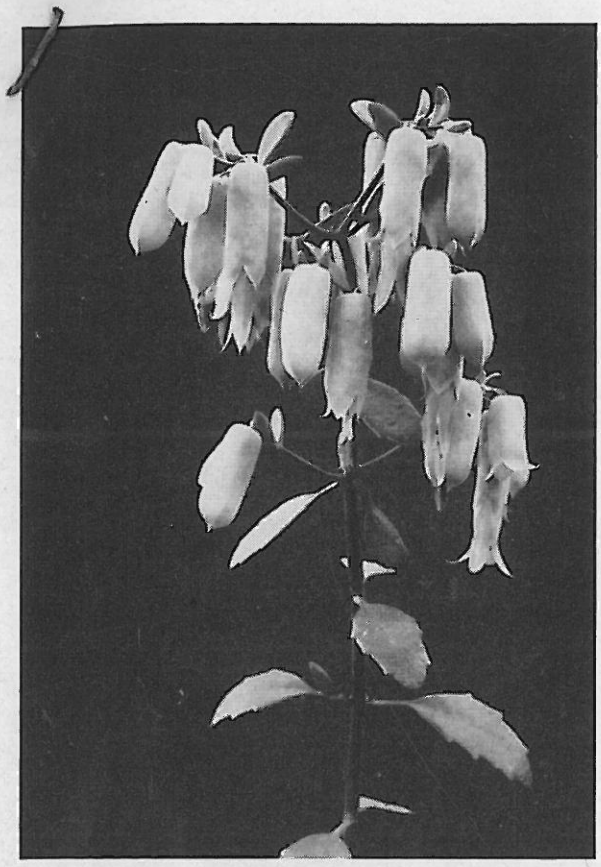


The graceful, pendent calyces of the life plant have earned for it the specific name of *calycinium*.

These calyces are of much longer duration and more conspicuous than are the rose-colored petals themselves.

Plants from Leaves

By ALEXANDER F. SKUTCH

Photographs by the Author

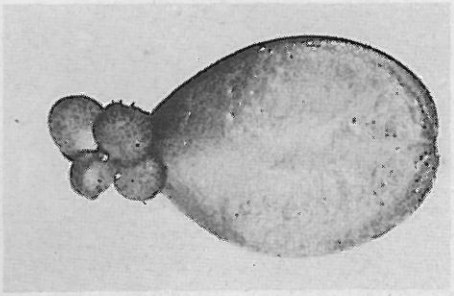
To follow the development of growing shoots, whether they spring from seed or cutting, bulb or bud, is for the Nature enthusiast always a delightful occupation. But when the new growth arises from a leaf instead of one of the more familiar bodies of propagation, the novelty and freshness of the occurrence give it a particular charm. The production of new individuals from leaves, although restricted to no single group of plants, is a somewhat rare faculty that crops up only here and there among the flowering plants and ferns. The leaves of most species, after performing their special task of manufacturing the food necessary for the growth and reproduction of the plant, wither away and die without leaving any progeny distinctly their own. But a few among the limited number of exceptions to the general fate that Nature has destined for her green leaves possess amazing vitality, and form charming subjects for observation and experiment.

Very few wild plants of eastern United States possess the faculty of reproducing from leaves. Perhaps the most familiar of these is the walking-fern, *Camptosorus rhizophyllus*, which is at home in deep, wooded valleys and ravines where the drying rays of summer seldom penetrate the canopy of foliage. Here the fern grows in the moist beds of mosses and liverworts that cover the tops of isolated boulders or outcropping ledges of rock. The long, slender, evergreen leaves, far simpler in outline than the fronds of most ferns, taper from a heart-shaped base to a whip-like terminal portion, and they grow in a tuft from the short rootstock. Sinking down into contact with the layer of mosses and moist humus that covers the rock, the tips of the older fronds strike root and each eventually gives rise to a new fern plant, a "step" away from the parent stock. Thus the plant "walks" from generation to generation over the mossy cliffs. In some forms of the walking-fern the auricles at the base of the frond are themselves greatly elongated; and their tips strike root in the same manner as the principal termination of the leaf, so that, to follow out the metaphor suggested by the common name, these fronds might be said to promenade simultaneously in three directions!

