAPTER V.

External and Internal Hairs. Where each may be found. Duration of Life. Terms used for the different kinds of Hairy Plant-Surfaces.

Hairs may be external as well as internal appendages; they may proceed, that is, from the epidermis on the outside of any plant organ, or, as we shall see further on, in a few instances, from certain cells in the interior of stems and other structures.

Externally, they may be found on young roots, whether aërial or subterranean; at the actual growing-point of a stem; or on the surfaces of stems generally, whether they grow erect or decumbent, above or below the soil. On leaves they are formed in greater or lesser quantities, either on the leaf-stalks and stipules, or the margins, surfaces, and veins, arranged, it may be, as on stems, in some definite manner, or else irregularly, and in no set order of growth. Then we meet with them on bud-scales and floral bracts; and almost everywhere within the actual flower itself; on the surfaces and margins of sepals, the surfaces and margins of petals, on the delicate filaments of stamens, on the surface of the stigma, style, and ovary of the pistil —on all these they are commonly met with, sometimes in very large quantities in the forms of "weels," clumps, circles, or tangled masses, sometimes sparsely, when they appear as silky or very delicate fringes, or a few solitary prolongations. On fruits, too, they are present, assuming the many varied forms of slender pappuses; the tiny rough out-growths on many berries (gooseberry, etc.); the silvery awns of many achenes (Clematis, Stipa), or the soft, silky appendages on the young pods of numerous species of the Leguminoseæ, etc.

Internally, they are met with in the interior of a pistil's stigma (as in some orchids), as well as in the style, the ovarian cavities, and actual placenta (the thickened layer of tissue within an ovary, from whence the ovules spring). Or, on the other hand, they appear as protuberances—when they are known strictly as "internal hairs"—that arise from certain cells surrounding the curious air-chambers or intercellular-spaces that appear between the tissue of massed cells found in the interior of some stems and leaf-stalks. They occur in the petioles (stems) of the Nymphaceæ (yellow and white Water-lily and their allies) and many other aquatic plants, where more often than not they take the form of stellate hairs; also in many tropical species of the Aroideæ (Arum). Owing to the presence of these internal hairs, the tissue of the above plants becomes extremely tenacious and stringy in texture. Their period of life is by no means of a uniform duration: some are formed only to wither within the briefest time, others for a longer period, and some to persist as long as the organ on which they grow remains alive. Those, for instance, found on roots beneath the soil last but for a few days; those met with in the Vascular Cryptogamic plants (Ferns, Horse-tails, Lycopodium, etc.), after very soon assuming a reddish colour, decay away, and, in dying, leave no trace behind. Similarly, those found on the leaves and internodes (the spaces between the leaf-stalks at the point where the latter join the main stem) of other Vascular plants—whilst remaining in the bud—fall off, and entirely disappear at a very early age; on such buds, both the woolly and glandular hairs grow extremely rapidly, maturing long before the actual bud-organs unfold. As a rule, those hairs which continue to last on during the entire life of the leaves, stems, or floral organs upon which they grow, take a much greater time to reach their full development, and, generally speaking, assume, during the course of their growth, far more varied forms; whilst on many fully-formed parts of plants the hairs, which are multi-cellular, largely devoid of sap, but filled instead with air, and often branched, may be seen to persist as a soft, white, and beautifully shining wool.

The appearance of the external surfaces of hairy plants, as well as the *feel* of them, is by no means always the same, and it needs but a casual observation of even humble "weeds" to make the truth of this fact easily apparent.

To the touch, many stems, leaves, bracts, etc., appear particularly soft and pleasant, so that, instinctively, we are led to consider them as silky, satiny, velvety, downy, woolly, or cottony, as the case may be. Again, others, when we touch them, strike us as being harsh and disagreeably rough (scabrous); whilst some, by reason of their extremely bristly texture or sharply-curved hooked-hair forms, are not only unpleasant to the touch, but even occasionally annoying, as well as painful. From the soft, woolly-textured leaf of Mullein, the silky Alpine Lady's Mantle (Alchemilla Alpina), and the downy under leaf-surface of many of the Compositæ, we may pass to the sharp and annoying stems and leaves of Cleavers and Hop (whose hooked hairs are able to tear the skin), and then to the sharp and painfully bristly stems and leaves of Viper's Bugloss, etc., finding on the way every transition form of textured species, many of which seem agreeable, others so unattractive as only to be hastily cast aside. The variety in general outward *appearance* is similarly caused by the way in which many hairs grow, the length of them, and their individual texture, special specific terms being applied by which such plants may be the more readily recognised and botanically described. Of these terms, the following are some of those most generally employed:—

(1) *Downy or pubescent,* when the hairs are short and create a soft appearance, as on the under surface of the leaf of White Beam; on the leaf-stems and under surface of leaf of Wild Apple; on the stems and leaves of Leopard's Bane (Doronicum); the leaves of Ploughman's Spikenard (Inula conyza); Foxglove.

(2) *Silky,* when the surface is covered with hairs that are long, even in length and distribution, and very shiny. Examples—the under surface of the leaf of Silver Weed, Alpine, and Silvery Lady's Mantle; in Salix Alba, Meadow Crane's bill, the flower-stem of Primrose, the leaf and leaf-stalk of Strawberry, etc.

(3) *Hispid,* which implies that the hairs are erect and very stiff, as in Borage (Borago officinalis) and Common Viper's Bugloss (Echium vulgare),

and the stems and leaves of Common Comfrey (Symphytum officinale); stem leaves of Nettle-leaved Bell-flower and Rampion Bell-flower.

(4) *Setose*, when each hair is long, very bristly, and spreading, such as are found on the stems and leaves of the Purple Viper's Bugloss (E. plantagineum), Bristly Hawk's-beard, Small Bugloss, etc.

(5) *Pilose*.—In this case, the hairs are distinctly scattered, and very long. Examples—the involucral bracts of the Alpine Saussurea, Achene of Pasque-flower (Anemone pulsatilla).

(6) *Floccose*, which means that the hairs are dense, but given off in small tufts as on the stems of Melancholy Thistle (Carduus heterophyllus), and on the upper surfaces of the leaves in White Beam, Winter Heliotrope (Petasites), Colt's-foot, etc.

