Glimpses of Nature.

II.—A PLANT THAT MELTS ICE.

BY GRANT ALLEN.

IF you have ever visited the Alps in early spring, you will know well by sight the dainty little nodding bells of the alpine soldanella — twin flowers on one stalk, like fairy tocsins, which push their heads boldly through the ice of the *névé*, and form a border of blue blossoms on the edge of the snow-sheet. Most people, to be sure, visit the Alps in August; and they go too late. Autumn is the time when heather purples our bleak northern moors, but when the central mountain chain of Europe, so glorious in April, has become comparatively green and flowerless. If you wish to see what nature can do in the way of rock-gardens, however, you should go to Switzerland in early spring. It is then that blue gentians spread vast girdles of blossom over the alpine pastures; then that the green slopes on the mountain sides are yellowed by globe-flowers; then that the poet's narcissus stars with its white petals and scents with its sweet perfume the rich meadows on the spurs of the lesser ranges. Higher up, sheets of creeping rock-plants, close clinging to the uneven surface, fall in great cataracts of pink and blue over the steep declivities. As the snow melts, upward, the flowers open in zones, one after another, upon the mountain sides, so that you can mark your ascent by the variations in the flora, and the different successive stages of development reached by the most persistent kinds at various levels.

There is one adventurous little plant, however, among these competing kinds, which in its eagerness to make the most of the short alpine summer does not even wait, like its neighbours, for the melting of the snow, but, vastly daring, begins to grow under the surface of the ice-sheet, and melts a way up for itself by internal heat, like a vegetable furnace. It may fairly be called a slow-combustion stove, not figuratively, but literally. It burns itself up in order to melt the ice above it. This wonderful plant is the alpine soldanella, the hardiest and one of the prettiest of mountain flowers; it opens its fringed and pensile blue blossoms in the very midst of the snow, often showing its slender head above a thin layer of ice, where it fearlessly displays its two sister bells among the frozen sheet which still surrounds its stem in the most incredible fashion.

So much every tourist to the Alps in May must have noticed for himself, for whenever he reaches the edge of the melting ice-sheet he can see the ice pierced by innumerable twin pairs of these dainty and seemingly delicate blossoms. Comparatively few observers, however, have proceeded to notice that the soldanella, fragile as it is, actually forces itself up through a solid coat of ice, not exactly by hewing its way, but by melting a path for itself in the crystal sheet above it. Yet such is really the case; it warms the ice as it goes. The buds begin to grow on the frozen soil before the ground is bare, under the hardened and compressed snow of the *névé*—which at its edge is always ice-like in texture. They then bore their way up by internal heat (like that of an animal) through the sheet that covers them; and they often expand their delicate blue or white blossoms, with the scalloped edges, in a cup-shaped hollow above, while a sheet of refrozen ice, through which they have warmed a tunnel or canal for themselves, still surrounds their stems and hides their roots and their flattened foliage. This is so strange a miracle of nature that it demands some explanation; the method by which the soldanella obtains its results is no less marvellous than the results themselves which it produces.

The winter leaves of soldanella, which hibernate under the snow just as truly as the squirrel or the dormouse hibernates in its nest, are large, leathery, tough, and evergreen. They are, in fact, just living reservoirs of fuel (like the fat of the dormant bear), which the plant lays by during the heat of summer in order to burn it up again in spring for the use of its flowers. When I use this language, you will think at first I am speaking figuratively. But I am not; I mean it in just as literal a sense as when I say that the coal in the tender of a locomotive serves as fuel for the engine, or that the corn in the bin of a stable serves as fuel to heat the horse's body. These leaves contain material laid by for burning; and it is by burning that material up at the proper period that the soldanella manages to melt its way out of the wintry ice-sheet, and so to steal a march upon competing species.