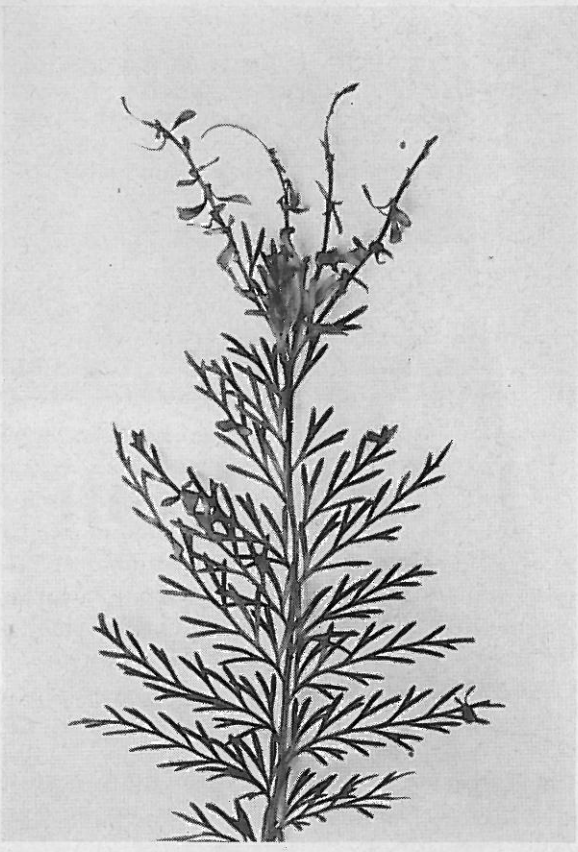
The dark forests of the Blue Mountains in Jamaica, however disappointing they may be to the lover of bright flowers, are an earthly paradise for those who find delight in ferns. The northeast tradewinds, blowing off the Caribbean, drench the upper mountain slopes with an almost daily cloud-bath; and in the deep shade and abundant moisture beneath the canopy of trees, ferns thrive wonderfully, and have almost outdone themselves in the display of diversities of size and form. Here, growing on the trunks of noble tree-ferns, which spread the intricate tracery of their enormous fronds in the woodland canopy, one finds delicate filmy-ferns and diminutive polypodies, so small that one wonders whether they can actually be full-grown ferns. Here one sees ferns with leathery, entire leaves that seem to belong to some exotic, thick-leafed tree rather than to a fern, and others with fronds of such delicacy of filigree design that they are the embodiment of our conception of what the most fern-like of ferns should be.

In all this wonderland of ferns, those which reproduce from the leaves are not lacking. There is a

spleenwort, *Asplenium radicans*, with fronds once-compound like the northern Christmas fern, the slender tips of which droop to the ground and take root, much as with the walking-fern. Because of this ready means of reproduction, this fern is very prolific, and is often found in extensive stands on the shady soil of the forest, the plants interlocked by the arched fronds, a telltale of their mode of origin. Another fern with simple, stiff fronds, *Polystichum plaschinckianum*, which I found growing in a dense thicket on a precipitous mountain-side, also produces a young plantlet at the tip of each mature frond, and is even more reminiscent of the walking-leaf. Near by on the difficult mountain-side there grew another fern, *Dryopteris effusa*, with large, much-dissected fronds, which employs a somewhat different method in the production of a new plant from the leaf. Instead of a new plantlet that springs directly from the very apex of the frond, a brown, scaly bud, about the size of a pea, is formed beneath the axis of the leaf about two inches behind its tip. Not until the frond weakens with age and sinks to the ground does this bud produce roots and leaves, and establish a new individual.



A fallen leaf of *Crassula arborea*. A new plant is growing out from the scar of detachment.