(7) *Hirsute*, when the hairs are very numerous, long, stiffish, or beard-like, but not harsh. Examples—Forget-me-not, Common Alkanet, Nettle, etc.

(8) *Villous*.—Such a surface is extremely pretty, for the hairs are long, very soft, white, closely-packed, and present a somewhat shaggy appearance, as in the leafy bracts of the Pasque-flower, the calices of Primrose, Cowslip, etc.

(9) *Tomentose*.—In this case the hairs are fairly short, soft, and so matted together that they form a whitish "down" like "nap" or wool. Examples—the under surfaces of the leaves of Colt's-foot, Red Currant, Winter Heliotrope, many of the Hawkweeds, etc.

(10) *Woolly*, when the surface is covered with hairs that are long and curly, but *not* matted, as in the case of the flower-heads of Diotis maritima,

Filago Germanica, and apiculata; also the stems and leaves of many of the Compositæ, etc.

(11) *Velvety*, when the hairs are very short and soft to the touch. The Marsh Mallow is covered with dense velvety stellate hairs.

(12) *Cobwebby.*—In this case the hairs are so extremely fine and thread-like, and interlace (by reason of their length) so in the manner of a spider's web, that the above name has been given to a surface so covered, as well also as that of "arachnoid," which denotes the same thing. This may be seen in the involucres of some Thistles and other species of the Compositæ; also in some species of House-leek (as Sempervivum arachnoideum, the Cobweb House-leek, a very striking plant, which has the appearance of a silvery clump of cobwebs above the leaves), etc.

(13) *Ciliated.*—This term is given to the hairs that form a white, silky, delicate fringe round the margins of many leaves, calices, petals, etc. As a rule, the hairs are long, very slender, and simple, and add a softness to the organ that is decidedly beautifying, as, for instance, in the young leaves of Beech. Here, as in many other cases, the hairs more or less disappear when the leaf matures, but, at the same time, in a great many cases this is not so, and the ciliation remains the same for the entire life of the organ, whether it be a leaf or any portion of the flower.

All these various hairy surfaces have an interest of their own, and, to a great extent, may be studied with the naked eye, but only with the aid of a microscope or magnifying glass is it possible to fully understand and appreciate how marvellously each individual hair is made. By this means alone can we enter into their strange loveliness, and realise something more of that inexhaustible fund of wonderment that lies in overwhelming abundance on almost every living plant by which we are surrounded—in the smallest English wayside "weed" no less than in the most lordly, gorgeous tropical creation.

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PLATE I.

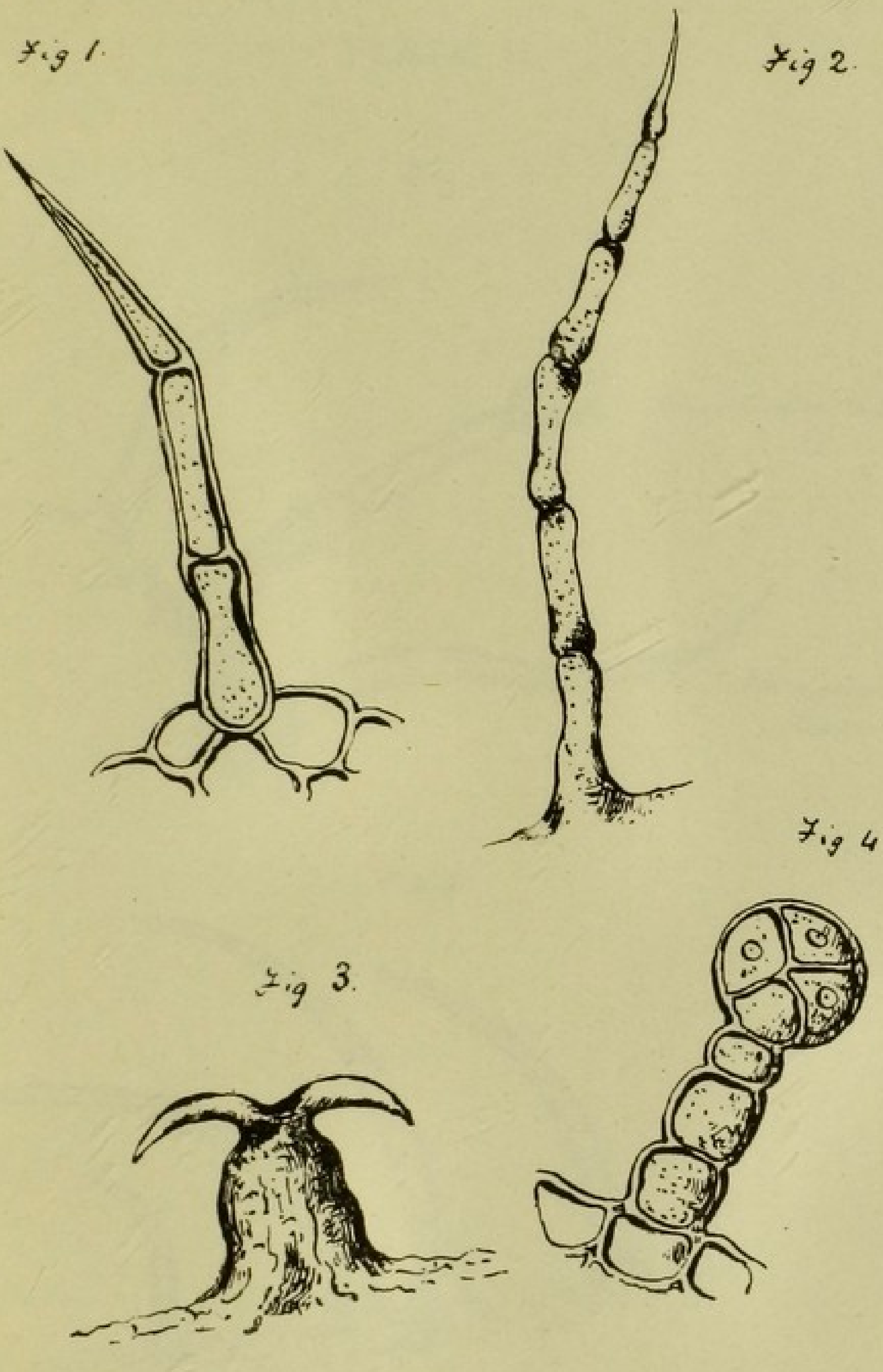

FIG. 1.—Simple multi-cellular jointed hair on the calyx of Purple Dead-nettle.

