the fact that, the phenomenon is not produced by the powdered mineral.

Whatever be the cause of the phenomenon, it is extremely curious; and the fact of the complete chromatic change being confined to the disilicate, and to the pisolithic compounds which have been supposed to be formed of dicarbonate and disilicate, appears to me to support the formulæ assigned to those bodies in a very curious way.

Art. XII. — *Some Remarks on a Proto-Morphic Phyllotype.*

By George Sigerson, M.D.

In the consideration of Phyllotaxis, too little importance seems to have been attached to the presence of stipules. To look on them merely as appendages, irregular growths, or leafy excrescences, hardly supplies a satisfactory reason for their existence. Having recently directed some attention to the subject, I was led to see in them indications of a protomorphic leaf-type, and tracing them through various modifications, I have been induced to conclude that type to be the orbicular leaf. The prototype of this, however, must be sought in a still simpler form, and will be found, I believe, in a cell. In the present instance it is intended that reticulated leaves be chiefly taken into consideration; hence it is unnecessary to refer to any type anterior to the orbicular, or to the modifications which precede it.

In the orbicular leaf, the stem is attached to the centre of the limb, and from this, ribs or vessels radiate at right angles to the stem, and to equal lengths. To have such a form, the stem must arise independent for each leaf, for if it come off from an overground stem, it generally approaches the limb with acute and obtuse angles; in which case the radii are not equally favoured, and those at the acute-angled side will be weaker and shorter. As a consequence, the circumference will not be circularly expanded at that side, but rather flattened; whilst at the other side the reverse takes place. An instance of the latter form may be found in the Indian cress (Tropæolum majus); of the former or orbicular, the sacred bean of India (Nelumbium speciosum) presents a good instance.

If, now, the mid-rib of each of the leaves which go to make up a whorl be regarded as a radius, and if the variable internodes be mentally effaced, or supposed ungrown, an orbicular leaf will

be the result, multisect and stem-pierced. Every leaf of the whorl will then be seen to be a segment, more or less modified, of the type-leaf; and the number of such segments will, of course, be the number of leaves in the whorl. And here, it may be proper to remark, that by whorl, I understand the full completion of the leaf-type, and nothing less: the whole number of leaves met with around the stem until is included the leaf preceding that which is immediately above the leaf from which the enumeration started.

Thus, a pair of opposite leaves forms but a semi-verticille; the whorl being incomplete unless the decussating pair above be added; the third pair is situated in the same sense as the first, and commences a new whorl. The complete verticille of the two decussating pairs will then be seen to form an orbicular leaf quaternisect. An instance is found in the Pimelæa decussata. Thus, also, as in Lysimachia vulgaris, where three leaves proceed from a node, and three also from the node above, covering the interspaces of the first, whilst the third triplet is situated exactly over the first—in this case, too, though the triplet has been called a whorl, I can look upon it merely as a semi-verticille, and regard the whorl as complete in two nodes only. Six segments here go to form the orbicular type, which may be called sextisect. Is it necessary to remark that, when the segments are brought into position, they may not generally be found to fit in with geometrical exactness? Possibly there will be overlapping or deficiencies in the segment-limbs, yet no one, I believe, will be surprised at such occurrences who has observed how readily change in form happens with regard to the limb-growth.

To regard the arrangement of leaves upon an axis from this point of view, affords a reason for their alternate or spiral position. In the orbicular leaf vessels radiate from every side, and thus it would seem that the stem is exhausted by giving off all its vessels at a node when the stem ceases. In order, then, to have another node, it may be supposed to reserve certain vessels, half of them in the decussating form or in Lysimachia, and a greater fraction in cases where the whorl is not completed in two nodes. But where there is more than one node, the giving off of vessels does not completely exhaust that side of the axis, yet not until the other portions of the periphery have been tapped equally, by the projection of vessels for segments, does it appear to retrieve its full productive power. In a young shoot of the ash-tree (Fraxinus excelsior), a ridge will be observed on the stem beneath the petiole; the leaf having been given off, the ridge disappears on that line, but commences to appear for the decussating leaf above. Thus, whilst two opposite sides are

ridged for one pair of segments, as soon as these are given off, the ridges appearing for the decussating segments above, give then a flattened form to the stem, where before it was prominent. So proceeding, the ridges may be said to decussate.

