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ON ASEXUAL REPRODUCTION
AND REGENERATION IN HEPATICAE,

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(WITH EIGHT FIGURES IN THE TEXT).

IT is well known that the Moss-gametophyte possesses in a marked degree the faculty of regeneration, and that almost every part of the plant may, under suitable conditions, give rise to protonemal filaments, from which new plants are developed. In many Mosses, the production of protonema is confined to more or less modified and specialised organs, which previously become detached from the parent plant. Correns has, in his valuable "*Untersuchungen*,"¹ framed a somewhat elaborate classification of these organs of vegetative propagation. Although various writers have described examples of similar phenomena in the Hepaticae, none has yet collected and summarised the available information on the subject, in the same way that Correns has so ably done in the case of the Mosses. The object of the present paper is to present a resumé of the principal results that have been published up to the present time, together with some new observations.

In many Hepaticae, asexual propagation is brought about by the dying away of the older parts of the shoot from behind and the setting free of the younger parts or branches as independent plants.

In other cases, the plant bears, often in very large numbers, small few-celled bodies (gemmae), which become free and produce new plants. A third method of propagation, not always easy to distinguish from those just mentioned, consists in the separation from the main axis of buds or branches, either normal or adventive in origin. It is sometimes difficult to draw a sharp distinction

¹ Correns, C., *Untersuchungen über die Vermehrung der Laubmoose durch Brutorgane und Stecklinge*. Jena, 1899.

between a caducous adventive shoot and a gemma, these types being connected by intermediate forms.

It will be convenient to deal first with the methods of propagation which have been actually observed in nature, taking the families of Hepaticae in turn, and afterwards to describe the processes of regeneration observed when the plants are cultivated and experimented with in the laboratory, under various conditions that differ more or less from those under which the plants grow naturally. The two sets of phenomena, which we may distinguish as natural and induced respectively, in some respects coincide, whilst the facts obtained by experiment often throw light on those observed in the field and lead to certain generalisations and conclusions which will be discussed later.

NATURALLY-OCCURRING ORGANS OF ASEXUAL REPRODUCTION.

I. *Marchantiales*. In this group, asexual reproduction is chiefly carried on by the dying away of the older parts of the branched ribbon like thallus and the liberation of the ordinary branches, or by means of adventive branches, though in some cases (*Marchantia*, *Lunularia*, *Fegatella*) specialised gemmae are produced.

Fam. I. *Riccioidae*. Very common in this family is the formation of adventive branches, which arise from the ventral surface of the thallus, ultimately becoming detached. In *Ricciella fluitans*, the sterile form of which occurs floating on water or submerged a little below the surface, the formation of these branches is often so abundant that the plants cover a sheet of water in much the same manner as Duckweed. In *Ricciocarpus natans*, the broad heart-shaped thallus after repeated branching often becomes split longitudinally, each half giving rise to a separate plant. This splitting occurs regularly in fertile plants and results in the rupture of the embedded capsules and the shedding of the spores. In several species of *Riccia* which inhabit dry regions, e.g., *R. vesicata*, *perennis*, *bulbifera*, the plant produces special ventral branches, each of which becomes swollen up terminally and forms a tuber. These tubers, the tissue of which contains reserve food materials, chiefly in the form of oil-drops and proteid grains, are adapted for enduring a dry period, afterwards giving rise to new shoots.

Fam. 2. *Corsinioideae*. In the two genera included here, *Corsinia* and *Boschia*, adventive branches are occasionally formed, as in the *Riccioidae*.

Fam. 3. *Targionioideae*. *Targionia* is characterised by the constant production of ventral shoots from the sides of the mid-rib. The main axis seldom shows apical branching, its growth in length being usually arrested by the formation of the female receptacle. The ventral shoots become detached at the base and form new plants.