FIG. 2.—Jointed simple hair on the stem of Mouse-ear Chickweed.

FIG. 3.—Hooked hair on the stem of Wild Hop.

FIG. 4.—Glandular hair on the calyx of Purple Dead-nettle.

PLATE II.

Fig 1

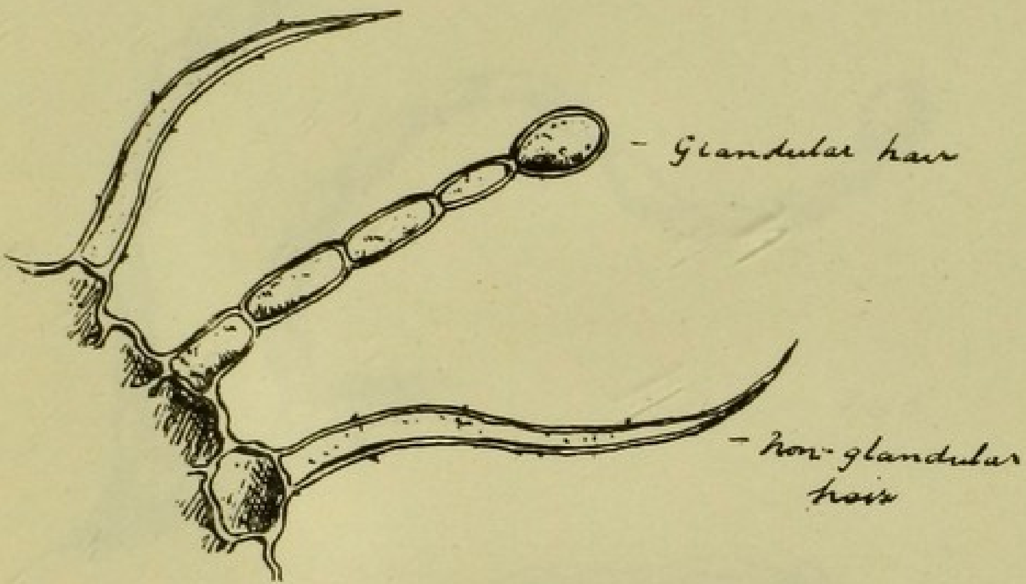

Fig 2

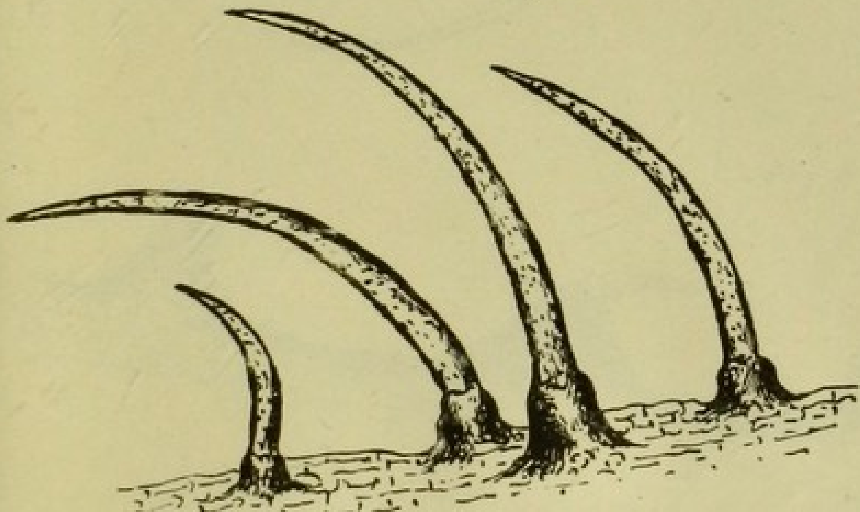

FIG. 1.—Simple glandular and non-glandular hairs on the stem of Garden Geranium.

FIG. 2.—Simple rough hairs on the stem of Wild Chervil.

PLATE III.

