



## V. On the Structure and Development of *Botrydium granulatum*. (Plate XII.)

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IV.—Account of Professor Balfour's Botanical Trip, with Pupils, to Moncreiffe and Kinnoull Hills in Perthshire. By Mr JOHN SADLER.

About 160 botanical students left Edinburgh on the morning of 16th June last for the Bridge of Earn; whence, after breakfasting, they walked by Moncreiffe, Kinfauns, and Kinnoull to Perth.

The principal plants observed by the party were—*Nymphaea alba*, *Montia fontana*, *Villarsia nymphaeoides*, *Lemna trisulca*, *Alisma Plantago*, at Moncreiffe Loch; *Epipactis latifolia*, *Hesperis matronalis*, *Scrophularia vernalis*, *Symphylum tuberosum*, *Erodium cicutarium*, *Geranium columbinum*, *Geranium sanguineum*, *Peucedanum Ostruthium*, *Mimulus luteus*, and *Mentha sylvestris* var. *velutina*, in the woods and on the Hill of Moncreiffe; *Lactuca virosa*, *Dipsacus sylvestris*, *Hesperis matronalis*, *Cheiranthus Cheiri*, *Sedum Telephium*, *Fumaria micrantha*, *Malva moschata*, *M. rotundifolia*, *Geranium pyrenaicum*, *Myrrhis odorata*, *Trifolium arvense*, *T. striatum*, *Potentilla argentea*, *Valerianella Olitoria*, *Poterium Sanguisorba*, *Rosa systyla*, *R. villosa*, *Cynoglossum sylvaticum*, *Lamium maculatum*, *Inula Helenum*, &c., at Kinnoull, and near Bridge End.

V. On the Structure and Development of *Botrydium granulatatum*. (Plate XII.) By GEORGE LAWSON, Ph.D., Professor of Chemistry and Natural History in the University of Queen's College, Kingston, Canada.

In prosecuting an examination of the freshwater Algæ of Lake Ontario, I have had a good deal of trouble in arriving at satisfactory results regarding a little plant growing on the lake shore, which I now believe to be identical with the "Bladder-headed Laver" found by Dillenius between "Newington et Hackney, prope Londinum." I presume, also, that it is identical with *Botrydium* (*Hydrogastrum*) *granulatum* of more modern botanists, although the conflicting descriptions and figures contained in works presently within my reach are by no means so satisfactory as the account given by the old cryptogamist of the last century. This, indeed, is the reason why I seek to place on record what I conceive to be a true explanation, so far as it goes, of the structure, mode of vegetation, and reproduction of this little plant, which seems to be as interesting to the botanist as *Amœba* is to the zoologist, a striking example of the manifold physiological phenomena that may be enacted by the very simplest apparatus of life.\*

\* Lindley observes—"One of the most remarkable plants of the order *Fucaceæ* is *Hydrogastrum*, which Endlicher describes as a perfect plant, with root, stem,

To the westward of Kingston, near Mr Morton's distillery, there is a flat piece of land jutting out into the lake, but protected from the action of the water by a barrier of shingle that has been thrown up by the waves. When an elevation of the water of the lake takes place (and this usually occurs, temporarily, several times a-year),\* this bit of flat land is inundated or temporarily covered with water, like other low-lying portions of land along the lake shore. Its vegetation consists chiefly of a singular form of *Ranunculus sceleratus*, not more than three inches high, intermixed with *Veronica peregrina*, &c., and the pools and moist spots are covered with a profusion of Algæ, such as *Nostochineæ*, *Oscillatoria*, *Vaucheria*, *Desmidea*, and *Diatomaceæ*. In clayey spots the surface is covered with patches or clusters of green glossy spheres, not much larger than pin-heads. This is the *Botrydium granulatum*, which is represented in fig. 1 in its natural site, the surface of a crust of mud. Fig. 2 shows the appearance of the plants as little stalked spheres, when seen in profile; and fig. 3 shows one taken apart, and the earth washed away from its minute radical fibres. The plants are rooted very firmly in the soil.