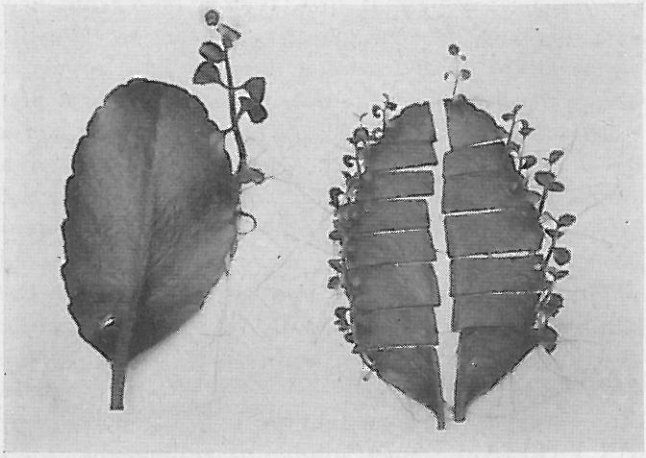


A viviparous spleenwort from the island of Mauritius, often grown as a conservatory plant. About thirty plantlets of various ages may be counted on the divisions of this frond.

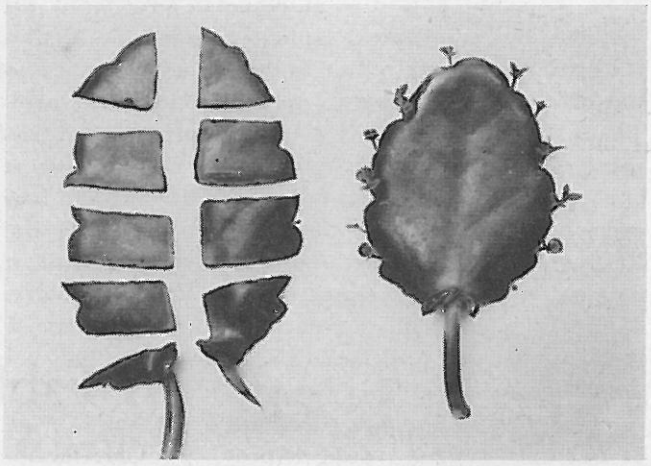
Half a world away, on the islands of Mauritius and Réunion, there grows another spleenwort, *Asplenium viviparum*, with a fecundity that has given its specific name and has been responsible for its introduction into distant lands as a greenhouse fern. The finely dissected fronds divide at the apex into several slender appendages, from each of which burgeon a number of new plantlets. Others spring forth farther back on the frond, and still more from its lateral divisions, so that a single leaf may bear a progeny of a score or more. Contact with the soil is not necessary for the initiation of the plantlets, which spring from the upper surface of the leaf while it is still held aloft.

In the great group of ferns that produce a single kind of spore—and this includes all of the familiar kinds—*Ceratopteris thalictroides* is unique in its habit of floating unattached at the surface of quiet bodies of water. A native of the Tropics, where it is of widespread occurrence in both hemispheres, it is often grown in greenhouses because of its great botanical interest. Unlike most other ferns, it is an annual; but the limited period of life of the individual fern is amply offset by the number of well-started progeny it leaves behind. The new plantlets are borne in more or less definite positions upon the upper surface of the floating leaves, and, upon the decay of the parent leaf, they become detached and float off by themselves as independent individuals.

Turning now from ferns to flowering plants, we find that there are certain groups under cultivation that gardeners habitually propagate from the leaves, so that their ability to reproduce from the foliage is well known. As a rule, propagation by leaf-cuttings is restricted to plants with thick and fleshy or else leathery, resistant leaves. With their reserve of food and water they are able to sustain life until a root system is established, even when the formation of roots is very tardy. The thick, firm leaves of the bowstring hemp, *Sansevieria*, remain in the propagating bed a full month before rooting commences. A thin or delicate leaf would have difficulty in surviving for such a protracted period even under the most favorable conditions. The thin-leafed ferns, which reproduce from their fronds, are not treated as cuttings; but the new plantlets arise from the leaves while they are still attached to the plant. Of course, all succulent leaves do not make successful cuttings; and the texture of a leaf does not alone determine its ability to produce new tissue, for this is a capacity that is linked with far more subtle physiological tendencies. The leaves of a number of plants become rooted when planted in the soil, but never succeed in forming a new shoot. Among the flowering plants, a few rare species produce plantlets, bulblets or tubers



