XXXIII. *On the Embryos of* Endogens *and their Germination.*

By Benjamin Clarke, *Esq.*, *F.L.S.*

Read June 16th, 1859.

It is now some years since L. C. Richard, in his original and very accurate work, the 'Analyse du Fruit *,' divided phanerogamous plants, with reference to their germination, into Endorhizæ and Exorhizæ; but notwithstanding that exceptions to the exorhizal character as regards the secondary radicles have been repeatedly observed in exogenous plants, and its universality in the primary radicle doubted, yet in general works in which germination is referred to, this division is considered practicable, and the Endogens also are still regarded as being constantly endorhizal.

In examining the germination of the Endogens, however, for the purpose of ascertaining the position of the first leaf of the plumule relatively to the cotyledon, the primary radicle proved, contrary to my expectation, to be perfectly exorhizal in the greater number of instances, and so obviously without any trace of a sheath (coleorhiza) in *Iris*, *Alströmeria*, *Smilacina*, *Butomus*, *Tamus*, and *Arum*, as to place the fact beyond question. The secondary radicles in the Endogens, it is true, are usually, if not always, endorhizal, inasmuch as they protrude from beneath the cellular integument common to the primary radicle and young stem, although no sheath may be present; but this is a character also common to certain Exogens, as *Menyanthes trifoliata*, in which the secondary radicles and their branches not only protrude from beneath the surface, but have small sheaths at their bases; and some of the more remarkable instances of this kind have been described as occurring in the germination of *Ranunculaceæ*, *Compositæ*, and other families. The germination of *Nuphar lutea* also presents another remarkable instance in which the primary radicle is perfectly exorhizal †, but the secondary radicles above it are endorhizal, the elongated sheaths remaining attached during the early stages of growth. (Pl. LXVIII. figs. 1, 2, & 3.)

Finding, therefore, the Endogens to be frequently exorhizal, as many of them as opportunity afforded were germinated, and the probability appears to be that the primary or true radicle is known to be endorhizal (with two additions afterwards noticed) only in *Marantaceæ*, *Commelynaceæ*, *Cyperaceæ*, and *Graminaceæ*. To these families should perhaps be added *Naiadeæ*, since Richard has figured *Zannichellia palustris* as having all the appearance of an endorhizal germination; but whether they are endorhizal may be a question, because the embryos of some genera in their radicular portion do not differ materially from those in which the germination is exorhizal; and also in the embryo of *Zannichellia* no trace of a sheath is perceptible in a longitudinal section, while in *Zostera*

* Démonstrations, ou Analyse du Fruit, 1808; H. A. Duval, Ed.

† The germination of *Nymphæa alba* has been referred to as being endorhizal, but as I have not had an opportunity of seeing it, this observation on *Nuphar lutea* was made with the greatest care; a fringe of minute radicles gives it in some degree the appearance of being endorhizal, but on examination it proves to be entirely an appearance.

marina the radicle is readily discernible lying in a canal directed obliquely towards the apex of the seed.

Although the germination of the Endogens is as yet known only in part, the subjoined instances of the exorhizal character occurring among them will, I believe, lead to the anticipation that the endorhizal is the exception rather than the rule, as most of those families in which the germination is unknown scarcely differ from one or other of the following, in which the primary radicle, as far as my observations have extended, is strictly exorhizal :—*Liliaceæ*, *Dioscoreaceæ*, *Juncagineæ*, *Alismaceæ*, *Butomaceæ*, *Irideæ*, *Amaryllideæ*, *Orchideæ*, *Palmaceæ*, *Araceæ*, *Typhaceæ*, and *Eriocauloneæ* *.