When viewed under a low power (as with a one-inch objective), the little plant is found to consist of an upper globular part, or head, with a more or less elongated neck or stalk, and a widely ramifying root, consisting of very delicate branched filaments, all as shown in fig. 4. Although these parts are distinctly enough defined, and have the semblance of separate organs, yet the whole plant consists of only one cell—there is but one internal cavity ramifying throughout the whole. This is filled throughout with a colourless, transparent fluid, slightly granular, as usual in cell contents. The head portion alone contains granular endochrome of a bright green colour, which, however, seems to be disposed as a lining on

bud, and fruit, in imitation of the most highly developed races, but all produced by the branching of one single cell!" If we except the reference to a bud, the idea here expressed is not carried further than the real structure warrants.

\* During the last year or two, a slight permanent rise in the level of the lake in this neighbourhood seems to have been going on, previous to which there was a subsidence.

the inner surface of the cell wall, rather than to be mixed indiscriminately throughout the cell contents, the bulk of which in the head (as elsewhere) consists of watery fluid. That the internal cavity of the plant is continuous, that there is no membrane or other obstacle separating the mass of green endochrome, may be readily seen by gently pressing the glass cover, whereupon the endochrome, previously confined to the globose part of the head, readily passes down the neck-tube, and finds its way into every ramification of the root, if the pressure be continued with sufficient force.

While the plant is immature, the endochrome does not present granules of any great size—the appearance, even under a one-eighth-inch objective of Grunow, being that shown in fig. 5. But as it gradually matures, it is found to contain spherical granules of larger size, which are filled up with green endochrome, often itself in the form of distinct chorophyll granules. It is these spherical granules, or gonidia, as they have been termed, that are concerned in the reproduction of the plant. They are represented in fig. 6. As the term *gonidium* involves theoretical considerations as to the genetic value of a body, I shall merely call them spherules.

From the above description, it will be seen that the mature *Botrydium* consists of a transparent sac, branched in the lower part, filled with fluid, and containing in the upper part or head endochrome, in which are numerous spherules. This sac, which is very tough and elastic, is distended with the fluid contents, and consequently presents a turgid appearance. Thus, if pricked with a sharp point, the sac bursts, and the watery contents are squirted out with force, scattering the spherules. This may probably take place spontaneously. When exposed to drought, the sac collapses, and allows exit to the spores by its gradual dissolution. But one of the most curious facts that I have to mention is one that probably explains the adaptation of the plant for its peculiar habitat. If a patch of *Botrydium in situ* is covered with water for a few hours, and then examined, it will be found that the sacs have burst spontaneously and scattered their contents, even although they did not appear to be quite mature. This result seems to depend upon a process of endosmosis. Moisture is absorbed

through the whole surface of the plant, and to such an extent as to burst the already turgid sac, and thus the spherules are set free, and floated away from the parent, to form new colonies. While the collapsing of the plant by drought, and its gradual dissolution on the subsequent application of moisture, is one means of permitting the freedom and development of the spherules, the inundation of the plant's habitat by the water of the lake is a more speedy, and probably a more certain mode of determining the rupture, and transporting the spherules to suitable localities for germination.

These spherules, when carefully watched after their exit, are found to assume a new aspect. They gradually lose their spherical form, becoming more or less elliptical or elongated, and then passing through successive stages, indicated in figs. 7-14, until they have acquired the globose head, and neck, and root of the parent. The whole process of transition is so simple, that I need not do more than refer to the figures. If a process of impregnation takes place, I think it must be looked for *after* the spherules have quitted the parent sac. I have certainly seen phytozoid-like bodies *apparently* produced from the granular endochrome; but as to the contact of these with the spherules, and the effect thereof, this is precisely the point at which all such investigations become misty.

Several points remain still to be noticed.

Most algæ absorb nourishment through their tissues from the surrounding medium. This is not the case with *Botrydium*. It is furnished with an extensively ramifying root, the object of which is, not to spread over the surface, and give off buds for new individuals, as has been stated by some writers, but to enter the soil and absorb nourishment. Several authors have admitted this to a certain extent. Berkeley suggested the probability that "the rooting threads of *Botrydium*, *Caulerpa*, &c., do absorb nutriment from the soil, and perhaps for the reason that they are frequently exposed to the dry air, and would therefore wither without such a provision," &c. Not only is it capable of so absorbing nourishment; it is truly a terrestrial plant, furnished with a widely ramifying absorbing root, whose fibres do not contain endochrome; and it is

incapable of being developed under water, for submersion has the effect of bursting its cell-wall.

Most authors regard *Botrydium* as unicellular, and truly so. Hassall, while merely quoting in the text brief characters from Greville and Harvey, gives a drawing (Plate 77, fig. 5) which by no means represents an unicellular plant, and I do not understand it.