Fam. 4. *Marchantioidene*. In many of the forms belonging here, especially in the section "Operculatae," e.g., *Reboulia*, *Asterella*, apical branching is largely replaced by the formation of ventral shoots which arise near the apex of the thallus or from the sides of the mid-rib farther back. In two Californian species of *Asterella*,¹ viz., *A. Bolanderi*, *A. violacea*, both the antheridia and the archegonia are borne on short latero-ventral branches, and doubtless in these, as in other species, sterile branches arising in this way may become detached and produce new plants. In *Fegatella supradecomposita*,² a Japanese form, the growing-point of each of the thallus-lobes frequently gives rise to a circular discoid outgrowth, which bears ventral scales and obviously represents a modified branch. Instead of simply growing out to form a continuation of the main shoot, like the resting branches formed in autumn in *F. conica*, each of these buds or branches in *F. supradecomposita* becomes detached at the base and gives rise to an independent plant. In *F. conica* itself, as was first shown by Karsten,³ tubers are often formed on the ventral surface of the mid-rib, especially in old plants which have become covered over by the younger shoots. Here and there the cells immediately below the surface grow and divide actively, giving rise to a mass of tissue which later breaks through the superficial layer and projects as a small spherical ovoid outgrowth, attached by a short narrow stalk. This tuber bears rhizoids, its cells contain starch-grains, and it ultimately drops off and grows out to form a new plant. The tubers of *Fegatella*, which grows chiefly beside streams, are not adapted to withstand drought, as are those of the xerophytic *Riccia*-species above mentioned; they perish if kept dry for a few days.

Adventitious shoots have in rare cases been observed to arise from the specialised female branches (archegoniophores) of *Mar-*

¹ Howe, M.A., The *Hepaticae* and *Anthocerotae* of California. Mem. Torrey, Bot. Club, Vol. 7, 1899.

² Lindberg, S.O., *Saudea* et *Myriorrhynchus* nova *Hepaticarum* genera. Acta Soc. pro Fauna et Flora Fennica, Vol. 2, 1884, nr. 5; Goebel, Organographie der Pflanzen, p. 274, fig. 174.

³ Karsten, G., Beiträge zur Kenntniss von *Fegatella conica*. Botan. Zeitung. 1887, p. 650.

*chantia*¹ and *Dumortiera*,² either from the grooves in the stalk or from the sterile lobes between the groups of archegonia.

In *Marchantia* and *Lunularia*, asexual reproduction is extensively carried on by means of specialised organs, the gemmae, produced in crescent-shaped (*Lunularia*) or cup like (*Marchantia*) receptacles on the dorsal surface of the thallus. These gemmae have been described and figured in various text-books and have formed the subject of much interesting physiological work. At the point where a receptacle is about to be formed, the development of the ordinary air-chambers of the thallus ceases for a time and a shallow depression is formed. At the margin of this depression, either only on the side farthest from the growing-point of the thallus (*Lunularia*) or all round (*Marchantia*), the air-chamber tissue grows up to form a ridge, which is in *Marchantia* cut up into numerous long triangular lobes. Each gemma is formed from a single cell, which grows up and first becomes divided by a transverse wall; the upper cell gives rise to the gemma, the lower one remains undivided and forms the short stalk. The gemma remains throughout bilaterally symmetrical³ and when fully formed consists of an oval disc, several cells thick in the middle and thinning out towards the margin, which shows two lateral notches at opposite points. Between the gemmae there grow out long club-shaped hairs; the mucilage secreted by these hairs swells up on absorbing water and causes the gemmae to be torn from their short stalks, the loosened gemmae then being washed away by rain-drops. Most of the cells of the gemma contain chlorophyll, and scattered through its tissue there are several cells each containing a large oil-body. Certain of the superficial cells, on both sides of the gemma, are distinguished from their neighbours by their large size and dense protoplasmic contents; these cells, which are devoid of chlorophyll, project from the surface of the gemma. When the gemma is sown, whichever of its two surfaces happens to come into contact with the soil, and therefore is farthest from the light, becomes and remains the ventral surface of the young plant. One of the growing-points, situated in the lateral notches of the gemma, becomes the apex of the thallus; sometimes both of these growing-points become active. In the dorsal region

¹ Klein, J., Ueber Sprossung an den Inflorescenzstielen von *Marchantia polymorpha*. Botan. Centralblatt, Band 5, 1881, p. 26.

² Lindberg, S. O., Hepaticae in Hibernia mense Julii 1875 lectae. Acta Soc. Sci. Fennicae, Vol. 10, 1875, p. 468.

³ Pfeffer, W., Studien über Symmetrie und spezifische Wachstumsursachen. Arb. des botan. Inst., Würzburg, Band 1, 1874, p. 77.

of the young plant, air-spaces are formed, whilst the cells towards the ventral surface remain in close contact with each other, and the large superficial cells mentioned grow out to form rhizoids. The germination of the gemmae has been carefully studied by Pfeffer, Zimmermann,¹ and Benecke.²

II. *Jungermanniales*. A. *Jungermanniaceae Anacrogynae*. In the thalloid forms belonging to this series, vegetative reproduction takes place by the same methods as in the majority of the *Marchantiales*, namely, the separation of the younger branches by the dying away of the older parts of the thallus, and the production of caducous adventive branches. When gemmae are developed, these are usually much simpler in structure than in the *Marchantiales*.