As the petals of the corolla have been regarded as modified leaves, they should naturally be regarded here as segments, and the corolla as a return to the orbicular type, more or less segmented. Hence, too, a reason for the appearance of bud of flower at the extremity of an axis. Generally, I have found the number of veins and veinlets of a segment to correspond with the number of vessels in the radial rib. Wherefore, I would expect something similar in the flower. The number of vessels in the floral axis will be seen to conform to the number of veins visible in the flower. The simplest form of the latter, however, is not what is generally present; as in the change from simple to double flowers, the increase has been seen to take place by the conversion of stamens into petals, so have I detected a corolla normally of four petals, which presented only two. A third, however, was in process of formation from a stamen. Between petals and sepals it is known that there are examples of transition; and that the pistil can be resolved as in the Double Cherry into leaf-segments. To seek therefore the evolution from the type, the Achlamydeous form is to be reverted to; and, I suspect, that a closer intimacy between Flowering and Cryptogamic plants than is usually thought. The attention which I have given to this part of the subject leads me, so far, to look upon the whole flower (not merely the corolla) as representing the orbicular leaf. The petal or sepal I regard as showing a leaf-stage, noticed in remarks on Fig. 22*o*, with the ternate leaf absent. The petals and sepals are, then, naturally simple, and not compound. Their vessels are not assembled together, as in petiole or mid-rib, but scattered; neither do they, in general, require a number equal to the leaf-segment. The others go to form the reproductive organs. Variations, then, in the number of parts easily occur: the vessels uniting together, or separating, where before united. In this way, I have observed not less than five stamens unite to form a petal of the Double Poppy,—some of these stamens were situated anterior to those with which they combined. The study of these matters occupies my attention, but of them it is perhaps irrelevant to make further mention here.

In axes producing leaves around the periphery, we see that the fibro-vascular organs are arranged circularly, having the pith for centre, whereas in general in the radial rib (mid-rib and petiole) producing limb laterally, the fibro-vascular fascicles present an

appearance more or less crescentic or semi-lunar in arrangement. The concave or flattened side looks towards the centre of the axis from which it is given off. The axil-bud will be found not to present such a disposition, but being an axis, has the character of that from which it is sent forth. In the radial rib, the concave or flat side being directed towards the axis, the cornua point towards the limb-producing line—towards the insertions, or more properly origins of the stipules, stipular ridge or frill, foliols, stipels, petiolules, or limb. Such a position of vessels accounts for the flattened or furrowed upper surface of the petiole. It occasionally happens that this disappears, for sometimes the vessels have almost succeeded in gaining a circular arrangement; but in general the circle apparently complete, especially externally, will be found somewhat defective. As the radial rib proceeds through the leaf, vessels go forth from the cornua to the leaflets in succession; the terminal foliol receiving those of the convexity.

It might be argued from this that it is an accident characterizing the leaf or plant, not an essential in the composition of the radial rib, that the latter should be without limb in part or with it—that we have the septenate leaf of the horse-chestnut (*Æsculus Hippocastanum*), the foliols of which proceed from a common point, or the impari-pinnate leaf of the Robinia pseudo-acacia, where the foliols are arranged at certain distances along the rib-sides;[1] or, in fine, those leaves, the limb of which is continuous along the radial rib, and apparent laterally from its origin until its termination.[2] From which it would seem deducible that the stipule, especially when petiolar, cannot be considered more foreign to the leaf than a foliol, though it may be variously modified, and that the subsequent denudation of the radial rib,

[1] Since writing the above, I have found it borne out by observing on a plant bearing primate leaves, some segments producing their foliols after the manner of the Horse-Chestnut, on account of the aborting or rather non-development in length of radial rib.