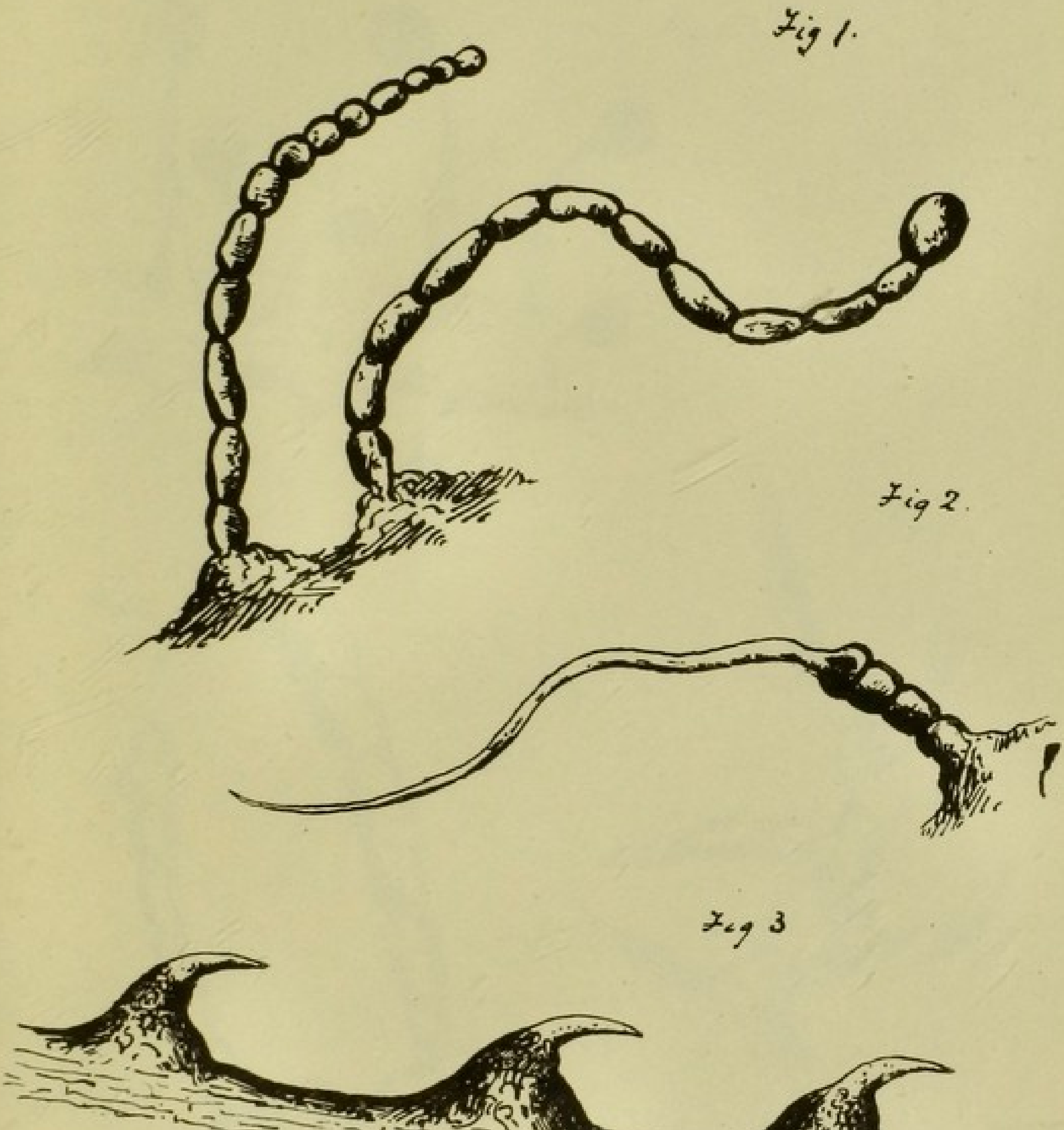

Fig. 1.—Multi-cellular glandular hairs on the stem of Groundsel.
Fig. 2.—Simple hair from the "felt" on the stem of Milfoil.
Fig. 3.—Hooked hairs on the stem of Cleavers.

PLATE IV.

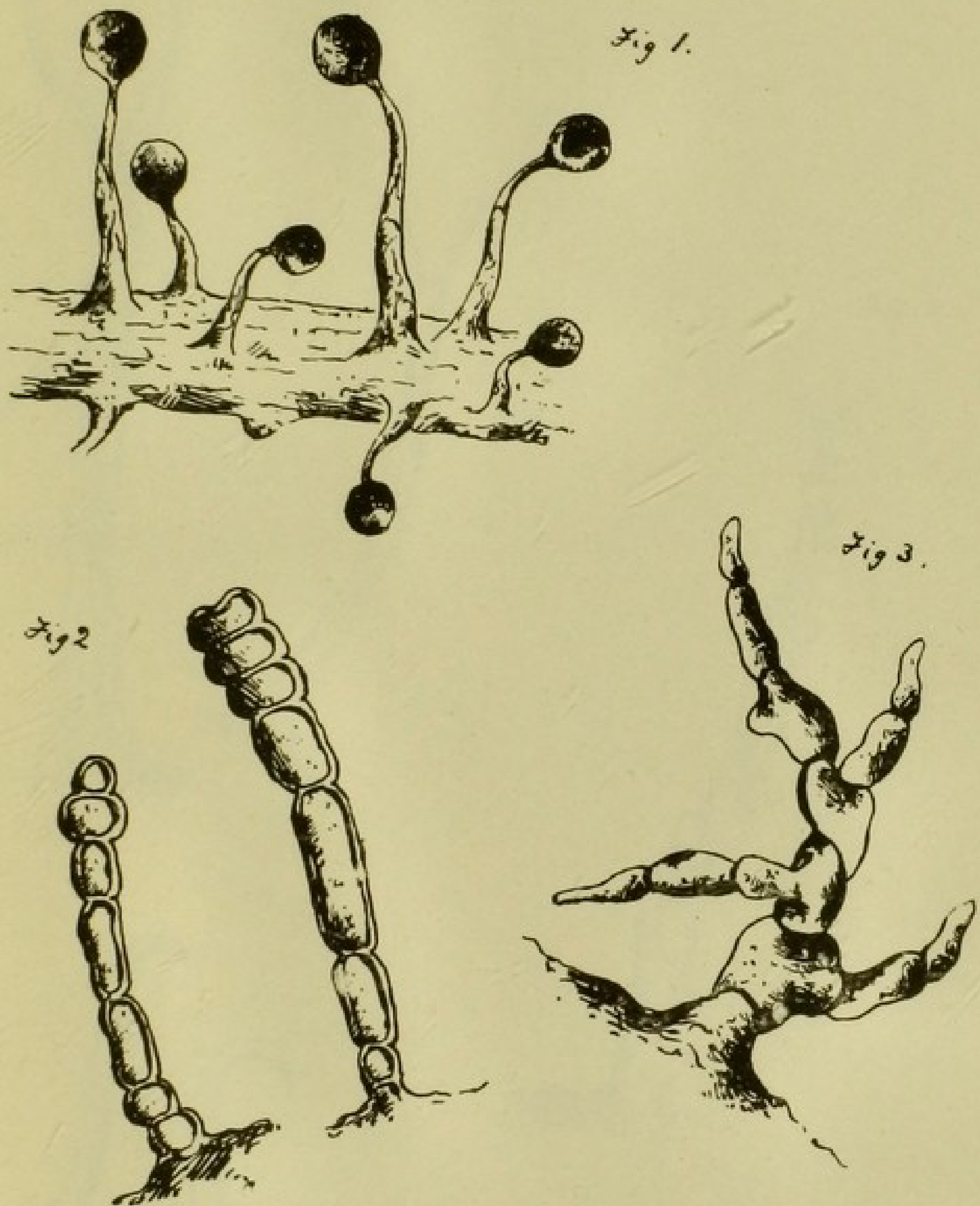

FIG. 1.—Glandular hairs on the stem of London Pride.

FIG. 2.—Glandular multi-cellular hairs on the leaf of White Bryony.

FIG. 3.—Branched multi-cellular hair on the corolla tube of Deadly Nightshade.

PLATE V.

FIG. 1.—Forked hairs on the leaf of Rough Hawkbit.