The inquiry relating to the position of the first leaf of the plumule originated in having observed that in the *Graminaceæ* the first leaf of the plumule is next the cotyledon, whilst in all other Endogens I had seen germinating it was directly away from the cotyledon, so as to be alternate with it, as in the ordinary genera of Liliaceous plants. For some years this phenomenon had appeared inexplicable, but further comparisons have led to the conclusion that the suggestion of L. C. Richard, as regards the embryo of the *Graminaceæ*, viz. that the apparent cotyledon is in reality an enlarged radicle, is the only practicable explanation of this departure from the regularly alternate position of the leaves of the embryos of the Endogens. But as objections exist to regarding the apparent cotyledon of the *Graminaceæ* as the radicle or a part of it, it may with equal propriety be compared to the enlarged cauliculus occurring in exogenous plants, or to the cormus as occurring in endogenous plants, and then the first leaf of the plumule will be the cotyledon, containing within it the leaves of the plumule occupying their usual alternate position. For the purpose, however, of being more readily understood, I shall, with Richard, still call it a radicle, though at first sight this view does not appear at all probable ; but yet the position of the first leaf of the plumule next the apparent cotyledon in *Graminaceæ* and *Cyperaceæ* (fig. 20 *c*) appears otherwise an anomaly not to be accounted for. But admitting that the cotyledon, as at present generally understood, is either an enlarged radicle or a cormus, the steps by which such an inference may be arrived at form an almost unbroken chain.

Beginning, for example, with *Caulinia*, *Naias*, and *Potamogeton*, we find that the first leaf of the plumule alternates with the cotyledon, being directly away from it; and the embryo does not otherwise differ materially from those of *Orontiaceæ*, *Araceæ*, and *Liliaceæ*, excepting that the plumule is situated higher up, in consequence of its radicular portion having become elongated. But in *Zannichellia* we find a commencing alteration in structure; the radicle has become more enlarged, and a partial ridge is formed on its upper part round the base of the cotyledon (figs. 4 & 5); but no further difference is observable, as the first leaf of the plumule is directly away from the cotyledon, as in *Naias* and *Potamogeton*.

Passing on to *Ruppia*, we find the cotyledon depressed and lying almost horizontally on the now enlarged radicle, which forms a shallow ridge surrounding it, so that it appears to lie in a furrow on its upper surface. This ridge is found to be divided into two parts ;

* The primary radicle, as afterwards described, becomes suddenly arrested in its growth, but, as far as it developes, it is not endorhizal.

and this, I believe, offers a practical explanation of the nature of the two portions of the cotyledon (as at present understood) of *Triticum*, *Oryza* (fig. 20 *a*, *b*), and other *Graminaceæ*, in which traces of a stipule-like process exist, regarded by some botanists as a second cotyledon. The two portions of the ridge of the embryo of *Ruppia* consist of, 1, the larger portion, which forms nearly the whole of the ridge; and 2, a small process, which fills up a notch in it, and which is always in apposition with the membrane which conceals the plumule, and is therefore always next the fissured or marginal side of the cotyledon * (fig. 6). There is, however, no further difference between *Zannichellia* and *Ruppia*, the first leaf of the plumule being directly away from the cotyledon, as in that genus †.

Again, passing on to *Zostera*, we find in *Z. marina* (figs. 7, 8, 9, & 10) all the parts of the embryo of *Ruppia* much enlarged; thus the ridge, which is there but feebly marked, has become an enlarged two-lobed body, appearing when artificially opened almost like a two-lobed cotyledon, and the second portion of the ridge before alluded to, which in *Ruppia* is only a minute body, has become sufficiently prominent to look like a second cotyledon (figs. 8 & 9 *a*). The cotyledon has become elevated on a cauliculus, which is curved (fig. 8); but this is the only difference between it and the embryo of *Ruppia*, as the smaller lobe or process of the radicle is opposite the membrane concealing the plumule, as in that genus (fig. 9 *a*). The cotyledon becoming elevated on a cauliculus is not uncommon, as it occurs in the *Irideæ*, *Juncaceæ*, *Alismaceæ*, &c., and is afterwards further noticed.