[2] So in tree or shrub, the great axis may be nude of twig or branches for a space, yet there is abundant reason to show that it is not essentially so, as it is not always. Here, too, the orbicular type may be traced. Axes, the branches, represent the radial ribs, whilst the twigs and twiglets give the vein and veinlets of the leaf. But are branches to be looked for in whorls? Decidedly. Axillary gemmation would presuppose it. But the observer will not meet so evident and agreeable a uniformity in branch-whorls as in foliar verticilles. Account must be taken of the bud often remaining latent, producing but a nodule, or otherwise aborting. Many irregularities will be met with, caused by these and other causes, such as the axis given off usurping as much nutriment as the parent axis, or two of a whorl receiving more than a third. One of a decussating pair, for instance, may be alone present, opposed to it being possibly a dry twig, a knot or a scar. The younger growths will generally be found more satisfactory than those long exposed to external influences.

then called petiole, does not argue against it. As the inter-foliolar, or inter-petiolular stipels (as in the potato leaf) indicate, as it were, an anterior type-state of continuous limb, so also with the inter-petiolar stipules. It might be objected, that in magnolias, potamogetons, etc., the stipules which protected the other portion of the leaf generally fall off as this enlarges; but it will also be recollected that the foliols of Astragalus, Massiliensis, etc., themselves fall off, leaving a spina.

Some specimens which I have been fortunate enough to obtain will probably explain more clearly the theory of mutations indicated above.

In plate I., figure 1, is represented the orbicular leaf of the sacred bean of India (Nelumbium speciosum), the circumference is continuous and the radii equal. The stalk of the leaf may be regarded as an axis. Figure 2 shows the leaf of the Hydrocotyle vulgaris. It may be looked on as presenting the first stage towards the segmented leaf. The circumference is not continuous, but somewhat indented. The indentations take place mid-way between each pair of radii; this is accounted for by insufficient nutrition being sent to those inter-radial points of the circumference. The tendency is apparent to divide the leaf into as many segments as there are radii, by formation of limb advancing in the direction of the radius.

Such a division into six segments appears in figure 3. But, when the division arrives at such a point that the limb is divided even to the axis, the action of the latter commences to separate the segments. Hence, each alternate segment (now commonly called a "leaf"), may be carried up, or its vessels not produced for an internode, as in Lysimachia vulgaris. In such a case there are two semi-verticilles of three segments each. Bird's-nest Fern presents the division with the segments almost in position; whilst in Platycerium Alcicorne, the type is shown in two kinds of division; two semicircular flat and several erect and more fractional fronds.

Instead of a leaf of six segments, let a leaf of four radii and segments be supposed. The leaf then may be separated into two parts, or semi-verticilles, by an opposite pair of segments being carried up or not produced for an internode. Then, of course, they decussate. An example of this is given in figure 4 (Calceolaria perfoliata). The limb has recovered its continuity, and unites the laminæ of the opposite segments. At *b* there is a slight projection, as though indicating a tendency to reproduce the lost radius and thus complete the type. But, so far from doing it, the limb at *a* would be deficient to fill up the interspace if the decussating pair was brought into position. The

limb has changed in direction of growth, and obtains in length what it loses in breadth here. The indentation at *a* reveals the tendency to denude the radial rib there, when it would be called a petiole: if the diminution of limb proceeds equally at *a* and *b*, it is evident that, as *b* is larger, there would some remain here. Then this would be called an inter-petiolar stipule.

The segment, figure 5 (leaf of Sonchus oleraceus, or Sow-thistle) is considerably anterior in form to those of figure 4. It resembles the segments of figure 3, but, as there are fewer radii in its type-leaf, the limb is broader near the axis. In fact, here is an example of the segment losing its primitive form, in order to grow in the direction of the radius. The slender apex has evidently shot out from a segment of circumference, the under part yet retaining somewhat of its form. In figure 6 the apex has increased and broadened, to the manifest decrease of the other part. Now, in figure 7, this order of change has so been followed up, that there remains little limb along half the rib; whilst in figure 8, that portion of the radial rib which (in figure 5) had been surrounded with the greatest breadth of limb is almost completely denuded. A little only remains, at *c*, *d*, to indicate the anterior state; here it may be termed stipules. Now segments 5, 6, 7, 8 have been obtained from the Sow-thistle, and it is possible to get from it segments representing mutations concluding with figure 17. Evidently, therefore, the change of shape is accidental in contradistinction to essential. I have, however, preferred another plant to show the further change from simple to compound, as not only the stages arrived at, but every intervening shade of mutations came under my notice more distinctly. Only the more striking shades are represented, as the changes are so gradual that to sketch them all would occupy too much space.