The process requires explanation, I admit; let us try to understand it. Everybody knows, as a matter of common experience, that animals are warmer in winter than the air which surrounds them; warm-blooded animals, that is to say, which form the only class most people trouble about. Not everybody knows, however, that the same thing is more or less true of plants as well—that many plants have the power of evolving heat for themselves in considerable quantities. But this is actually true; indeed, all growing parts of a stem or young leaf-shoot must necessarily be slightly warmer than the air around them. For, when you come to think of it, whence do animals derive their heat? "From the oxidation of their food," the small boy of the day, crammed full of knowledge, will tell you, glibly. And what do you mean by oxidation but very slow burning? You may take a load of hay, and set a match to it, and it will burn at once quickly, by combining with the oxygen of the air in the open; or you may, if you choose, give it to a pair of horses to eat instead, and then it will burn up slowly, by combining with the oxygen of the air in their bodies. Lungs, in fact, are mere devices for taking in fresh oxygen, which then combines with the food or fuel in the blood of the animal. But whether you burn the hay slowly in a horse's body, or burn it fast in a fire, the main results are the same; you reduce the whole in the end to water and carbonic acid (with a few by-products), and you evolve an exactly equal amount of heat in the total process.

A century ago, Count Rumford pointed out that you might burn your hay as you chose, either in a horse or in a steam-engine; and that in either case you produced alike heat and motion. What we call fuel is just carbon and hydrogen, separated from oxygen; and what we call burning or combustion is just the re-union of the oxygen with the other elements, accompanied by a giving-off of heat equivalent in amount to that originally required in order to separate them.

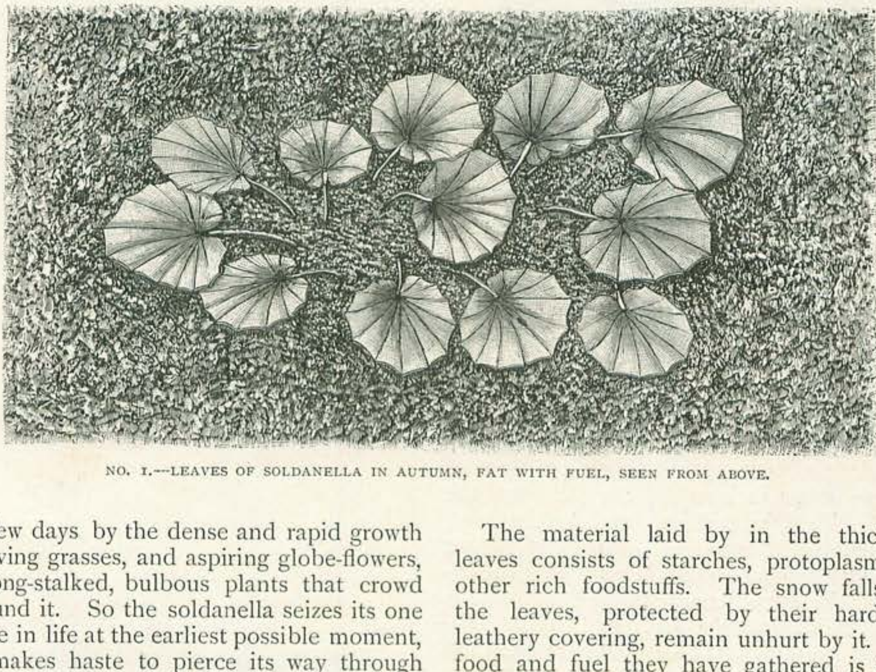
Now, the foodstuffs of most animals are plants or parts of plants, especially seeds or grains, as well as the rich stores of starch or oil laid by in roots, bulbs, and tubers. These are all of them reservoirs of food or fuel, produced by the plant for its own future growth, and meant hereafter to sprout or germinate. All seeds, when they begin to quicken, unite with oxygen and evolve heat; and this heat is just the same in nature, whether it happen to be set free within or without an animal body. If you give an ox corn, he will oxidize it internally and warm his own body with it; but if you let it germinate, it will oxidize itself, and so produce a very small but slow fire, which warms both the corn and the space around it. Similarly, all growing shoots combine with oxygen, and, therefore, rise in temperature. In early spring, when the ground just teems with sprouting seeds and swelling buds, with growing bulbs or shooting tubers, the temperature of the soil is sensibly raised; and this very heat, evolved by germination, becomes itself in turn a cause of more germination; each seed and root and bulb and sucker helps to warm and start all the others. Spring largely depends upon the warmth thus produced. The earth, during this orgy of growth, is warmer by a good deal than the air about it; warmer even than it is in summer weather—indeed, were it not for the number of plants which thus start growing at once, growth would be almost impossible in very cold countries. Like roosting fowls, they warm one another.