FIG. 2.—Branched (compound) hair on the leaf of Mouse-ear Hawkweed.

FIG. 3.—Hooked, or curved hairs on the stem of Scarlet Runner Bean.

PLATE VI.

Fig 1.

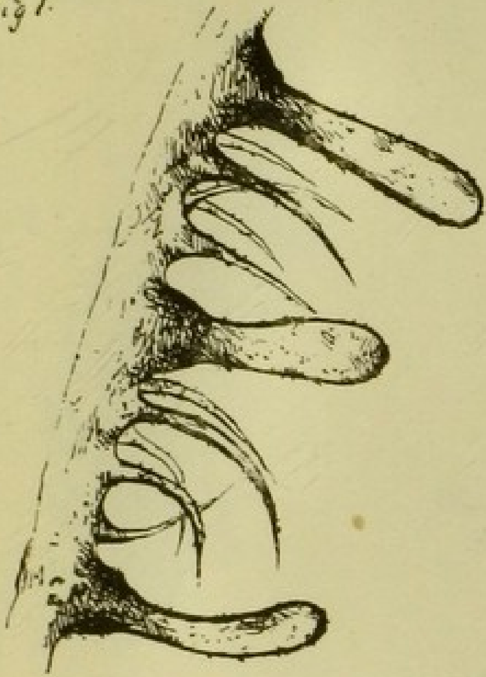

Fig 2.

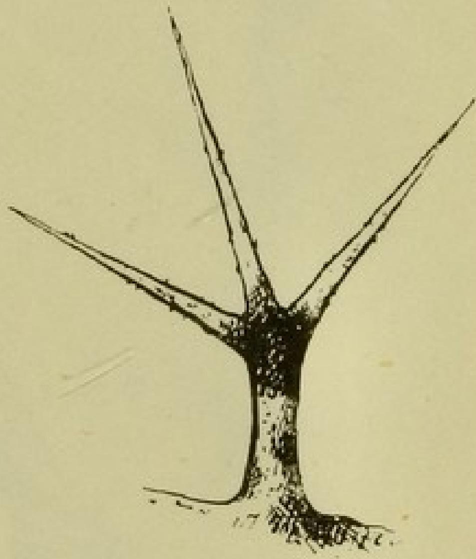

Fig 3.

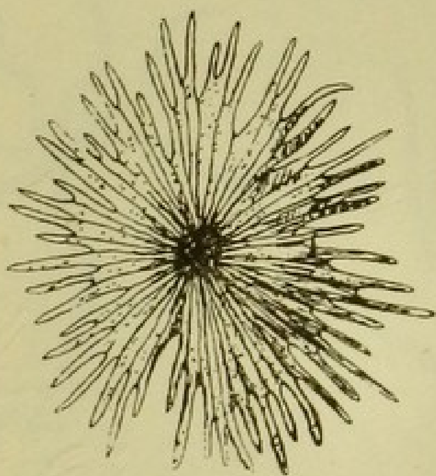

Fig 4.

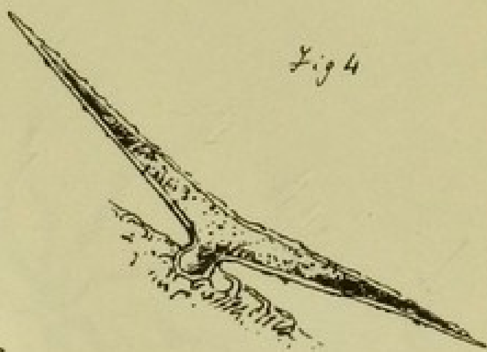

FIG. 1.—Clubbed hairs from the stem of Scented Geranium.

FIG. 2.—Forked hair from the leaf of Aubretia.

FIG. 3.—Peltate hair from the under surface of the leaf of Eleagnus.

FIG. 4.—Peltate hair from under the surface of the leaf of Wall-flower.

PLATE VII.