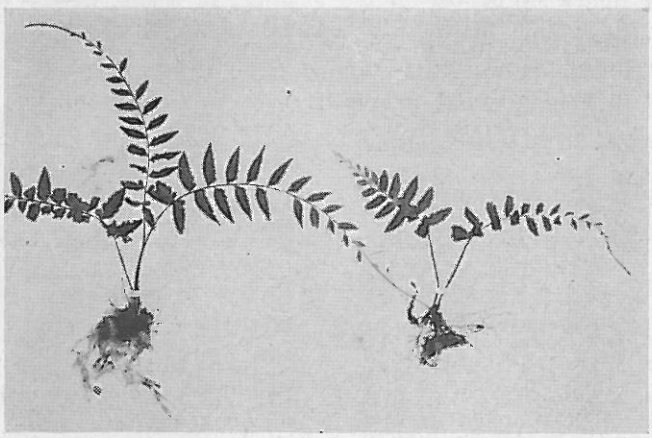
Sister leaves of the life plant 68 days after their removal from the stem. The leaf to the right was cut into 15 pieces and has produced the same number of healthy plantlets. The entire leaf has given rise to only a single, although much larger, shoot.



In an entire leaf of *Bryophyllum crenatum* all of the notches produce plantlets, which grow out quickly and then fall away. The plantlets on the cut leaf are growing extremely slowly. These leaves have been detached from the plant sixteen days.

on leaves that are still attached; but this form of vegetative propagation is not nearly so prevalent as among the ferns.

The begonias and gloxinias are perhaps the most familiar examples of plants that may be multiplied by leaf-cuttings. New plants are readily produced from the cut end of the leaf-stalk of begonias of various species if this is set in well-prepared soil in a pot or bed. A leaf of *Begonia heracleifolia* produced fifteen plantlets in this manner. In order to ensure the formation of a good number of plants from a single leaf, several methods are practiced by propagators. In some species of begonia, an incision is made through the principal veins, which project from the lower surface of the leaf. This is then pegged or weighted down to bring it into close contact with the soil. New plantlets may arise from each of the severed veins. Another procedure is to cut the leaf into triangular pieces, each of which contains at the apex a portion of the end of the petiole. These are stuck in the earth point downward, and the new growth springs from the buried apex of the triangle. Or the leaf is simply cut into halves along the midrib, and each half planted vertically, the cut edge downward. *Begonia phyllomaniaca* is remarkable for its propensity to form at certain seasons, often without apparent provocation, a multitude of adventitious plantlets, which sprout out from all portions of the leaf-blade, leaf-stalk and stem. When a leaf of gloxinia has been treated as a cutting, a tuberous swelling is first formed at the severed end of the stalk, and from this the new plant eventually arises. In the bowstring hemp, a long, curving offshoot grows out from the lower end of the leaf-cutting and forms the new plant.



A walking spleenwort from Jamaica. A frond of the larger plant to the left has given rise to the fern at the right. The older front of the latter, at the extreme right, is swelling at the tip preparatory to producing a third generation.

Among the most remarkable of plants that reproduce by means of their leaves are the "life plants". The botanical name of the genus, *Bryophyllum*, is compounded of two Greek words which we may translate "prolific leaf", and commemorates, as well as the English name, the extraordinary fecundity of the foliage. There are a number of species of bryophyllum, succulent herbs native to South Africa and Madagascar, and in other parts of the world often grown in greenhouses and conservatories. The best-known of these is *Bryophyllum calycinum*, an erect, usually unbranched plant, two or three feet tall at the time of blooming. The name *calycinum* refers to the large, cylindrical, inflated calyces, often prettily tinted and streaked with rose, which hang bell-like from the panicled inflorescence. The calyx is prominent for many days before the four rose-colored petals push out from its cover, and remains to adorn the plant and enclose the seed-pod after the petals have withered. It is probable that the life plant was originally restricted to Madagascar and the neighboring islands, and possibly South Africa, where all of its closest relatives

grow wild, but now it is at home in practically all tropical and subtropical lands. It seems likely that it owes its wide distribution to the agency of man, who has carried it as a curiosity to all parts of the world. Thanks to its ready means of multiplication, it has prospered and grows spontaneously wherever frost is absent. Tourists to Bermuda know it well; and it is even listed among the flora of tiny Guam in the Pacific Ocean. Like most plants of succulent habit, it is a native of arid regions, and thrives best in dry, open places. In many sun-parched districts of tropical America it flourishes as a roadside weed.