You think, however, the amount of heat that can be thus evolved must be very insignificant. By no means. Take an example in point. What do we mean by malting? We collect together a number of seeds or grains of barley, we wet them thoroughly, and allow them to begin germinating. Each grain individually gives out only a small amount of heat, it is true: but when many of them lie together, the total volume of heat produced is very great, and the amount would be even greater if it were not artificially checked at a certain stage: for the maltster does not wish his malt to be "over-heated." Malt, then, is nothing more than sprouting barley; and the heat it begets in the process of malting shows us very clearly how much warmth exists in sprouting seeds, or in the growing portions of young plants, buds, shoots, and tubers.

At the risk of seeming tedious in this preliminary explanation, I must also add that flower-buds and flower-stems which grow and open very rapidly must similarly use up oxygen in their growth, and therefore distinctly rise in temperature. In a very few large and conspicuous flowers, such as the big white calla lily, this rise in temperature during the flowering period can be measured even with an ordinary thermometer. No bud can open without giving out heat; and the amount of heat is sometimes considerable.

And now, I hope, we are in a position to understand how soldanella acts, and why it does so. It is a plant which grows under peculiarly trying conditions. It has to eke out a livelihood in the mountain belt, just below the snow-line; and it is a low-growing type, which must flower early, or else it would soon be overshadowed by taller rivals. For growth is rapid in the Alps, once the snow has melted. Soldanella has thus to blossom, and to secure the aid of its insect fertilizers, at the precise moment when they emerge from their cocoons in the first warm days of the short alpine summer. If it waited later it would be overtopped and obscured in a very few days by the dense and rapid growth of waving grasses, and aspiring globe-flowers, and long-stalked, bulbous plants that crowd all round it. So the soldanella seizes its one chance in life at the earliest possible moment, and makes haste to pierce its way through the solid ice-sheet, while lazier rivals passively await its melting. That alone has secured its survival and success in the crowded world of the alpine pastures. For you must not forget that while to you and me the Alps are an unpeopled solitude, to the alpine plants they are a veritable London of competing life-types.

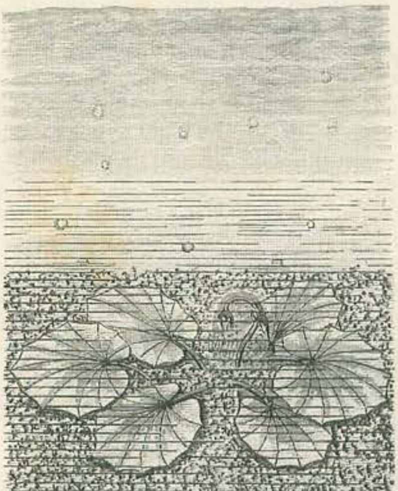
The canny plant lays its plans deep, too, and begins well beforehand. It has made preparations. All the previous summer it has been spreading its round leaves to the mountain sun, and laying by material for next year's flowering season. Leaves, you know, are the mouths and stomachs of plants; and the soldanella has a type of leaves admirably adapted to its peculiar purpose: expanded in the sunlight, they eat carbon and hydrogen the live-long summer, and turn the combined oxygen loose upon the air under the influence of the sun. By the time winter comes, they are thick and leathery, filled with fuel for the spring, and, of course, evergreen. They have also long stalks, which enable them during the summer to stretch up to the light; but in autumn, they descend and flatten themselves against the soil, so as not to be crushed by the snows of winter. The first of my illustrations (No. 1) shows a group of these fat leaves, seen from above, and flattened against the ground in expectation of the snow-sheet.