Fam. 1. *Sphaerocarpoideae*. In *Sphaerocarpus*, adventive branches are frequently formed from various parts of the thallus, arising from the superficial cells and ultimately falling away and growing independently. The tubers of *Geothallus tuberosus*, an interesting Californian liverwort described by Campbell,³ may be mentioned here, though their function appears to be rather that of enabling the plant to persist during seasons of drought rather than that of bringing about asexual multiplication of the plants. The tuber is formed immediately behind the growing-point of the shoot, its tissue consists of cells with dense proteid contents, and it remains alive after the rest of the plant has become withered up. The growing-point at the anterior end of the tuber ultimately resumes its activity and gives rise to a new shoot.

Fam. 2. *Metzgerioideae*. Most of the species of *Aneura* and *Metzgeria* are distinguished by the frequent formation of adventive branches which become detached and form new plants.⁴ In *Aneura*, these branches are usually formed at the margins of the thallus; in *Metzgeria*, they arise chiefly from the lower surface of the mid-rib, but may spring from any part of the thallus, on either the upper or the lower surface. Each of these branches is developed from a single cell; this cell projects from the surface and becomes divided by intersecting walls, cutting out a wedge-shaped ("two-sided") cell, which forms the apical cell of the new shoot.

¹ Zimmermann, A., Ueber die Einwirkung des Lichtes auf den Marchantieenthallus. Arb. des botan. Inst., Würzburg, Band 2.

² Benecke, W., Ueber die Keimung der Brutknospen von *Lunularia cruciata*. Botan. Zeitung, 1903, Abt. I, p. 20.

³ Campbell, D. H., The Development of *Geothallus tuberosus*. Annals of Botany, Vol. 10, 1896, pp. 431-510.

⁴ Goebel, K., Ruckschlagsbildungen und Sprossung bei *Metzgeria*. Flora, 1898, p. 69.

In several species of *Aneura* (*A. multifida*, *pinnatifida*, *palmata*, *punguis*), there are formed, especially at the tips of the thallus-lobes, large numbers of two-celled gemmae. These gemmae were figured accurately by Hofmeister,¹ but Goebel² was the first to call attention to their development, which differs from anything hitherto observed in other Hepaticae, except *Metzgeria*. The writer has carefully followed out the process of gemma-formation in *A. multifida* (Fig. 1).

Fig. 1. *Aneura multifida*. I. Part of a plant, showing the ends of the branches covered with gemmae; $\times 5$. II. Cells from the end of a branch, showing stages in formation of gemmae; $\times 150$. III. Two fully-formed gemmae, still within the cells; that on the left is escaping through the pore in the outer cell-wall; $\times 300$. IV. Free gemma, in optical section, showing nuclei and chloroplasts; $\times 400$.

The gemmae are developed endogenously, each being formed within one of the cells of the thallus and escaping by the rupture of the outer cell-wall. The cell-contents contract away from the cell-wall and become covered by a delicate membrane of cellulose. The nucleus then undergoes division; the two daughter-nuclei move towards the opposite ends of the ovoid protoplast, and a median septum is formed. A large portion of the outer wall of the mother-cell becomes absorbed, and the two-celled gemma slips out of the opening thus formed. The gemma contains numerous chloroplasts embedded in dense protoplasm; sometimes starch is also present. The writer has occasionally found that further divisions occur in the gemma before its liberation, so that instead of being two-celled, as is usually the case, the gemma may consist of three or even four cells whilst still enclosed within the mother-cell.

¹ Hofmeister, W., Vergleichende Untersuchungen, 1851, Taf. vi., Fig. 29a.

² Goebel, K., Die Muscineen (Schenck's Handbuch der Botanik, Vol. ii.), 1882, p. 338.