The leaves of the life plant are of two kinds. When young it produces only simple leaves, but as it attains maturity it forms compound leaves with three divisions. Each simple leaf, and each leaflet of the compound leaves, have a crenate or notched margin; and it is from the depths of these notches that the new plantlets spring. While the leaf is still attached to a normal, healthy plant it never produces new growths. However, if we cut thin sections of the leaf through the notches and examine them under a microscope, we can detect a minute rudiment or germ of a new plantlet tucked away in the deepest part of each notch. To cause these rudiments to awaken and develop it is only necessary to remove the leaf from its parent plant. Having accomplished this, we have a wide choice as to the next move, for the fleshy leaf is most resistant and will remain alive in all sorts of situations, although naturally some are more favorable to the development of the plantlets than others. It will suffice simply to let it fall to the ground beneath the plant; or we may hang it in the window if the house is not too warm and dry, as it is likely to be in winter in the north —one way or the other, one is almost certain to witness something of interest.

One of the best ways to study the behavior of the leaves is to place them in a shallow tray with a piece of moistened blotting paper on the bottom. The vessel should be covered loosely with a piece of glass to prevent the too-rapid drying of the blotting paper, but it must not be sealed so tightly that air is excluded. It is best not to expose the leaves to the direct sunlight, especially if some of them have been divided into small pieces, as that causes them to dry too quickly; a north-facing window is preferable. A whole leaf, placed in a closed vessel in this fashion, will in about a week's time produce rootlets from each of the notches; a pair at first, then a larger number. The shoots of the new plantlets appear more slowly, and it will be some days after the roots have appeared before one is likely to notice them. Although at first practically every notch shows signs of activity and a developing plantlet, after a while a few, often a single, plantlets on each leaf will forge ahead of the others, grow taller and produce a more abundant crop of rootlets. Then the roots of the less-favored plantlets will turn dark and shrivel up, and the shoots will stop growth while hardly more than visible to the naked eye. They may remain dormant for a long period, or may gradually follow the roots in decay. Thus from each leaf, with perhaps two dozen notches, each with its potentiality of new life, one obtains only a single, or at most a very few, new plant.

Should we desire to obtain more plantlets from each leaf, to utilize all of its potentialities of producing new life, it is only necessary to cut the leaf into pieces, and thus remove the rudiment in each notch from the repressive influence of its more vigorous neighbors. Only in the case of two notches that are very close together, as at the apex of the leaf, it is best not to separate them, as the resulting pieces will be too small and will decay without producing a plantlet. The results of the experiment are most spectacular when the pieces into which the leaf is cut are merely separated a little from each other but left in the same relative position as in the intact leaf. By proceeding in this manner one may produce, in a few weeks' time, a leaf that is bordered by about a score of thrifty green plantlets that have sprung from its marginal notches.

In the life plant, two leaves spring from opposite sides of the stem at each node. To make our experiment as convincing as possible, it is well to use such sister leaves, cutting one into pieces and preserving the other whole. One winter, from six whole leaves I obtained ten plantlets, while from the six sister leaves, divided into a total of seventy-seven pieces and placed beside the former, my crop was seventy-two plantlets. One leaf, cut into twenty-two pieces, produced seventeen plantlets; whereas the largest number obtained from a whole leaf was three. But the reader should not hastily conclude that I had outwitted Nature. On February 27, after the plantlets had been growing for ten weeks, the tallest from the leaf that had been cut into (Continued on page 164)

PLANTS FROM LEAVES

(Continued from page 152)

twenty-two pieces measured only one inch, while the single vigorous shoot from the sister leaf was thrice as high. Although by cutting up the leaf we can to a certain extent increase the efficiency of the utilization of the substance of the leaf by the new plantlets, which means that we are rewarded by a greater total weight of new growth from the cut leaf, the difference is not nearly so considerable as appears at first sight. In a rough way, the size of the new plantlet is proportional to the amount of leaf tissue it has to draw nourishment from.