If this is admitted as the only practical explanation of the structure of the embryo of *Zostera marina*, it appears to follow that the same explanation is the only mode of accounting for the relative position of the parts of the embryo of the *Graminaceæ*; for the cotyledon, both in *Ruppia* and *Zostera*, being next the larger lobe of the radicle, we should expect to find it so in the *Graminaceæ*, if the apparent cotyledon is in reality a radicle, and this I have found to be the case in both British and exotic genera (fig. 20). All the parts of the embryo have precisely the same relation to each other; and in *Zea Mays* the cotyledon (plumule as at present understood) in germination becomes elevated on a cauliculus (fig. 21 *a*), making the embryo in all respects like that of *Zostera marina*, except that it wants the minute secondary lobe, which is, however, present in *Triticum*, *Avèna*, and *Oryza* (fig. 20 *b*). *Zostera* also further agrees with the *Graminaceæ* in being endorhizal in a remarkable degree, as afterwards noticed; from which it might almost be anticipated that the structure of their embryos would prove to be the same.

Most of the *Graminaceæ* I have seen also agree with *Ruppia* and *Cymodocea* in the cotyledon (plumule as now understood) not being enclosed by the radicle, but lying in a

* This small process is distinctly figured by Richard in *Ruppia maritima*, and his figures correctly show also its position relatively with the marginal side of the cotyledon. (*Vide* Ann. du Muséum d'Hist. Nat. tom. xvii. pl. 9. figs. 43, 58.)

† *Cymodocea Webbiana* and *Posidonia Caulini*, as figured by Ad. de Jussieu, form a connecting link between *Ruppia* and *Zostera*: in *Posidonia* the cotyledon is more than half enclosed in the upper part of the radicle, and the position of the cotyledon is distinctly shown in both of them by the plumule being exposed; and they cannot be supposed to differ in this character from *Ruppia* and *Zostera*. (*Vide* Ann. des Sciences Nat. 2me série, xi. Bot. pl. 17. figs. 15, 16.)

furrow on its surface, as in *Avena* and *Hordeum*. The embryo of *Hordeum vulgare* is in this character much like that of *Cymodocea Webbiana*, as figured by Ad. de Jussieu*, the position of its leaves being precisely the same; so that the evidence of the identity of the embryo of *Zostera* with those of the *Graminaceæ* appears to be complete, and the comparatively large radicle of this genus and its allies may be regarded as supplying the place of the deficient albumen.

As a further argument that the apparent cotyledon of the *Graminaceæ* is a radicle, it deserves remark, that in germination it scarcely enlarges, and its smaller lobe, by some botanists regarded as a second cotyledon †, also remains almost stationary; whereas the stipulary process of the cotyledon, which occupies the same position in *Smilacina*, *Tamus*, *Iris*, and *Canna*, grows in favourable circumstances so as to be as long or longer than the cotyledon, or even as long as the seed, and sometimes forms a sheath for the young stem.

In this view of the structure of the embryo of the *Graminaceæ*, the second or rudimentary cotyledon, which is a minute body, usually referred to as being alternate with, and rather lower down than the larger (fig. 20 *b*), is the smaller lobe or process of a two-lobed radicle, as in *Zostera* (fig. 8 *a*); so that the division of flowering plants by Ray into Monocotyledonous and Dicotyledonous is quite correct, and the Endogens are separated from the Exogens more completely by this character than by any other.

For the purpose of further explanation as regards the germination, the position of the first leaf of the plumule, and a proposed division of the Endogens, particular notices of the embryos of the families examined are added.

Cyperaceæ.—I have seen germinating the seeds of *Cladium Mariscus*, of a *Cyperus*, and of a *Carex* from Japan, and find that they agree with the *Graminaceæ* in having the first leaf of the plumule always next the cotyledon, as at present understood, from which, as this family is so nearly allied, it may be inferred that the embryo has the same structure, and therefore consists of a radicle partially enclosing a cotyledon. There is nothing in the germination to contradict this supposition, unless it is that the radicle is endorhizal in the lowest degree, as no coleorhiza forms, and the nascent spongiole emerges from beneath the surface without a distinct appearance of a rupture of tissue taking place. This is the only family I have observed to agree with the *Graminaceæ* in the altered position of the first leaf of the plumule, but it not improbably occurs in other glumaceous Endogens, as *Restiaceæ* and *Desvauxiaceæ*.