In a tropical epiphytic species of *Metzgeria*, described and figured by Ruge,¹ the thallus bears erect cylindrical outgrowths arising from the dorsal surface of the mid rib. The superficial cells of these erect shoots grow out into discoid gemmae, oval in outline, each gemma being attached by a single stalk-cell and readily becoming detached. In *Metzgeria conjugata*, erect gemmiferous shoots were observed by Goebel,² who states that the gemmae arise in the same manner as those of *Aneura*, but before being set free each gemma has by continued growth and cell-division assumed the form of a concave cell-surface, the "two-sided" apical of the shoot being recognisable on the margin of the discoid gemma. Lett³ states that in *M. furcata*, var. *aeruginosa* (Hook.), "the fronds mostly bear gemmae in abundance on their ends, and then the branches have their margins so much curved back as to appear cylindrical, and not wider than the nerve."

Fam. 3. *Leptothecae*. In *Pallavicinia* and *Symphyogyna*, which are included in this small family, and also in *Hymenophyton*, which belongs to the Metzgerioideae, asexual propagation is effected by the formation of ventral branches which arise from the sides of the mid-rib and ultimately become separated from the parent shoot. In these forms, the cylindrical mid-rib of the thallus is traversed by one or more axial strands, the cells of which are long, narrow, pointed at the ends, and bear spirally arranged slit-like pits on their walls. When a branch is laid down, its apical cell for some time produces only broad thin-walled cells, so that the later-formed axial strand of the branch is not continuous with that of the parent shoot, from which the branch readily becomes detached.

Fam. 4. *Codonioideae*. *Pellia* frequently bears adventive shoots, which arise from the superficial cells on the dorsal surface or the margins of the thallus and ultimately become detached. Similar adventive shoots are sometimes observed on the ventral surface of the stem in *Blasia pusilla* and in *Petalophyllum Ralfsii*.⁴

Gemmae occur in three genera belonging here, namely, *Treubia*, *Blasia*, and *Cavicularia*. In *Treubia insignis*, a large foliose form

¹ Ruge, G., Beiträge zur Kenntniss der Vegetationsorgane der Lebermoose. Flora, 1893, Heft. 4, p. 30 of reprint.

² Goebel, K., Organographie der Pflanzen, p. 275.

³ Lett, H. W., A list, with descriptive notes, of all the species of Hepatics hitherto found in the British Islands, 1902, p. 21.

⁴ For material of this interesting and rare form, the writer is indebted to the kindness of Mr. W. H. Pearson.

discovered by Goebel¹ in Java, the gemmae, each of which consists of from two to four cells and is borne on a short stalk, are formed from the superficial cells of the stem. In *Blasia* and *Cavicularia*, the gemmae are larger and are produced in large numbers in special receptacles.

Fig. 2. *Blasia pusilla*. Dorsal view of plant bearing four flask shaped gemma-receptacles, each with a long tubular neck; the darkly shaded patches represent the *Nostoc*-cavities, two of which are usually found at the base of each of the broad lateral lobes or leaves. $\times 5$.

In *Blasia pusilla* (Fig. 2), the shoot consists of a broad stem bearing on either side a series of oval leaves which lie in the same

Fig. 3. *Blasia pusilla*. Part of a longitudinal section, traversing a gemma-receptacle; from the inner surface of the receptacle there arise numerous gemmae in different stages of development, together with club-shaped mucilage-hairs. $\times 60$.

¹ Goebel, K., Ueber Javanische Lebermoose. I. *Treubia insignis*, Annales du jardin botanique de Buitenzorg, Tome 9, 1890, p. 1.

plane as the stem and consist for the most part of a single layer of cells (Fig. 4, L.). The upper surface of the stem sometimes bears here and there scale-like outgrowths, somewhat resembling the ventral scales (amphigastria) found in two rows on the ventral surface. These dorsal outgrowths may be regarded as discoid gemmae, as they ultimately become detached and give rise to new plants.¹ Gemmae of a different kind and much smaller size are produced within flask-shaped receptacles, each of which stands

Fig. 4. *Blasia pusilla*. Part of a transverse section, traversing a gemma-receptacle and a *Nostoc*-cavity (N.c.); L., leaf; amph., amphigastrium or ventral scale; rh., rhizoids. $\times 60$.

near the growing end of a branch and consists of an ovoid basal portion and a long tubular neck. The neck projects forwards and ends in a trumpet-shaped mouth; its wall is from two to four cells in thickness. The gemmae are produced on nearly the whole of the inner surface of the receptacle (Figs. 3, 4), each gemma consisting of an ovoid or spherical mass of cells, about 0.14 mm. in maximum diameter, borne on a slender stalk about 0.3 mm. in length when the gemma is mature. Between the gemmae there arise numerous club-shaped glandular hairs, the mucilage secreted by which swells up on absorbing water and is forced out through the long neck of the receptacle, carrying with it the gemmae, which have been torn from their stalks.