A very informative experiment may be carried out with a whole leaf that has produced only one or a few plantlets. If these are cut away close to the leaf, other notches spring into activity, and from these arise new shoots to replace the excised ones. Usually these will be suppressed plantlets that were visibly larger than the rest, but whose further growth was prevented by the dominant shoot. As these spring up with fresh vigor, they, in turn, dominate those that had been still weaker. Or it is possible to obtain the same result without sacrificing the most advanced plantlets, by cutting up the old leaf as we have described for a fresh one. If the leaf has been several months removed from the parent plant, certain of the pieces will be unable to form plantlets, because the bud in the notch has died during its long period of suppression. One is tempted to moralize, and to think of one of the great empires of history, which, after the death of its Alexander or its Genghis Khan, fell again into its constituent kingdoms, of which each raised up a ruler of its own.

How do the one or two plants that somehow get the better start so effectively prevent the development of all the other rudiments on the leaf, all of which have like potentialities of growth? If we knew this, we could explain how it is that the terminal bud of the life plant, which grows up straight and branchless, inhibits the development of the buds in the axils of all the leaves, and how these together prevent the growth of plantlets from the notches of leaves still attached to the stem. The problem is not at all confined to the life plant, nor to any single group of plants, but is fundamental to all vegetation. By cutting a potato, we cause eyes to sprout. Left in direct communication with the other eyes of the tuber, they would remain dormant. By pruning a fruit tree, we stimulate the development of buds, which, but for the removal of other buds, would continue indefinitely in their winter sleep. It is because of this faculty of certain favorably situated buds to dominate over and suppress other buds of equal potentialities of growth that trees grow tall and straight and shapely, instead of sprawling over the ground, as they otherwise most certainly should. Some have supposed that the most rapidly growing shoots hold their neighbors in subjection by drawing off the nutrient materials from them and keeping them in a state of starvation; other botanists believe that the dominant buds of fastest growth send off hormones or chemical messengers that repress the activity of their weaker neighbors. There is doubtless a certain amount of truth in both views, but in the present state of our knowledge we cannot give definite answers to our questions. But in our experiments with the leaves of bryophyllum we are brought face to face with one of the most fundamental and at the same time most baffling problems that face the student of plant development.

The related *Bryophyllum crenatum* differs in many respects from the more familiar life plant. The thick, fleshy, glaucous leaves are smaller, have fewer notches, and are always simple. While they are still attached to the stem, the germ of the plantlet in each notch is so far advanced that it may be seen with a good pocket-lens; and with a microscope the rudiments of the first two leaves can be discerned. Upon the removal of the leaves from the plant, the shoots appear first in the notches and are followed by the roots, although in the common life plant the order is the reverse. Nor can we in this species increase the number of plantlets produced by a leaf through isolating the notches by cutting the leaf into pieces; for all of the notches even of an intact leaf as a rule produce plantlets which, if the leaf is kept moderately moist, shoot up quickly and soon fall away from the parent leaf, which then either withers or decays. On the other hand, many of the pieces of a cut leaf wither without giving birth to shoots.

The Crassulaceae, or orpine family, of which the life plant is a member, contains a large number of succulent, thick-leafed herbs and half-shrubs. The foliage of many of these plants, in addition to bryophyllum, has the ability to produce new individuals. In a greenhouse, the fallen leaves of *Crassula*, *Sedum* and *Echeveria* sprout as they lie on the dry earth or cinders between the pots. The new growths, roots as well as shoots, arise from the scar left by the detachment of the leaf from the stem; for no preformed buds are present on the margins, as with bryophyllum. The growth of the plantlets is almost entirely at the expense of the water stored in the swollen leaves.

Nature is at once resourceful and capricious. Leaves are among the organs she least frequently uses for the production of new individuals; but even here the variety in detail is quite amazing; and we have been able to mention only a small proportion of the plants that produce new growth from their leaves, and of the methods by which this is accomplished. Why should *Bryophyllum calycinum* and *B. crenatum* form plantlets from their leaves and not from their roots, whereas *Bryophyllum proliferum* produces plantlets from roots and flower-stalk more readily than from the leaves? How does it happen that the white-margined leaves of the bowstring hemp produce new plants readily, but these without exception differ from the parent in that their leaves lack the white border, although they retain the attractive, wavy cross-variegation? These and other caprices we shall perhaps never fully comprehend; but the effort to unravel them lends zest to the study of Nature, and gives us a deeper appreciation of the marvellous complexity of plant life.