Zosteraceæ.—The embryo of *Zostera marina* has been accurately figured by Richard ‡: the cotyledon is seen elevated on a cauliculus, and the position of the plumule is distinctly shown, and even the smaller lobe or process of the radicle is faintly indicated, but it is imperfectly seen in consequence of the embryo being closed; but its endorhizal character does not appear to have attracted notice. This, however, is quite obvious, as the

* Ann. des Sciences Nat. 2me série, xi. Bot. pl. 17. fig. 16.

† Dr. Schleiden states that this is not a second cotyledon, but a part of the cotyledon itself, which he terms the "ligula," and regards it as being of the same nature as stipules, to which it certainly has a close resemblance; but, as it does not enlarge in germination, it wants one of the characters of stipulary processes, as far as my observation has extended. (*Vide* Schleiden's Principles of Scientific Botany, translated by Dr. E. Lankester, p. 272.)

‡ Ann. du Muséum d'Hist. Nat. tom. xvii. pl. 9. figs. 47, 48.

radicle lies in a canal directed obliquely towards the base of the embryo (fig. 9), and is so unattached that it may easily be taken out entire. But in *Z. nana* the radicle is short, less oblique in its direction, and the orifice of the canal is not closed, as in *Z. marina*, being covered only by a delicate semitransparent membrane (fig. 22). In *Triticum*, *Avena*, and *Hordeum*, there is a tubercle immediately under the radicle, which looks not unlike a closed orifice.

As thus described, therefore, the embryo of *Zostera marina* differs from those of *Oryza sativa*, *Zea Mays*, &c., only in the cotyledon and its cauliculus being curved by becoming bent downwards, and in the smaller lobe of the radicle being removed from the base of the cauliculus (fig. 8 *a*), which may be the effect of the pressure of the bent cauliculus, as it makes a depression in the substance of the radicle.

Eriocauloneæ.—The germination of *Eriocaulon septangulare* is very singular, differing from that of any other plant I have seen. The embryo first protrudes a horizontal process, having a small speck on its outer part, consisting of a circular portion of the testa, in the same way apparently as Mr. Wilson has described to occur in the germination of *Lemna gibba* (Bot. Misc. i. 145. t. 42); but in its after stages it differs in sending up a leaf, which is directly away from the cotyledon, as in *Juncaceæ* and *Liliaceæ*, and it cannot, therefore, be compared in this character to either *Graminaceæ* or *Cyperaceæ*. Subsequently to the appearance of the first leaf, the horizontal process protrudes a root from its under surface, which has no coleorhiza, although it most probably escapes through a fissure in the tissue, as the subsequent radicles do. As growth proceeds, the horizontal process becomes fissured by the enlargement of the root, which soon breaks through it, and its remains are finally left as a root-like process on the root itself. (Figs. 11, 12, 13, 14, & 15.)

On referring to Klotzsch's figures of the germination of *Pistia texensis* *, I was agreeably surprised to find a satisfactory explanation of the germination of *Eriocaulon*; and no doubt it will also serve to explain that of *Lemna*, as figured by Mr. Wilson (*loc. cit.*), which is admitted to be very obscure. In Klotzsch's figures the horizontal process is no doubt the primary radicle, as it has so entirely the appearance of the primary radicle of *Araceæ* and their allies, and the same therefore must be the conclusion with regard to the horizontal process of *Eriocaulon septangulare* (fig. 11) and the analogous process of *Lemna gibba*. But whether this kind of germination is endorhizal or exorhizal remains a question, because the growth of the radicle is arrested about the time the coleorhiza first appears; and possibly such a germination may be common to both endorhizal and exorhizal plants, so that *Pistiaceæ* and *Lemnaceæ* may be, like *Araceæ*, exorhizal. I am obliged, however, to differ from Klotzsch in his description of the plumule of *Pistia texensis*: what he calls the first leaf, I should undoubtedly regard as a stipulary process, or perhaps only as the lips of the fissure in the cotyledon; and what he calls the second leaf must, of course, be the first leaf, which is figured as being directly away from the cotyledon, as in *Arum*.