In *Cavicularia densa*, an interesting Japanese form,² the gemmae are borne in crescent-shaped receptacles, resembling those of *Lunularia*. Two kinds of gemmae are produced, either in the same or in separate receptacles. Some of the gemmae are lens-shaped, resembling those of *Marchantia* and *Lunularia* in having

¹ Leitgeb, H., Untersuchungen über die Lebermoose, Heft I, 1874, p. 64, Taf. 4.

² Schiffner, V., Ueber einige Hepaticae aus Japan. Oesterr. botan. Zeitschrift, 1899, nr. 11; p. 7 of reprint.

two opposite marginal notches, whilst the others are spherical and much smaller. Each gemma is borne on a slender unicellular stalk, and between them there grows out numerous mucilage-hairs. The spherical gemmae differ further from the lenticular ones in the fact that they usually begin to germinate and to produce young plants before being set free. This gemination in situ is sometimes observed in the case of *Blasia*, the gemmae of which may put out rhizoids before leaving the receptacle. It is interesting to note that the archegonia in *Cavicularia* are produced in receptacles exactly similar to those containing gemmae.

III. *Jungermanniales*. B. *Jungermanniaceae Acrogynae*. In this group, which includes the vast majority of the species of Hepaticae, asexual reproduction takes place by means of caducous shoots (normal or adventive in origin) and gemmae, these two main types being connected by transitional organs.

Caducous branches. By the dying away of the older parts of the shoot, the branches become separated and grow independently. This simple process of multiplication is of extremely common, perhaps universal, occurrence in the Acrogynae. The branches thus separated may either be those formed in the ordinary manner at the apical growing-point or adventive branches of relatively late origin. The adventive branches appear invariably to arise from the ventral surface of the stem, and in species provided with ventral scales (amphigastria) each of these branches usually appears in the axil of a ventral leaf. In most cases, these ventral branches are at least partially derived from the inner cells of the stem. The growing-point of the branch is laid down immediately behind that of the stem itself, but instead of at once growing out, as the ordinary lateral branches do, it remains dormant for a considerable time. The apical cell of the ventral branch becomes covered by a superficial layer of cells, forming a sheath through which the resting-branch breaks when the apical cell resumes its growth. In some genera, e.g., *Lophocolea*, *Cephalozia*, *Kantia*, nearly all the branches are of this intercalary type and spring from the ventral surface of the stem, normal lateral branches being very seldom formed. The slender small leaved shoots ("flagella") of *Bazzania* may be cited as further examples of the same type of branching.

In cases where the growth of the main stem is arrested by the formation of archegonia, it is very common to find one or more branches arising immediately below the involucre or perianth. These "innovation-shoots," like the intercalary ventral branches,

often become detached and form new plants. In *Jungermannia* (*Aploxia*) *caespiticia*, Ekstrand¹ found within the perianth a number of young shoots, as many as fifteen in one case, arising amongst the archegonia. A still more interesting observation is recorded by Schiffner,² who found in *Bazzania pectinata*, collected in Amboina, a perianth from which there projected a slender shoot bearing small leaves. This shoot had arisen within the calyptra or fertilised archegonium, and appeared to spring from the base of the sporogonium itself. The latter was well developed, but had not grown beyond the calyptra, which had been ruptured by the adventive shoot. Schiffner was unable to determine exactly whether this shoot had arisen from the inner surface of the calyptra or from the base of the sporogonium itself, but the former would appear to be the more likely place of origin.

Under the heading of caducous branches may be placed the leafy "propagula" described by Evans³ as occurring in some species of *Leptolejeunea* and *Drepanolejeunea*, which live epiphytically on trees in tropical America. Each of these "propagula" arises immediately behind an ordinary lateral leaf and may be regarded as a short bud-like branch, bearing discoid leaf-like organs the cells of which secrete mucilage; by means of these adhesive organs, the branch after separation from the main shoot becomes attached to the substratum and grows to form a new plant.

In *Frullania fragilifolia*, the hood-shaped lower lobe ("lobule" or "auricle") of each leaf is joined to the upper lobe only by a very narrow stalk, consisting of two cells, so that it readily becomes detached. Berggren⁴ observed that when the lobule becomes free, or even whilst it is still attached to the plant, it gives rise to a leafy shoot. A single cell on the margin of the cup-like lobule grows and divides by intersecting walls, which cut out a tetrahedral apical cell from which the young shoot takes its growth.