Not only is part of the radial rib nude of limb in figure 9 (leaf of Rubus idæus), but the stipules, *e f*, have become mere threads. To look at such a leaf alone, it might not appear very probable that stipules and lamina were the same, but considering it in its grade, that difficulty, it is hoped, disappears. Such thread-like stipules, it is apparent, may often be overlooked; sometimes they are not persistent, yet even if absent, so long as the radial rib maintains its distinctive characteristic, so long would I hold it part of the segment, and capable of producing limb.

Having arrived so far, it is proposed to show the change from a simple to a compound leaf, or more properly segment. The specimens from figure 9 to 17 (inclusive) are segments obtained from the cultivated raspberry. In figure 9 a simple leaf is shown. The change commences by an increase of nutrition

being sent to one of the veins, *g*, figure 10, which increases. The growth of limb proceeds here with greater activity than in the other parts. The apex juts forth prominent, and limb is formed at either side of the vein, whilst the veinlets branching from it increase in size. A vessel on each side of the radial rib is seen to increase with some equality of growth in segment figure 11. The vessel nearest the axis generally has the advantage over one at the opposite side placed higher up. In figure 12, one vessel only so far has developed; the process is completed by its separation in figure 13. A very short portion of radius intervenes between the edges of limb *i* and *j*. In figure 14, whilst the opposite vessel enlarges, it will be seen that the separated leaflet is farther from the limb *k*, with which it had been one. The greater length between *k* and *l* than between *i* and *j* shows not only how much the radius has increased in length here, but how much the limb between the enlarging vessel and its neighbour *m* has increased in formation. In figure 15, the separation of the second leaflet is complete. Here is a ternate segment or "leaf", somewhat irregular, apparently, one of the leaflets being closer to the terminal than the other is. This seeming irregularity the reader can at once explain, after seeing how the ternate segment is formed—one of its leaflets coming off before the other, and the inter-limb increase of the radius having separated it more from the terminal leaflet. The inter-vascular limb formation appears to increase more rapidly than the radius. Be it observed that the enlarging vein or vessel (in figure 10 marked *g*), comes off in the simple leaf, figure 9, at an acute angle, and pursues its course in the direction it comes off in. But, in figures 10, 11, 12, 13, etc., it will be seen that this is no longer the case, as there is a curve in its direction close to the radial rib. This curve is caused by the formation of limb between the enlarging vessel and the next vein superiorly (marked *h* in figure 10), being more rapid than the lengthening of radius. The vessel *h*, backed by the body of the leaf, serves as a kind of fulcrum, whilst the limb-increase between it and the seceding vessel acts, so to speak, as a wedge which urges it away from its first direction, inclining it towards the free edge, and produces the curve. When this limb-formation is irregularly developed, the vein shows it in departure from the straight line. Might it not be supposed that this curve may act with some compression on the upper side of the vessel, thus somewhat depriving the veinlets of that side of their abundant nutriment, and preparing a means to effect the scission?

However, there is a limit to the length of veins or veinlets, their strength is exhausted in giving off smaller branches.

When, then, this point is arrived at, in the inferior veinlets from *h*, and the superior from *g*, the inter-growth will cease, the growth of radius continuing the same, there will be line of rupture lightly compelled. In Philodendron pertusum, the separation, instead of approaching from edge to radial rib, proceeds at various independent points along the line; so that it is curiously pierced.

A next stage of change is shown as commenced in the terminal leaflet (fig. 16); here, too, I have been able to trace all the shades of mutation with as much ease as in the progress from simple to ternate. But, it needs not to follow these steps, as they are precisely similar, until the compound segment of this plant is completed in the quinate form represented in figure 17. These specimens, although all taken from the Raspberry, were not all found on the same plant; nature seems reluctant to reveal too openly her secret processes. Nor have I found the shades of mutation so visible in other plants; the different complete stages arrived at being oftenest only shown, the intervening process concealed.

There is considerable variety in the manner of mutation from the simple to the compound. One has been shown above. The foliols separate from the simple leaf.