NO. 1.—LEAVES OF SOLDANELLA IN AUTUMN, FAT WITH FUEL, SEEN FROM ABOVE.

The material laid by in the thickened leaves consists of starches, protoplasm, and other rich foodstuffs. The snow falls, and the leaves, protected by their hard and leathery covering, remain unhurt by it. The food and fuel they have gathered is stored partly in the foliage and partly in the swollen underground root-stock. All winter through, the plant is thus hidden under a compact blanket of snow, which becomes gradually hard and ice-like by pressure. But as soon as the spring sun begins to melt the surface at the lower edge of the sheet, water trickles down through cracks in the ice, and sets the root-stock budding. It produces, in fact, the very same effect as the water which we pour upon malting barley in order to make it germinate. And the same result follows, though here more definitely, for the soldanella has collected its material deliberately as fuel, and uses it up on purpose to melt its passage.

It absorbs oxygen from the air below the snow, combines it with the fuels in its own substance, evolves heat from their combination, and begins to send up its nodding

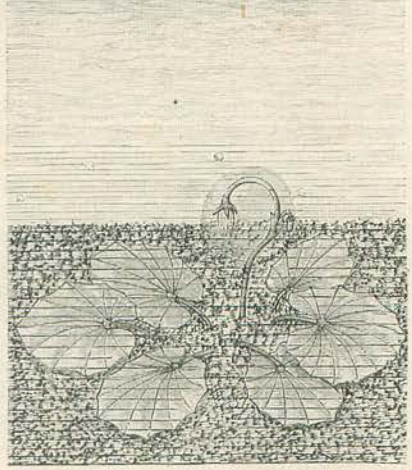


NO. 2.—BUD BEGINNING TO MELT ITS WAY UP THROUGH ICE IN A DOME-SHAPED HOLLOW.

flower-buds through the icy sheet that spreads above it.

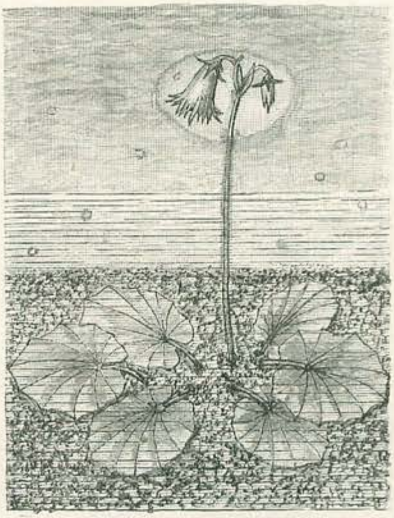
The warmth the plant obtains by this curious process of slow internal combustion it first employs to melt a little round hole in the ice for its arched flower-buds (No. 2). At the beginning, the hollow which is formed above each pair of buds is hemispherical or dome-shaped; the stem pushes it way up through a dome of air inclosed in the ice; and the water it liberates trickles down to the root, thus helping to supply moisture for further growth with its consequent heating. But by-and-by the stem lengthens, and the bud is raised to a considerable height by its continuous growth. Still, so slight is the total quantity of heat the poor little plant can evolve with all its efforts, that by the time the stem is an inch or two long, the lower part of the tunnel has curiously frozen over again, by the process which Tyndall called "regelation," and whose importance in glacier action he so fully demonstrated. In this stage, then, the melted space is no longer a dome; it assumes the form of a little balloon or round bubble of air, surrounding the flower-bud. At the same time, the ice beneath, having frozen again, almost touches the stem, so that the bud seems to occupy a small, clear area of its own in the midst of the sheet, with ice above, below, and all round it (No. 3). You would say that growth under such circumstances, in almost icy-cold air, was impossible—but if you examine the ice-sheet at the edge of the *névé*, you will find it studded by hundreds of such bubbles, each inclosing an uninjured soldanella bud in its centre. The reason is that the heat from the flower keeps the inclosed air just above freezing-point; and so long as it is not actually frozen, soldanella is indifferent to the cold of its surroundings.