Commelynaceæ.—The endorhizal character is here well marked; the coleorhiza is, however, very thin, and soon disappears. The first leaf of the plumule is directly away from

* Ueber Pistia (Abhandl. der K. Akademie zu Berlin, aus dem J. 1852). Berlin, 1853. Taf. ii. figs. Q, R, S.

the cotyledon. On the face of the germinated cotyledon in *Commelyna tuberosa*, and another species, there is always present a small process looking like a bud, which is not, however, present on any of the succeeding leaves; possibly it may be analogous to the buds that occur on the ribs of the inferior paleæ of the Grasses.

Juncaceæ.—As this family is intermediate between *Liliaceæ* and *Cyperaceæ* and their allies, and its limits are not well defined, its germination presented a more than usually interesting subject of inquiry, and was rather expected to prove like that of the *Liliaceæ*. *Luzula campestris* is, however, distinctly endorhizal, being more so than the *Cyperaceæ*, and, I believe, strictly agrees with the *Commelynaceæ* in this character; it may therefore serve to show that *Juncaceæ* have no near affinity with either *Liliaceæ* or *Palmaceæ*, from which they further differ in the cotyledon, as growth advances, becoming elevated on a caulieulus. The coleorhiza is of delicate texture, and disappears within a day or two from the enlargement of the root *. The cotyledon has a well-defined opening for the plumule, the first leaf of which is directly away from it. (Fig. 23.)

Hydrocharideæ.—This family has the embryo (the plumule only being rather larger) as well as the habit of *Naiadeæ* and their allies, and so may, perhaps, supply a connecting link between the hypogynous and epigynous Endorhizæ. It also agrees with them in having the first leaf of the plumule directly away from the cotyledon.

Marantaceæ.—The germination of *Canna indica* has been figured by Richard with his usual accuracy †, with the exception of the primary radicle, which, from his figures, might be supposed to possess a coleorhiza of the same kind as the secondary, which is not at all the case. The coleorhiza of the primary radicle is of comparatively delicate texture, and unless the germination is daily examined from its commencement, may escape observation, as it very soon disappears entirely; whereas the secondary radieles break through the epidermis from a considerable depth, and the torn fissures through which they escape remain for a much longer time. At the last stage figured, the coleorhiza of the primary radicle has almost or entirely disappeared, so that the appearance of it there represented is, I believe, only that of the lateral radicle on either side reflected down upon it. The first leaf of the plumule alternates with the cotyledon, and as germination advances, the cotyledon sends up a stipulary process, forming a short sheath for the growing plumule.

Alismaceæ and *Butomaceæ*.—In the germination of *Actinocarpus Damasonium* the plumule becomes elevated on a caulieulus, which elongates, while the radicle has scarcely begun to protrude; the first two leaves of the plumule are lateral, *i. e.* neither directly towards the cotyledon nor directly away from it, but yet, as growth advances, the external of the two shows a tendency to turn more directly away from it. *Butomus umbellatus* germinates in the same way, the cotyledon having a very distinct fissure for the emission of the plumule, but its first leaf is directly away from the cotyledon. The germination was repeatedly observed, and no trace of a coleorhiza was perceptible. (Figs. 24 & 25.)

* The coleorhiza cannot be seen unless the seed is first completely deprived of its mucilaginous coat by placing it in water for two or three days, when it swells, and is easily removed. If this is not done, the radicle becomes covered with mucus, so as entirely to prevent observation.

† Ann. du Muséum d'Hist. Nat. tom. xvii. pl. 5. figs. 3, 4, 5, 6.