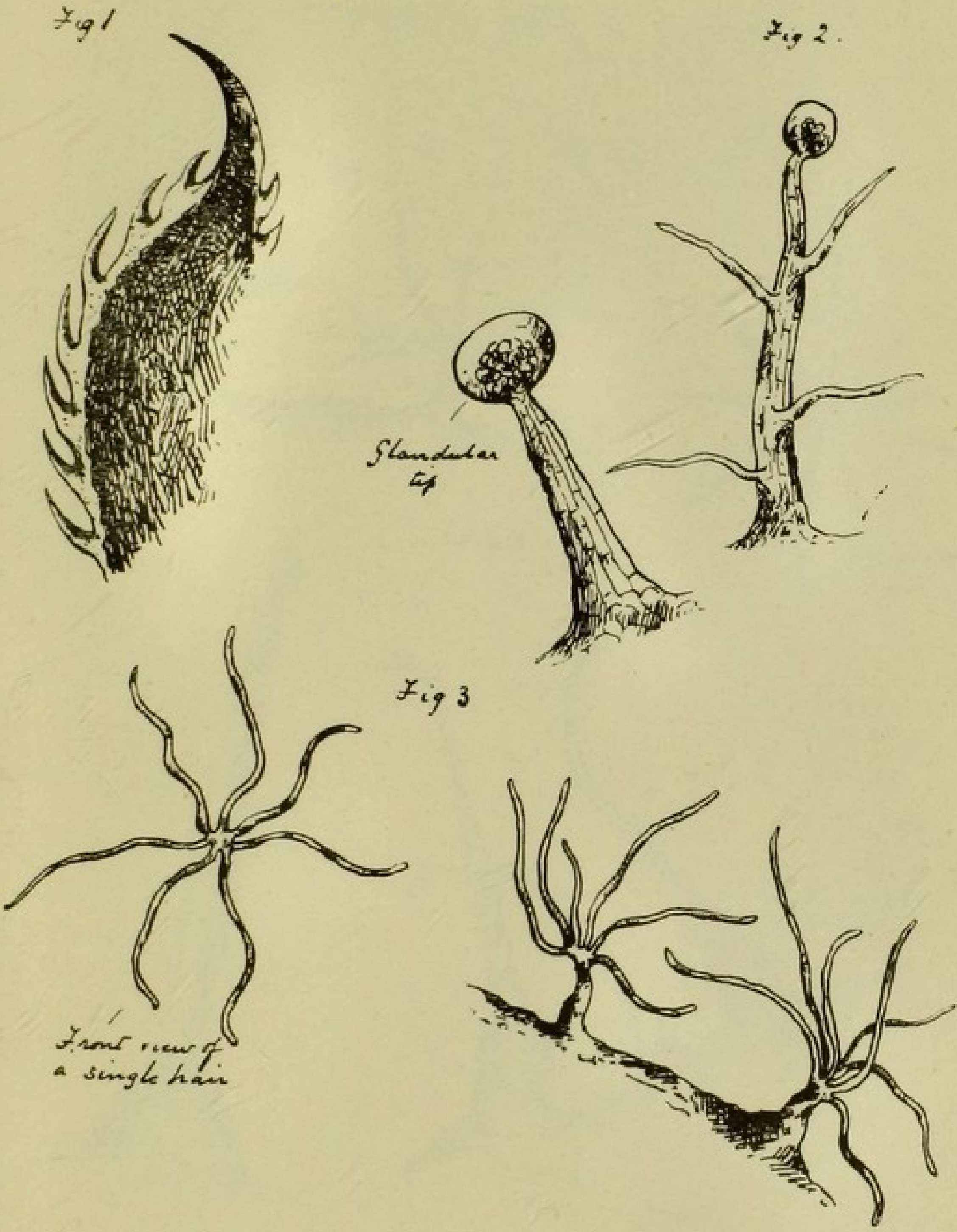

FIG. 1.—Saw-like hairs on the leaf-edge of Wild Mugwort.

FIG. 2.—Multi-cellular, glandular, compound hairs on the calyx tube of Garden Ribes.

FIG. 3.—Stellate hairs on the stem and involucral bracts of Mouse-ear Hawkweed.

PLATE VIII.

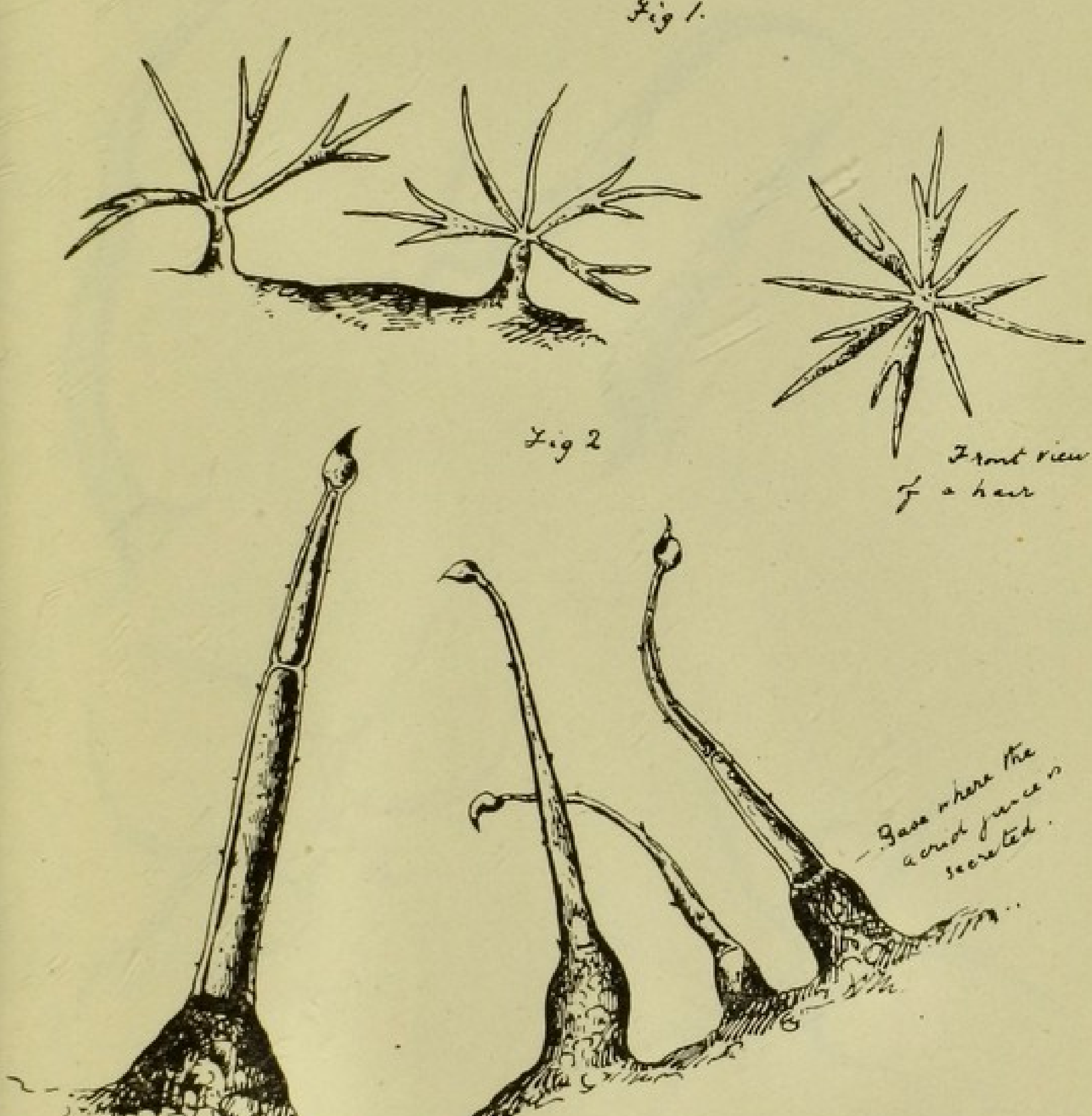

FIG. I.—Stellate hairs from the "felt" on the surface of the leaf of Lavender.

FIG. 2.—Stinging hairs from the stem of Nettle.

PLATE IX.