While correctly describing this plant as developed from a "spore" or "gonidium," we find many authors also describing an additional mode of increase. This is best shown in Endlicher's figure (Lindl. Veg. K. fig. 9). In the words of Griffith and Henfrey, it is described as follows:—"The figure represents a specimen with a second budding from it by vegetative increase, and in this way the plants come to form tufts or groups like little bunches of grapes; hence the name" (Microgr. Dict. p. 103). In reference to this statement, I would mention that I have not been able to find a single instance of a bud arising or being given off in this way from a filament to form a new plant. It may, however, occur. But it must be observed, that the appearance of the plants in clusters does not depend upon such a mode of growth. If it did, we should have each cluster consisting of differently sized globules, according to their respective ages; whereas there is usually a general uniformity in size, showing that all the plants of each cluster are about the same age, and have probably arisen contemporaneously from one batch of spores.

I shall, in conclusion, offer a few observations on the nomenclature of the plant, which must be prefaced by a list of synonyms:—

*Lichenoides fungiforme, capitulis vel vesiculis sphericis aqueo humore repletis.*—"Ray, Syn. iii. p. 70." (Dill.)

*Tremella palustris, vesiculis sphericis fungiformibus.* *The Bladder-headed Laver.*—Dillenius, *Historia Muscorum*, p. 55, t. x. fig. 17.

*Uva spherica aggregata.*—"Linn. Fl. Suec." (Linn. Sp. Pl.)

*Uva granulata.*—Linn. Sp. Plant. ed. 3, t. ii. p. 1633. Syst. Veg. Lichfield ed. vol. ii. p. 831. Oeder, Enumer. Pl. Fl. Danicæ, p. 14. Lightf. Fl. Scot. 2 ed. vol. ii. p. 976.

*Tremella granulata.*—Linn. Syst. Nat. ed. Gmelin. Reg.

- Veg. tom. ii. p. 1446. Hudson, Fl. Anglica, p. 566.  
 Wither. Arr. Br. Pl. 3 ed. vol. iv. p. 80. Roth, Sims' Ann. Bot. vol. i. p. 279 (description very good).  
*Ulva radicata*.—"Retz. in Act. Holm. p. 251" (Agardh).  
*Vaucheria radicata*.—Agardh, "Disp. p. 22." Species Alagarum, vol. i. p. 465.  
*Vaucheria granulata*.—"Lyngbye, Hydroph. p. 78" (Agardh).  
*Linkia granulata*.—"Wiggers, Prim. Fl. Holsaticæ, p. 94," according to Agardh, but not of Micheli, nor Roth. Consult Sims' Bot. An. vol. i. p. 269, &c.  
*Botrydium argillaceum*.—"Wallr. Ann. Bot. p. 153" (Agardh).  
*Hydrogastrum granulatum*.—"Desv." "Endl." Lindl. Veg. K. 3 ed. p. 21, fig. 9.  
*Botrydium granulatum*.—"Grev. Alg. Brit. p. 196, t. 19." "Hook. Br. Fl. p. 321." (Hass.) Hassall, Brit. F. W. Algæ, p. 305 (pl. lxxvii. fig. 5, is unlike the Canadian plant).  
 Mohl, Veg. Cell. p. 3, fig. 1. Berkeley, Int. Crypt. Bot. p. 83, fig. 24. Griffith and Henfrey, Micrographic Dict. p. 103, fig. 75.  
 "*Gongoseira clavata*, Kutz.?" (Hass.)

Although some modern works on Algæ do not contain any but recent references, it will be seen from the above list that this plant was familiar to our early English botanists, and it was correctly understood by them so far as their means of observation permitted. They seem also to have vied with each other in giving it new names, most of which have proved unfortunate. The old descriptive names of Ray and Dillenius are good. Linnæus first termed the plant *Ulva granulata* (1764), and subsequently in Gmelin's edition of the "Systema Naturæ," we find it removed to the genus *Tremella*, the specific name *granulata* being still retained. These two names were followed by many authors, both in continental Europe and in England; but Retzius had at an early period (1769) described it under the name of *Ulva radicata*, and this, as a *specific* name, was subsequently taken up by Agardh in preference to the prior one of Linnæus. Another specific name (*Botrydium argillaceum*, Wallr.) originated about 1815. From this statement it will appear that whatever generic appellation is chosen, the proper specific name is the Linnean one (*U.*) *granulata*.