In *Pteropsiella frondiformis*, a remarkable form discovered by

¹ Ekstrand, E. V., Anteckningar öfver Skandinaviska lefvermossor. Botaniska Notiser af Nordstedt, 1880.

² Schiffner, V., Ueber exotische Hepaticae. Nova Acta d. K. Leop.-Car. Akad., Band 60, 1893, Nr. 2; p. 260, Taf. 11, Fig. 11.

³ Evans, A. W., Hepaticae of Puerto Rico. I. The species of *Leptolejeunea*. Bulletin of the Torrey Botanical Club, Vol. 29, 1902, p. 496. II. *Drepanolejeunea*. Ibid., Vol. 30, 1903, p. 19.

⁴ Berggren, S., Jakttagelser öfver mossornas könlosa fortplantning genom grodknoppar och med dem analoga Bildningar. Akademisk Afhandling, Lund, 1865, p. 26; Tab. iv., Fig. 26-28

Spruce in Brazil, the vegetative portion of the plant consists of a branching thallus, closely resembling in appearance that of *Metzgeria* (Fig. 5). On either side of the cylindrical midrib there is a broad lamina consisting of a single layer of cells. Apical branching seldom or never occurs, but numerous branches arise ventrally from the sides of the midrib, and as each of these branches is joined to the main shoot only by a narrow base, it readily becomes detached and grows independently. The sexual organs are borne on ventral shoots which arise in the same manner as the sterile branches, but which bear well developed leaves in two lateral rows. The writer has, thanks to the kindness of Mr. M. B. Slater, F.L.S., Malton, had an opportunity of examining a large

Fig. 5. *Pteropsiella frondiformis*. Part of a male plant, showing above a male branch which has, after producing antheridial bracts grown out as a thalloid shoot; below are two branches, one flagellate and rhizoid-bearing the other antheridial; *m.*, midrib; *rh.*, rhizoids. $\times 10$.

number of plants from the Spruce collection, and can confirm the observations and conclusions of Goebel on the morphology of this genus. Goebel¹ states that in the material at his disposal, the growth of the male shoots had invariably terminated on the development of the antheridia, but the writer has found in two cases that the male shoot had resumed its growth after producing the antheridia, the apex growing out to form a flattened branch, the margins of which bore the characteristic unicellular appendages (Fig. 5).

In addition to the intercalary or adventive branches described in the preceding paragraphs, we occasionally find in the Acrogynae that adventive branches grow out from the leaf-cells or from the

¹ Goebel, K., Rudimentäre Lebermoose. Flora, 1893, Heft 2; p. 91.

superficial cells of the stem. Leitgeb¹ worked out the development of these branches in *Cephalozia bicuspidata* and in *Lophocolea bidentata*. In both of these commonly-occurring forms, the writer has found that the older parts of the plant frequently bear adventive shoots, each of which arises from a single leaf-cell or superficial stem-cell. In these old and more or less decayed parts, the cells are often filled with branched and coiled fungal hyphae and have become brown, but here and there we find cells which have retained their living protoplasm and are free from fungal attack, and it is from such cells that the adventive shoots are developed. As a general rule, the shoot springs immediately from the surface of the leaf or stem, but sometimes the parent cell grows out to form a long tube, the distal end of which swells up and undergoes repeated divisions to form the growing-point of the new shoot. As a general rule, the adventive shoot becomes detached from the parent plant at an early stage, but sometimes it remains attached until it has formed a considerable number of leaves and a few rhizoids. Such a case of vivipary was observed in *Lophocolea bidentata* by Massalongo,² who figures a leaf bearing three young plants; two of them replace the pointed lobes of a normal leaf and are furnished with rhizoids. As will be pointed out later in dealing with gametophytic regeneration in Hepaticae, adventive growths of this kind are often abundantly produced on leaves which have been isolated and kept under cultivation, but it is interesting to find that the process of regeneration may also occur in nature, the viviparous shoot reaching a fairly advanced stage of development before becoming severed from the parent plant.

¹ Leitgeb, H., Untersuchungen über die Lebermoose, Heft 2, 1885, p. 38.

² Massalongo, C., Sopra un interessante caso di viviparità nelle Epatiche. Bullettino della Soc. bot. ital, 1901; reprint of 4 pp.

(To be continued).

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