Juncagineæ.—The germination of *Triglochin palustre* agrees with that of *Arum*, showing no trace of the endorhizal character; but after the radicle has protruded, a slight ridge forms, which marks its junction with the cotyledon, and is produced by the base of the cotyledon; and this gives the radicle in some degree the appearance of having been endorhizal.

Typhaceæ.—Repeated examination failed in showing any traces of the endorhizal character in *Typha latifolia*, the germination of which is much like that of *Butomus*, in the cotyledon becoming elevated on a short cauliculus, which is distinctly separated from the radicle by a slight ridge, and it agrees with it also in the position of the first leaf of the plumule. A fringe of minute radicles gives it the appearance of being endorhizal, and renders the examination difficult unless made in water. Richard's figures do not represent it as endorhizal *.

Araceæ.—It was after repeated unsuccessful attempts that the seeds of *Arum maculatum* and *Dracunculus* germinated, and neither of them proved endorhizal. At first there is no distinction between cotyledon and radicle (fig. 16), and subsequently only a faintly marked ridge shows the junction between them (figs. 17 & 18); this consists of the base of the cotyledon, and is seen at the bases of the succeeding leaves (fig. 19). In *A. Dracunculus* the first leaf of the plumule is alternate with the cotyledon, being directly away from it; but *A. maculatum* does not produce its first leaf till after it has formed a small cormus, and in the meantime its cotyledon has withered. Supposing therefore the cormus in the latter to develope rather earlier than the cotyledon, so as partially to envelope it on its dorsal side, or only to form a concave tuberosity beneath it, then it might be compared with the embryo of *Zosteraceæ*.

Palmaceæ.—The germination of *Phœnix dactylifera* agrees with that of the *Araceæ* and *Liliaceæ*, except that it protrudes its radicle like a *Commelyna*, forcing the embryotega away in much the same manner †; a shallow furrow, extending the whole length of the cotyledon, shows its marginal side, and at its base, close to the radicle, is the opening for the plumule, looking like a small scar. It is, however, if pervious, so minute, that the plumule escapes by an artificial opening, sometimes through the back of the cotyledon, but often through the furrow, in consequence of the tissue being thinner. Taking this furrow as a guide, the first leaf of the plumule is directly away from the cotyledon.

Liliaceæ.—*Smilacina*, *Funkia* ‡, *Asparagus*, and *Allium*, all agree in having the primary radicle exorhizal, and the first leaf of the plumule directly away from the cotyledon. *Asparagus* has the plumule sheathed by a stipulary process of the cotyledon, as in *Iris* and *Canna*; it is found on the inner side of the plumule, and becomes, in favourable cir-

* Ann. du Muséum d'Hist. Nat. tom. xvii. pl. 5. figs. 8, 9.

† About ten days after germination has commenced, the cuticle at the apex of the radicle sometimes exfoliates in minute irregular scales, having in some degree the appearance of a commencing coleorhiza; but the same kind of exfoliation soon takes place from the whole surface of the elongated cotyledon, which becomes an inch or more in length, and therefore, I believe, is not at all analogous to a coleorhiza.

‡ One of the species of this genus is remarkable for a triple plumule, the parts of which, growing during germination, produce a singular appearance. It is in cultivation in the Botanic Gardens, Chelsea. Before germination the plumules are enclosed within the fissure, and all spring from one point.

cumstances, as long as the cotyledon, but no trace of it is present before germination. It cannot be a rudimentary leaf, because it has no connexion with the base of the plumule, but only with the margins of the opening in the cotyledon.

Irideæ.—The embryos of several species of *Iris* agree in their germination with those of *Araceæ* and *Liliaceæ*; they are, however, remarkable for the cotyledon sending up a sheath surrounding the plumule, which sometimes becomes longer than the cotyledon itself, and terminates by elongating internally between the plumule and cotyledon (fig. 26). In other species of the same genus, this sheath exists only as membranous margins of the elongated opening in the cotyledon, which proves beyond doubt it is of the nature of stipules.