In regard to the generic name there is more difficulty. Our

modern ideas of classification require that the plant should not remain either in *Ulva* or *Tremella*, and there seems also to be good reason for separating it from *Vaucheria*. It must, in fact, form a genus by itself. Of the special generic names that have been proposed for it, that which has priority is undoubtedly *Linkia* or *Linckia*; but that genus of Algæ, originally proposed by Micheli, does not seem to have been intended by him to include this plant, much less to be restricted to it. On the contrary, Roth describes four species of *Linckia*; one of which he compares to *Tremella granulata*, L., in regard to form and size, expressly stating that it is distinguished from that plant by important characters which are detailed. Moreover, we find (Lindl. Veg. K.), not only *Linkia*, Micheli, among the *Nostochineæ*, but *Lynckia*, Lyngb., among the *Oscillatorieæ*, besides a "*Rivularia Linckia*, Roth;" *Linkia*, Persoon, in *Gentianaceæ*; and *Linkia*, Cavanilles, in *Proteaceæ*. Herr Link might well exclaim, "Save me from my friends!" The result seems to be that all these generic names are practically sunk into synonymes. Whatever group may be chosen by botanists to commemorate Link, it is evident that it cannot be the bladder-headed laver of Dillenius. The next generic name that appears is *Botrydium*, Wallr., which is expressive enough, and has been adopted by most English writers; but it was originally associated by its author with the unnecessary specific name *argillaceum*. Greville retained the generic term, and restored the Linnean specific name, and I hope in future the example will be followed. *Hydrogastrium* is more recent, and should be dropped; so also of *Gongo-seira*, Kutz., if it refers to our plant, which seems doubtful.

I ought to mention that I have not had an opportunity of referring to the works in which correct descriptions of *Botrydium* are most likely to be found, viz. those of Dr Greville and Kützinger.

The conclusions that seem warranted by the above observations are these:—

1. *Botrydium granulatum* is an unicellular plant.
2. It is strictly terrestrial, and is incapable of being developed under water, like most algæ.
3. It is furnished with finely branched root fibres, which en-



able it to absorb nourishment from the soil, like other land plants.

4. Reproduction is effected by means of young spherical cells, formed in the endochrome in the interior of the parent one, which are set free at maturity, by the bursting of the cell membrane of the parent.

5. Even where the plant is not mature an inundation of the habitat by water bursts the membrane, and thus effects the liberation of the spores.

6. If a process of impregnation occurs, it probably takes place after the spherules and endochrome have been ejected.

7. The plant does not increase by buds given off from the radical filaments (as stated by several writers), so far as the author has observed.

#### *Explanation of Plate XII.*

1. Crust of mud, with numerous specimens of *Botrydium granulatum* on its surface. Natural size.
2. The same seen in profile *in situ*. Natural size.
3. A single plant detached from the soil. Natural size.
4. The same as seen under a low power (one inch objective).
5. Endochrome from the globose head of the immature plant, as seen under an eighth-inch objective with low eyepiece.
6. Spherical cellules, ("gonidia," "resting spores"), from endochrome of mature plant. ( $\frac{1}{8}$ th inch.)
- 7-14. Spores or spherules in successive stages of development, showing the principal steps of transition into a plant ( $\frac{1}{8}$ th inch.)

#### VI.—*On the Effects of Lightning on an Ash-Tree.* By Dr JOHN ALEXANDER SMITH.

Mr Smith remarked—"I send a splinter and piece of bark of an ash-tree, which may perhaps be considered worthy of a place in the Botanical Museum. The tree was demolished by lightning on Saturday the 16th June. I examined the tree and found it had been about two feet in diameter at the base, and formed one of a long row of old trees of a similar kind (none of which were injured except itself) on the farm of Hollydean, in the parish of Bowden, Roxburghshire. It had been struck apparently at the upper part of the trunk (the branches not being stripped of their bark), and the tree was cloven in two to the very root, two stumps only remaining in the ground, and these were shattered again in a lateral direction, as if the bolt had exploded in the tree, and blown the trunk into numerous fragments, some of the pieces being picked up at the distance of fifty yards or more. The wood of the tree seemed quite sound, and the fragments, when examined, were apparently perfectly dry and sapless. Could the sap of the tree (for it was just coming into full leaf, and therefore full



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