Gradually, in this way, the little buds manage to bore their way to the surface and to the sunshine on the outside of the ice-sheet. At last the stalk melts its path out, and a flower appears on the top, in the centre of a small cup-shaped or saucer-shaped depression (No. 4). The exquisite blue bells are thus seen blooming in profusion, apparently out of the ice itself, or as if stuck into it. Unless you looked close, and noticed that their stems came from the ground beneath, you might even imagine they were rooted in the crystal mass of the *névé*. The edge of the snow-field in early spring is often pierced and riddled by hundreds of such soldanella borings; others above are in process of formation: and if you cut a piece open you will see inside how each is produced, with its narrow tunnel below, its balloon in the centre, or later, its saucer-shaped depression on the surface. Moreover, if you look at the



NO. 3.—BUD, SOMEWHAT LATER, INCLOSED IN A GLOBE OF AIR WITHIN THE ICE-SHEET.

foliage on the bare ground beneath, you will find that, when the flowers open, the leaves are no longer thick and swollen. All the fuel they contained has by this time been

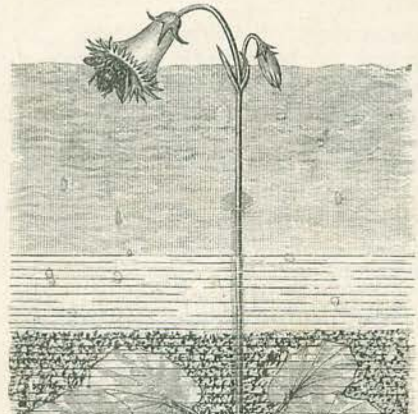


NO. 4.—FLOWER REACHING THE SURFACE OF THE ICE AND OPENING IN A CUP-SHAPED DEPRESSION.

burned up for warmth; all the formative material has been duly employed in making the buds or blossoms, with the stems that raised them; and nothing now remains but drained and flaccid skeletons, from which every particle of living matter has been withdrawn and utilized. Later on, new leaves are produced in turn from the root-stock, after the ice has melted; and these new leaves, raising themselves on their long stalks, and catching the sunlight, begin afresh to accumulate material for next year's growth and next year's burning.

But why do the flowers want so much to reach the open air at all? Why should they not blossom contentedly under the inclosing ice-sheet? A glance at No. 6 will serve to explain the reason. Flowers, after all, are mere devices for the fertilization of the fruit; it is the seeds and the next generation that the plant itself is mainly thinking about. The blossoms of soldanella are noticeable to us lordly human beings chiefly because they are so pretty; they have a delicate blue or violet corolla, exquisitely vandyked at the edge, and divided (on a closer view) into five more or less conspicuous lobes; so it is their colour and their daintiness that make us so much admire them. But to soldanella itself—which, after all, has to earn its livelihood with difficulty on a stern and rocky soil—this beauty that charms us is a mere matter of advertisement. The plant wants its blossoms to attract the early spring bees and honey-sucking flies, which carry pollen from head to head, and so fertilize its seeds for it. And fertilization, to the practical-minded plant, is the whole root of the question. It cares no more for the beauty of its flowers in themselves than the British manufacturer of cocoa or soap cares for the gorgeous colours and striking designs he lavishes on his advertisements. "Use Jones's Detergent" is the key-note of the poster. The object of an advertisement is to catch the eye and secure the money of customers; the object of the flowers, for all their beauty, is just equally to catch the eye and secure the visits of the fertilizing insects.