Amaryllideæ.—The germination of *Alströmeria aurantiaca* agrees precisely with the species of *Iris* in the primary radicle being exorhizal, and the secondary endorhizal, or at least breaking through the cellular surface; but the stipulary process, as I have termed it, is wanting, which is a further proof of its real nature in *Iris*.

Dioscoreaceæ.—The germination of *Tamus communis* agrees most with that of the *Liliaceæ*. The first leaf of the plumule alternates with the cotyledon, and not only is it exorhizal, but it is some time before any distinction between the cotyledon and radicle is apparent. The opening for the emission of the plumule is horizontal, and a sheath, like that which forms in *Asparagus*, rises round the nascent plumule, and, as growth advances, becomes external to it instead of next the cotyledon, which gives it in some degree the appearance of a second cotyledon; it is, however, often bifid, and the young leaves, as well as those which are mature, have lateral stipules, which alone might be sufficient to explain its true character *.

With reference to the value of the characters, it may be observed that they will probably prove of some practical use in subdividing the Endogens; *Graminaceæ*, *Zosteraceæ*, *Naiadeæ*, and their allies forming a natural section, and containing, it may be anticipated, all the truly endorhizal and macropodal hypogynous families; and, on the other hand, *Araceæ*, *Liliaceæ*, *Dioscoreaceæ*, *Irideæ*, and their allies, in which these characters are wanting, are all otherwise in near affinity to each other.

Such a subdivision, however, would involve the placing of the *Marantaceæ*, *Musaceæ* and *Amomeæ*, and also the *Orchideæ* and *Burmanniaceæ* on account of their large radicle, in the endorhizal section, with which they have scarcely any connexion except the affinity between *Orchideæ* and *Triurideæ*; but yet their epigynous character should not perhaps be regarded as excluding them, because of the truly epigynous character of the *Hydrocharideæ*. If, however, Von Martius is right in his comparison of *Burmanniaceæ* with *Hydrocharideæ*, to which he refers them, another link of connexion between *Orchideæ* and the hypogynous endorhizal families may be traced; and it may also deserve notice, that the embryo of *Orchis Morio* in germination becomes in shape much like that of a *Ruppia*, the young plumule also springing from the same part. The ovules of *Burmanniaceæ* are orthotropal, and the distichous inflorescence of *Burmannia dasyantha* †

* This stipulary process occurs in the ungerminated embryo of *Dioscorea cordifolia*, as figured by Ad. de Jussieu, and is represented as bifid. (Ann. des Sciences Nat. 2^{me} série, xi. Bot. pl. 17. fig. 13.)

† Nov. Gen. et Sp. Plant. Brasil. tom. i. tab. 5. fig. '

occurs in *Alismaceæ*, a near ally of the *Hydrocharideæ*; besides which, they may not improbably prove to have the embryo of *Triurideæ*, which would lend some further support to such a comparison. And if the *Bromeliaceæ* should prove endorhizal, such a subdivision of the epigynous families would not be unnatural, as they connect *Hydrocharideæ* and *Marantaceæ*.

The following is added as a provisional arrangement of the Endorhizæ and their allies, including especially all those families in which the radicle is enlarged; and the remainder of the class Endogens thus separated will, I believe, be found to form by themselves a very natural section. But it must be confessed that no entirely natural arrangement can be expected to be made until the structure of the embryo and its germination in all the families is definitely ascertained.

Epigynous.		All. 1. Orchideæ. Apostasiaceæ. Burmanniaceæ.	All. 2. Hydrocharideæ.	All. 3. Musaceæ. Amomeæ. Marantaceæ. All. 4. ? Bromeliaceæ. ? Taccaceæ.
Hypogynous.	All. 5. Commelynaceæ. Mayaceæ. Xylideæ. Eriocauloneæ. All. 6. Restiaceæ. Desvauxiaceæ. Cyperaceæ. Graminaceæ.	All. 7. Philydraceæ. Juncaceæ.	All. 8. Triurideæ. Alismaceæ. Butomaceæ. All. 9. Potamogetoneæ. Naiadeæ.	
Primordial form.	Zosteraceæ.			