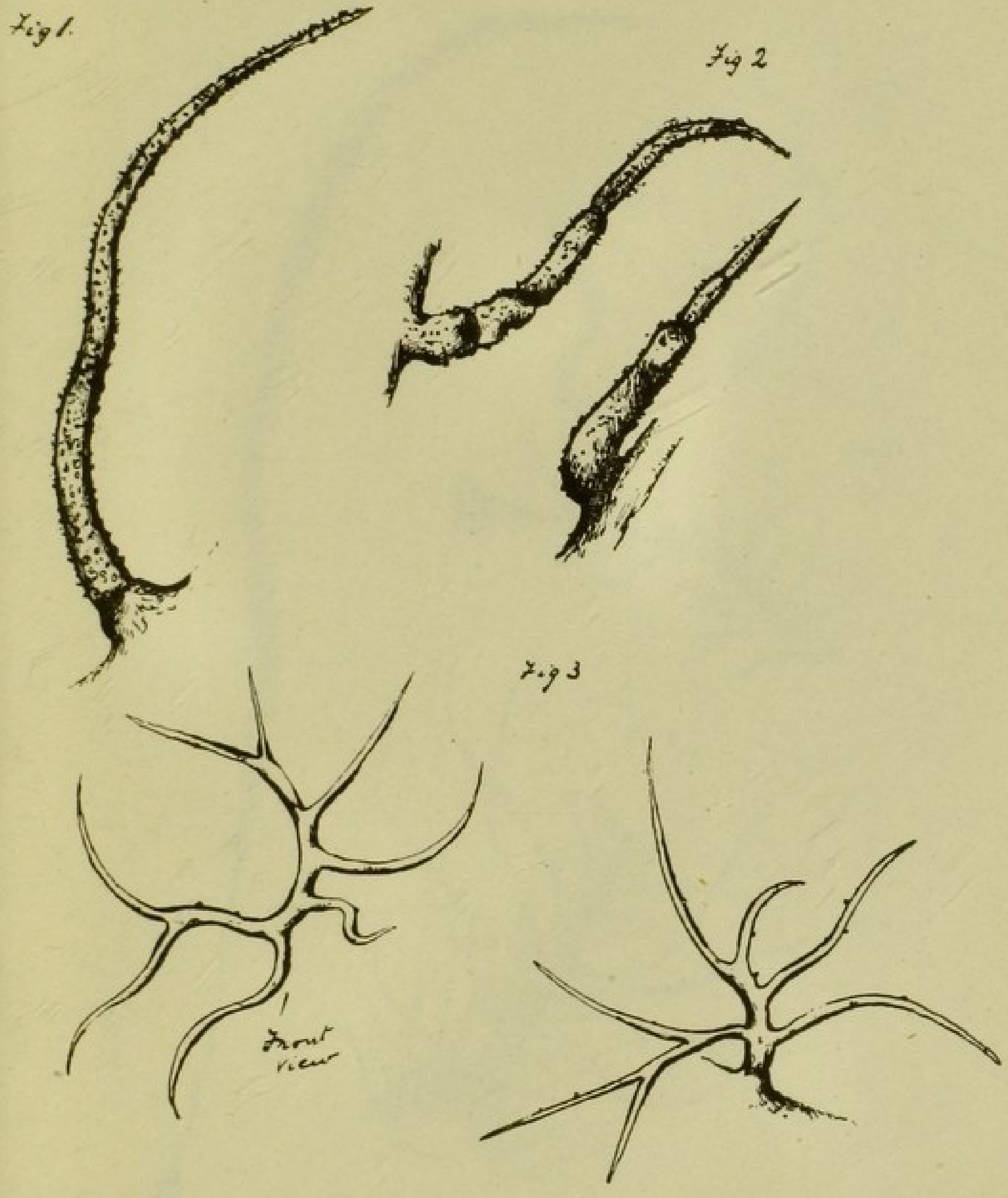

FIG. 1.—Simple, uni-cellular scabrous hair on petal edge of Larkspur.

FIG. 2.—Scabrous hairs on stem of Garden Harpalium.

FIG. 3.—Branched stellate hairs on the upper leaf-surface of Stock.

PLATE X.