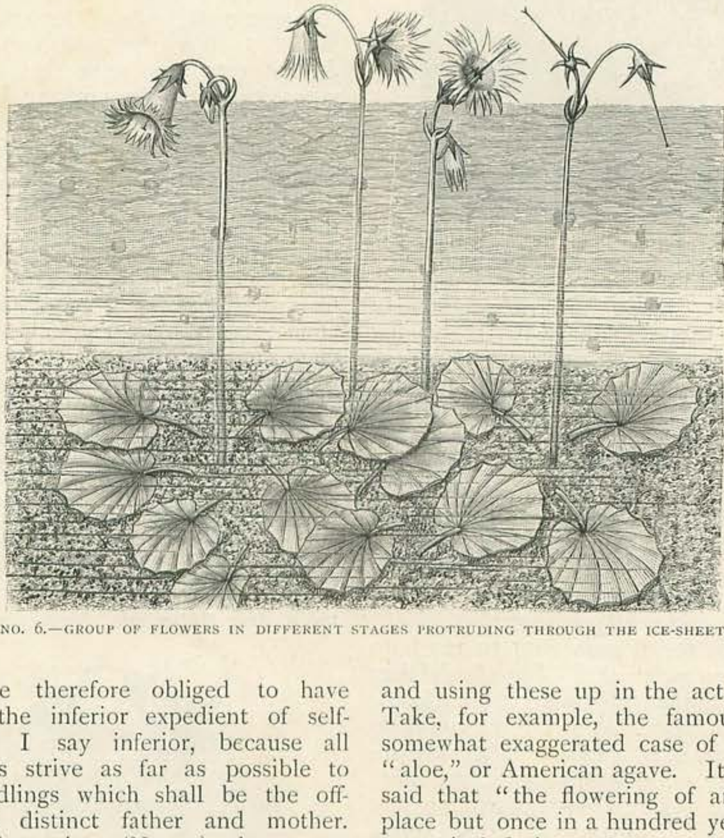
No. 5 shows how all this is managed. At the very same time that the soldanella raises its timid flowers, the bees and flies a little lower down the mountain sides are just escaping from their cocoons as full-fledged winged insects. It is for their sakes alone that the pensive blossoms tint themselves in blue or violet; for you will find throughout nature that blue is the true bee colour; and flowers that depend most for fertilization on bees or their allies are almost always decked out in blue or purple. If you examine a soldanella closely, too, you will see that all its parts are exactly adapted to the shape and organs of its most frequent visitor, here represented in the act of rifling its honey. Its bell-shaped blossoms just fit the insect in size; its stamens shed pollen just where his hairy body is adapted to receive it; its sensitive stigma is so arranged that he rubs the golden grains off on the receptive surface of the next flower he visits. Then the little capsules swell, and the seeds ripen; and the happy



NO. 5.—FLOWER VISITED BY A BEE, WHICH FERTILIZES IT.

soldanella, becoming a fertile mother of future generations, has fulfilled the main purpose of its stormy existence.

Sometimes, however, the ice-sheet above is too thick to pierce; and then the bud, after making manful efforts to melt its way out to the open air, is forced to give up the attempt in despair, and unfold its petals within its icy cavern. In that case, of course, no insect can visit it; and such cloistered blossoms are therefore obliged to have recourse to the inferior expedient of self-fertilization. I say inferior, because all higher plants strive as far as possible to produce seedlings which shall be the off-spring of a distinct father and mother. The last illustration (No. 7) shows two flowers which have lengthened their stalk in vain to the furthest point for which they possess material, but have failed to melt a way out of the solid ice-sheet. They are therefore driven to curl round the tips of their stamens and fertilize themselves; a process which almost always produces inferior seeds and very weak seedlings. It is in order to prevent such disastrous results on a large scale, and to avoid the evils of constant "breeding in and in," that soldanella has invented its curious device for pushing its way boldly through its native ice-sheet to the sky and the insects. It goes there, not to look beautiful for you and me, but to secure the aid of its established pollen-carriers.

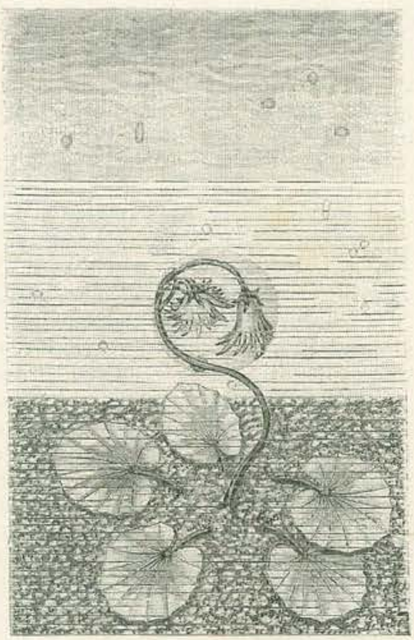


NO. 6.—GROUP OF FLOWERS IN DIFFERENT STAGES PROTRUDING THROUGH THE ICE-SHEET.