EXPLANATION OF THE PLATE.

Tab. LXVIII.

Fig. 1. *Nuphar lutea.* The radicle at the time of its first protrusion, before the first leaf appears.

Fig. 2. The seed of the same after the first leaf has appeared. This leaf is rudimentary, having no lamina.

Fig. 3. The same, after the second leaf has formed, and a secondary radicle protruded, which has a coleorhiza. The same coleorhiza appears on the secondary radicles, which succeed.

Fig. 4. An embryo of a *Zannichellia*, the membranous sheath containing the plumule having been laid open to show the position of its first and second leaves.

Fig. 5. A longitudinal section of the same, showing that the radicle is perfectly adherent to the surrounding tissue, and that in the ungerminated embryo no trace of a canal is formed for it.

Fig. 6. The embryo of *Ruppia maritima*, the membranous sheath containing the plumule having been laid open to show the position of its first and second leaves: *a*. the smaller lobe of the radicle.

Fig. 7. The embryo of *Zostera marina*, showing the smaller lobe of the radicle coiled over the cotyledon in its cavity.

Fig. 8. The same, opened, and the cotyledon raised out of its cavity: *a*. the smaller lobe of the radicle.

Fig. 9. The same, in longitudinal section, showing the radicle lying in a narrow canal at its base. The membranous sheath containing the plumule is opened to show that it is situated on that side of the cotyledon which is next the smaller lobe of the radicle, *a*.

Fig. 10. The plnmule more magnified, showing that it consists of two leaves: the first leaf, *a*, is directly away from the cotyledon.

Fig. 11. A germinating seed of *Eriocaulon septangulare*, showing the primary radicle protruding, with a small circular portion of testa on its apex.

Figs. 12 & 13. The same more advanced, fig. 13 showing the position of the first leaf of the plumule.

Fig. 14. The same, showing the commencement of the formation of the first secondary radicle.

Fig. 15. The same more advanced, showing that the secondary radicle has broken through the primary, and the first leaf of the plumule become elevated on a cauliculus. From the cauliculus another secondary radicle has protruded; it has no coleorhiza, but the surface of the cellular tissue divides to allow its escape.

Fig. 16. A seed of *Arum Dracunculus* commencing to germinate, showing that it has no trace of a coleorhiza.

Fig. 17. The same more advanced, showing a slightly elevated line marking the base of the cotyledon.

Fig. 18. The same more advanced, showing the position of the first leaf of the plumule.

Fig. 19. The same more advanced, the cotyledon having been removed to show a circular line at the base of the first leaf, similar to that at the base of the cotyledon in fig. 17.

Fig. 20. A germinating embryo of *Oryza sativa*: *a*. the upper part of the radicle as understood by Richard; *b*. the smaller lobe of the radicle (the epiblastus of Richard), which has been regarded as a second cotyledon; *c*. the cotyledon, showing its relation to the upper part of the radicle.

Fig. 21. A germinating embryo of *Zea Mays*: *a*. the cauliculus; *b*. the cotyledon as understood by Richard, the plumule having been partly drawn out of the fissure to show its position.

Fig. 22. The embryo of *Zostera nana*, showing the aperture for the emission of the radicle, covered by a semitransparent membrane.

Fig. 23. A germinating embryo of *Luzula campestris* extracted from the albumen. The stricture in the cotyledon is produced by the pressure of the testa after the radicle has protruded.

Fig. 24. A germinating embryo of *Butomus umbellatus*.

Fig. 25. The same more advanced: *a*. part of the cauliculus (not cotyledon) is seen above the radicle.

Fig. 26. A germinating embryo of an *Iris*, extracted from the albumen: *a*. the sheath of the plumule in its earliest stage.