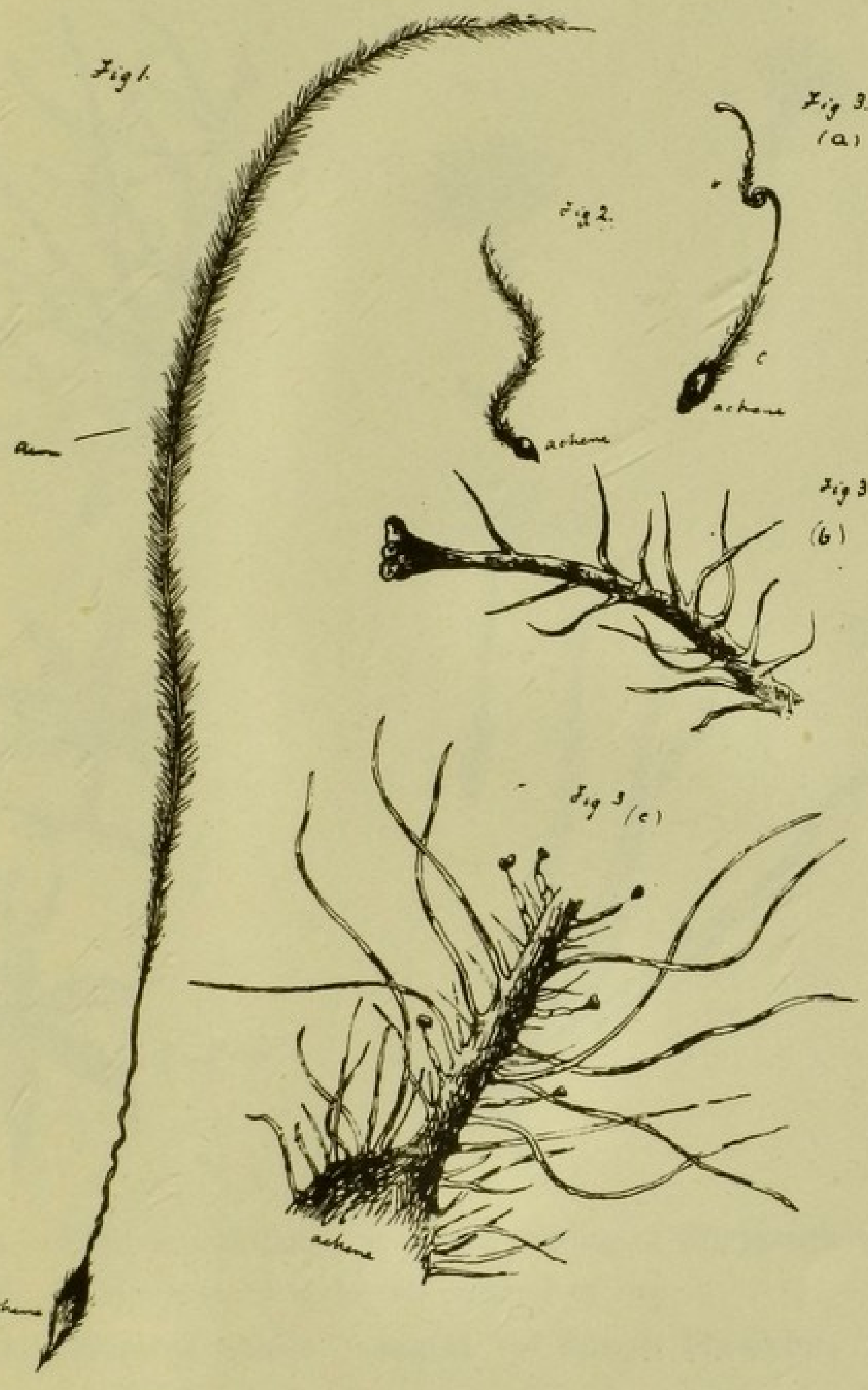

FIG. 1.—Awned achene of Stipa pennata ($\frac{1}{3}$ nat. size).

FIG. 2.—Awned achene of Clematis vitalba (life-size).

FIG. 3.—(*a*) Awn of Geum palustris (slightly enlarged) ; (*b*) tip of same ; (*c*) base of same, both largely magnified.

PLATE XI.

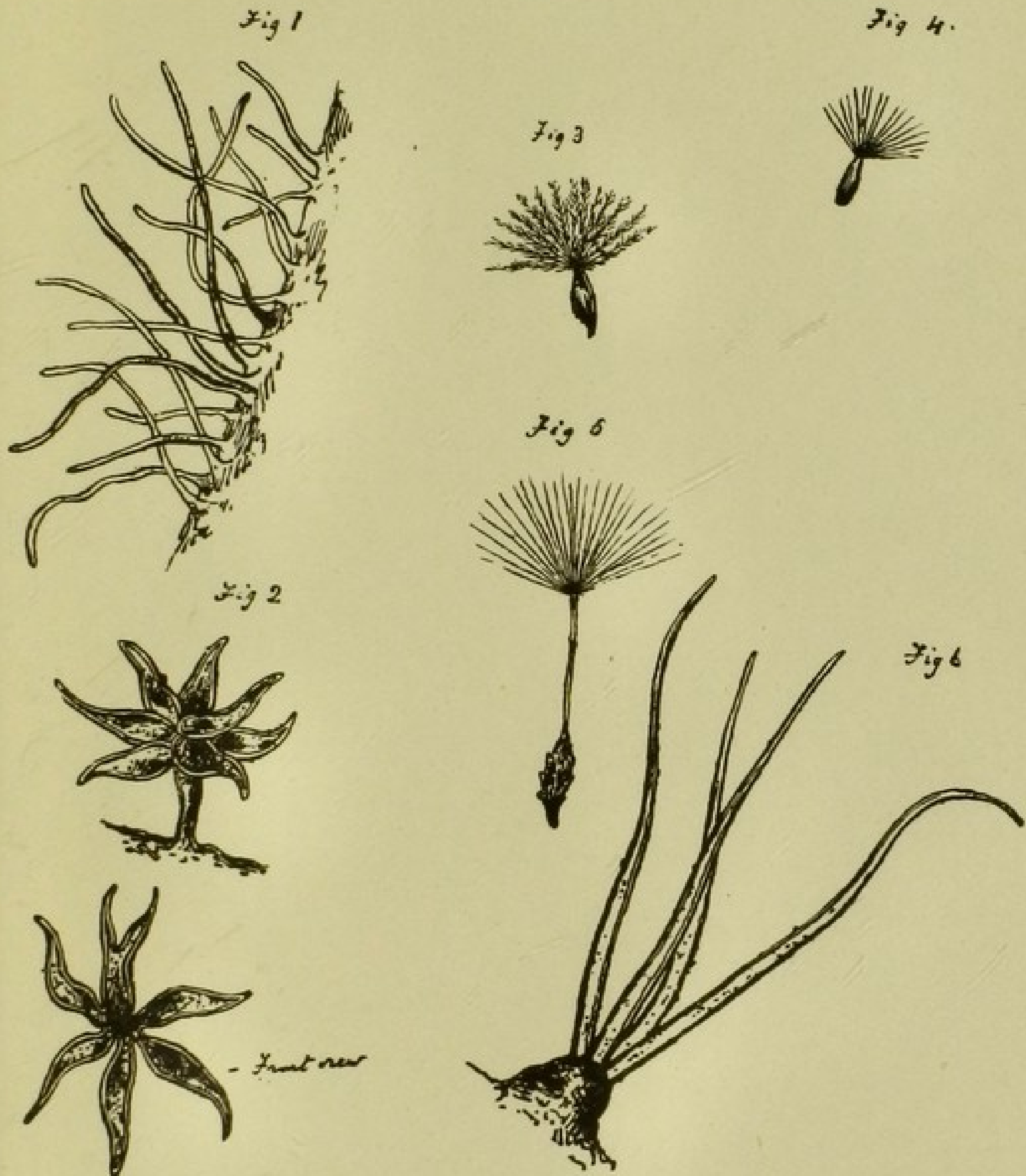

FIG. 1.—Simple root-hairs on young cutting of Chrysanthemum.

FIG. 2.—Stellate hairs from the pedicel of Ivy.

FIG. 3.—Plumose sessile "pappus" of Rough Hawkbit. (Life-size.)

FIG. 4.—Pilose sessile "pappus" of Mouse-ear Hawkweed. (Life-size.)

FIG. 5.—Pilose stipitate "pappus" of Dandelion. (Life-size.)

FIG. 6.—Stellate hair on leaf of Hollyhock.

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