You must not suppose, however, that in doing all this the soldanella is displaying any extraordinary amount of unusual originality. Its speciality consists merely in the somewhat abnormal volume of heat which it generates. A great many plants, indeed, proceed much as the soldanella does in the matter of laying by materials for future growth in the leaves, and using these up in the act of flowering. Take, for example, the famous and often somewhat exaggerated case of the so-called "aloe," or American agave. It is commonly said that "the flowering of an aloe" takes place but once in a hundred years. This is a poetical fiction. As a matter of fact, the agave flowers on an average after fifteen or twenty years; and then dies down utterly. Every visitor to Italy or the Riviera knows this huge plant well—a gigantic house-leek in form, with its big spiny leaves and its points sharp as a needle, which defend it as by a bristling row of bayonets. Now, the agave lays by its material for future growth in the thickened base or lower portion of its leaves; it thus forms a huge rosette, very much swollen and enlarged at the bottom. For years it goes on with exemplary patience, collecting supplies for its one act of flowering; then at last, feeling its time has come, it suddenly sends up a huge stalk, or trunk, like a vast candelabrum, fifteen, twenty, or even thirty feet high, and supporting at its top a great bunch of big yellow blossoms. This enormous stem, with its colossal cluster of branching blossoms, takes only a few weeks to grow; and as it rises and flowers, or still more as the immense capsules ripen their seeds, the bases of the leaves, once swollen and thick, become by degrees flaccid and empty. The stem and blossoms have drained them dry. At last, as the seeds fall, the whole plant dies away, having used itself up for ever in its one great act of flowering, just as the egg-laying rose-aphis uses itself up in its orgy of motherhood.

Now, this is much the same as the way in which soldanella behaves, except that soldanella continues to flower, spring after spring, for many years together. It does not exhaust itself in a single blossoming. Otherwise, the two plants, though so different in size, behave in much the same general fashion. For agave must necessarily evolve a great deal of heat during its rapid flowering period; but this heat is useless to it, as heat, just as the heat we evolve in running a race is, as such, of no advantage to us. The main difference here is that soldanella has need of the heat, and employs it deliberately for its own purposes. That constitutes the really curious part of the performance; soldanella intentionally lays by rich living material, not only for growth, but also for fuel. It uses up part of its stock merely as building material for the stem and flowers: but it respires with part just as truly as you and I do—combines it with oxygen to form carbonic acid, and so to liberate heat; and gives off the heated product on purpose as an ice-melter. As the flower-bud grows, it keeps on respiring; and it is this respiration that produces the heat to melt the dome-shaped or balloon-shaped cavity within which the flower continues to develop.

Nor is such a rise of temperature in the opening flowers by any means confined to soldanella. Almost all flowers, it is probable, are rather warmer under certain circumstances than the air about them, exactly as almost all animals are. Indeed, you cannot have growth without a corresponding degree of warmth. Bell-shaped flowers, such as the foxglove, often display a sufficient amount of heat within their hanging heads to be measured by a thermometer, because their peculiar shape and their downward position are favourable for keeping the heated air undisturbed within them. The peculiarity of the soldanella thus resolves itself into this: that it alone of its type has learned how to employ this rise of temperature to the best purpose, and to melt a way for itself through the edge of the ice-sheet. In the struggle for existence, every point of advantage any creature possesses must tell in its favour, and the soldanella has thus been enabled to hold its own bravely in the intermediate belt at the margin of the ice-field. But its limits are narrow. In the open ground it is soon lived down by more hardy kinds, which rise higher into the air; its range is almost entirely bounded by a narrow belt just where the ice is melting. Above that point it cannot grow; below it, taller enemies soon oust and dispossess it. It utilizes its short time between these two impossibilities.