The simple segment of the Blackberry (Rubus fruticosus) is similar in shape to figure 9. The first and second lateral foliols come off in the same manner from it. But, as will be seen in figure 18, the third and fourth lateral foliols do not come off from the terminal, but from the first and second lateral foliols. The foliols separate from simple segment and foliols. In the pinnate segment, figure 19, the increase of foliols from the terminal leaflet, as well as from lateral foliols, is shown. In Ailanthus glandulosus may be traced indications of a production of foliols from the upper alæ of lateral foliols as well as from the under, as in figure 19.

The bi-pinnatipartite segment, figure 20 (leaf of a species of Poppy), shows the process of increase of foliolules as well as foliols. From the terminal, a foliol is developed, from this another. The lateral foliol developes on the upper as well as on the under side. Many developed remain there, or only approach the radial rib a little; they may be called foliolules, and the same process of developing goes on in their case. A vessel ramifies, or a ramified vessel increases, hence a change in form of leaf, from simple to compound, and from that compound form to one yet more so.

In segment, figure 21 (22, 23, leaves of Rose géant), besides a leaflet in process of separation from the terminal limb, there is

also a foliol organizing and proceeding to separate from the stipule. The ala of the stipule, from being of a secondary reticulation, advances a grade. A veinlet increases gradually, gives off branchlets, and a process of growth and separation takes place somewhat similar to those already described. This would sufficiently show that stipule and "leaf" were of a like nature. Further proof of this may be found in figure 22 *n*, where the lateral leaflets are in an embryonic state, whilst the stipules and terminal foliol are again continuous in limb. There is a reversal of the ordinary rule here, for the lateral foliols assume the appearance of stipules. Figure 23 *o*, represents another irregular phase of Rose segment; the stipular portion is chiefly developed, whilst there is but a slight indication of a ternate leaf at its extremity. In other phases, not given, the ternate leaf is absent or variously modified, and the segment is brought to the condition of a bract. Something similar may be observed in the Acacia heterophylla, the phyllodia of which may be found on the same tree sometimes bearing a bi-pinnate leaf, sometimes not. In certain shrubby species of wood-sorrel, the phyllodia appear with ternate leaflet, and also without it. In such instances, whether the petiole be flattened in phyllodium or not, it may be observed that the phenomenon of passage from the straight to the reticulate venation is here to be discerned.

Figure 24 represents a segment (leaf of potato, Solanum tuberosum), where stipels indicate on the nude inter-foliol radial rib what the stipules show in another place—an attempt, as it were, to regain the continuity of limb in the phyllotype.

Segment, figure 23 (leaf of Francoa appendiculata), explains and makes more clear the last specimen, for here there is continuity of limb between foliols, stipels, and stipules.

It may be supposed that in leaves of less complex forms, the reduction to a protomorphic type would be more easily accomplished. Such is the fact. But, here, it is proper that this subject, briefly treated, should terminate; the compass of the present paper would not include observations embracing the vegetable kingdom more fully. These I purpose reserving till another time.

NOTE.

It is, perhaps, hardly necessary to state that the third article of this volume of the *Atlantis* was written and printed ten months before the death of Sir George Cornewall Lewis, for whose personal character and high and varied attainments no one could entertain a deeper respect than the writer of the Article.

A few passages in the translation of the *Tale of the Two Brothers* would require to be modified in accordance with the *Note on some Negative Particles of the Egyptian Language* (London: Williams and Norgate, 1862), since published by Mr. Renouf. In consequence of his absence from the country whilst the sheets were passing through the press, some corrections arrived too late. One of the most important of these is the Egyptian word "chetbu", to kill, for "cherbu", throughout the story. At page 55, line 29, "er meri" should be translated "to the water side". Egyptologists will at once perceive other blunders, which are, however, of no great importance to the ordinary reader.

END OF VOLUME IV.

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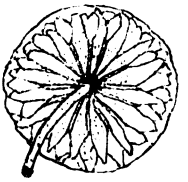
PLATE I

DR SIGERSON "ON A PROTOMORPHIC PHYLLOTYPE".



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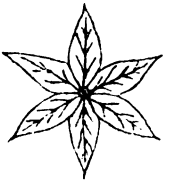

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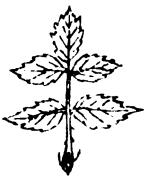
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