NO. 7.—PAIR OF FLOWERS WHICH HAVE FAILED TO REACH THE SURFACE, OPENING IN A SPHERE-SHAPED HOLLOW.

Strange as it sounds, too, the ice itself acts as a sort of protective blanket or coverlet to the trustful soldanella. Only a plant that could pierce the ice could ever have hit upon such a paradoxical mode of warming itself by its own internal combustion. If a herb that flowers in the open were to make experiments in warming itself in the same manner, its attempt would necessarily fail, because as fast as it heated the air, the wind would blow the heated portion away, and the plant would therefore derive no benefit from its expenditure of fuel. But we all know how Esquimaux can live in a snow hut, keeping it warm inside by their own breath and the heat of their bodies. It is just the same in principle with the soldanella's ice-cave. The little dome or cavern gets warmed within by the respiration of the flower-bud; and the heat thus produced is retained within the walls of the cavity. It is almost as though a mouse or other small animal were to try to bore a path for itself through an ice-barrier, not by gnawing the ice, but by breathing upon it slowly till it melted. And the soldanella, we must remember, breathes just as truly as the mouse, though it breathes not with a mouth, but from all its surface.

See, then, how absolutely the soldanella behaves like a man who is making a conservatory. It lays by fuel for the stove in its leaves to keep its flower-buds warm and to force them in spring, at a time when they could not blossom without the artificial heat thus supplied them. It keeps in this heat within a transparent covering, the doors of which are never opened. As for light, that reaches it through the crystal summit. But it employs the heat also to bore its way out; and, as its ultimate object is to get its young seeds fertilized, it finally pushes its flowers out into the open air, where they may receive the attentions of the fertilizing insects—just as the gardener does, without knowing why, when he wishes seed set. The pendent bell-shaped blossoms, again, even after they open, are admirably adapted for keeping in the heat; and they are also exactly fitted to the shape and size of the bees and flies that act as their chartered carriers of pollen. A plant, in short, has to accommodate itself at every point to the needs of its situation; it has to secure for itself a firm foothold in the soil, and a due share of food from the surrounding air (for its diet after all is chiefly gaseous); it has to provide for its marrying and giving in marriage; it has to take care that its pollen shall be duly dispersed, and its seedlets fertilized; and finally it has to see that its young are satisfactorily settled in the world, and deposited on likely spots where they can germinate to advantage. It must be a good parent as well as a prudent and cautious adventurer.

The struggle for life carried on under these circumstances has sharpened the wits of plants to a far higher degree than most people imagine. Plants have developed almost as many dodges and devices for securing food or avoiding enemies as animals themselves have; and this single instance enables us to see with what forethought and cleverness they often provide against adverse chances. Soldanella, indeed, could not exist at all upon its ice-clad heights if it did not lay up food and fuel in summer against the needs of winter, like the bee and the ant; if it did not burn up its own fat for warmth, like the dormouse; if it did not tunnel the ice as the mole tunnels the earth; if it did not retire beneath the snow-sheet on the approach of winter as the queen wasp retires into the shelter of the moss when frosts begin to kill her worker sisters, or as the squirrel retires into his hole in a tree at the approach of December. Ancestral instinct teaches the one just as much as it teaches the other; and those who have closest watched the habits and manners of plants have the highest respect for their industry and intelligence.

Looked at from this point of view, we may consider indeed that every seed, bulb, or tuber is not merely a reservoir of material for future growth, but also a reservoir of fuel for supplying the heat necessary to the first stages of sprouting or germination. And without elaborating this question further, I may add that if you will examine closely many early spring buds and flowers, especially such as willow and hazel catkins, you will find not only that they are formed over winter and inclosed in warm overcoats to protect them from the cold, but also that they grow in spring before the air is warm enough to stimulate growth directly—or in other words, that they depend in part for heat on the consumption of their own internal fuels. You must thus give up the idea that plants are quite cold-blooded and passive things; you must remember that they can to some extent warm themselves; a conspicuous example of such warming being given us by soldanella, which manages not only to grow under thick ice, but even to melt its way up through the inclosing sheet by internal combustion.