seems to be that in May the trees are only developing their leaves, without which wood cannot be formed; and that in September they are busy forming their buds for next spring, and also ripening their new wood. More extensive observations are necessary for settling the relative rate of growth in the several months. Already, however, the table gives an indication that June and July are the most favourable.

The only other general conclusion to be drawn from the table is that evergeen trees begin to increase in girth a month earlier than leaf-shedding trees—a fact which is intelligible enough, as they have leaves ready to make use of the sap at its first rise. It is not so easy to understand why most of these made the subject of observation added little, or even nothing, during the month of August, when the weather was invariably fine.

On the Morphology of the Pitcher of Cephalotus follicularis.

By Alexander Dickson, M.D., Professor of Botany in the University of Edinburgh. (Plates V. and VI.).

In a paper on the Structure of the Pitcher of *Cephalotus follicularis*, read at the Plymouth meeting of the British Association, and published in the "Journal of Botany" in January 1878, I pointed out the remarkable difference as to the position of the lid of the pitcher between *Cephalotus*, on the one hand, and *Sarracenia* and *Nepenthes*, on the other. In *Cephalotus* the lid is placed on that side of the orifice of the pitcher *nearest* to the main axis, while in *Sarracenia* and *Nepenthes* it is on the side *farthest* from the main axis. At that time I was inclined to assume that the pitcher-lid in *Cephalotus* represented the extremity of the leaf, and this led me to suggest—although under reserve—that, while the pitcher in *Sarracenia* and *Nepenthes* appears as a pouching of the leaf from the upper surface, in *Cephalotus*, on the other hand, the pouching would, on the assumption indicated, be from the lower leaf-surface. Developmental evidence is at present scarcely attainable, requiring, as it would do, the sacrifice of many specimens of a plant not very easy of cultivation, and never

very common; and in absence of this we are glad to meet with any teratological deviations which may throw light upon the subject.

Some time ago our esteemed foreman at the Botanic Garden here, Mr Robert Lindsay, told me he had once seen what appeared to him to be a pitcher springing from an ordinary leaf, and I asked him to look at our plants from time to time in hope of abnormalities presenting themselves. The result has been the detection of several very interesting and instructive forms intermediate between the ordinary foliage-leaf and the pitcher; and I have now very great satisfaction in being able to pronounce a decided opinion on the general morphological relations of the *Cephalotus*-pitcher, even although I have to admit the complete reversal of my previous conceptions of the subject.

These abnormal leaves are four in number, of small size and feeble development. I shall now describe them in order of their extent of deviation from the form of the ordinary foliage-leaf towards that of a pitcher.

Specimen A (Plate V., fig. 2).—In general form this closely resembles the foliage-leaf, presenting a somewhat ovate blade narrowed gradually below into the leaf-stalk. It exhibits, however, on the upper surface a somewhat elliptical spoon-like excavation involving the terminal two-thirds, or thereby, of the lamina. This excavation is deepest at the end next the petiole, where it is bounded by a pretty sharply defined border. On the lower surface, towards the leaf-apex, there is distinct development of a keel-like ridge in the middle line. In this specimen we have the pitcher cavity foreshadowed by the spoon-like excavation, while the keel-like ridge represents the middle dorsal wing, which is a very prominent feature in the perfect pitcher.

Specimen B (Plate V., fig. 3).—Here the excavation has advanced to the formation of a narrow somewhat elongated funnel with oblique mouth, the *far* side of the orifice, from the main axis, extending out beyond the *near*; the leaf-apex (in this case a little truncated) being at the far side of the orifice. The *near* side of the orifice, instead of exhibiting the simply rounded excision seen at the deeper end of the spoon-like excavation in the first-mentioned

specimen, is here developed in the middle line into a small but distinct tooth-like projection. This lobe is the first indication of the pitcher-lid. As in the former specimen, there is here, also, a keel-like ridge in the middle line on the lower leaf-surface.

Specimen C (Plate V., fig. 4).—In this we have a still greater approximation to the pitcher-form. As in the last, we have a funnel-like structure with oblique mouth, the far side of which retains, however, more of the original pointed form of the leaf-apex. The greater advance towards the ascidium consists in the greater development of the structure representing the pitcher-lid, which is of considerable size and deeply cut into three lobes, two longer and stronger lateral lobes, and a shorter, feebler median one. Here, again, we have along the middle dorsal line a keel-like projection.

Specimen D (Plate V., figs. 5 and 6).—In this, a misthriven leaf of very small size, we have a still greater approximation to the normal ascidium. The lid is relatively larger, and exhibits two lobes separated by a considerable notch, in this respect according more with the structure of the normal lid, where we have the extremity emarginate, corresponding to the dichotomous disposition of the principal veins. Further, in addition to the middle dorsal keel or wing, which is more pronounced in this than in the other specimens, we have, on one side, a slight indication (Plate V., figs. 5 and 6, *lw*) of one of the oblique lateral wings of the normal pitcher. The far side of the orifice of the funnel has still the pointed form of the apex of the foliage-leaf.

In all these specimens it is to be noted that the tip of the middle dorsal keel or wing and the apex of the leaf are coincident. Inasmuch, however, as none of them show the slightest trace of the remarkable development of the corrugated rim, with its inflexed teeth, it may still be open to question what represents the leaf-margin in the perfect pitcher. If the lower (outer) border of the corrugated rim represents the leaf-margin, then the tip of the middle dorsal wing would represent the leaf-apex. If, on the other hand, the leaf-margin is represented by the line of the inflexed teeth, then the middle dorsal tooth (Plate V., fig. 6, *mdt*),

in line with the middle dorsal wing, and conspicuous by its larger size, would represent the leaf-apex.* Of the two possibilities I am disposed to look upon the first as the more probable; partly from the coincidence of the tip of the middle dorsal keel or wing with the leaf-apex in the abnormal specimens mentioned above, and partly from the vascular distribution in the normal pitcher. In the latter, the vessels from the extremity of the petiole divide into two sets, an upper going to supply the lid, and a lower which diverge radiatingly and are distributed to the pitcher-wall. Of the last mentioned set there are three somewhat more marked than the others, viz., a lateral vein on either side curving downwards and outwards past the lower extremity of the lateral wing, and passing obliquely across the lateral glandular patch to curve upwards towards the pitcher orifice, and a middle vein which runs in the ventral wall of the pitcher to the bottom, whence it passes on to the dorsal surface, where, however, it leaves the pitcher-wall, and, passing into the middle dorsal wing, continues its course just within the curiously expanded edge of that structure. In my opinion this course of the middle vein seems to prove that the middle dorsal wing is a development of the midrib, and that its apex really represents the leaf-apex.

In the three specimens exhibiting the funnel-shaped excavation, it is to be observed that the sharp margin of the far side of the orifice of the funnel—representing, as it undoubtedly does, the margin of the leaf—is continuous with an angular ridge, or *lateral line*, as we may call it, on either side of the funnel (Plate V., figs. 3, 4, and 5, *ll*). These "lateral lines" can scarcely be anything else than the downward continuations of the leaf-margin; and if they are so, it follows that all above the "lateral lines" is *upper*, all below them *lower* leaf-surface. In this way I am led to view the pitcher-lid as wholly developed from the upper leaf-surface, with which *both* its aspects are continuous. This conclusion might, indeed, have been anticipated from inspection of Specimen A, where the portion of the margin of the spoon-like excavation next the petiole

* Somewhat similarly, the teeth in line with the lateral wings of the pitcher are also of conspicuous size.

belongs manifestly to the upper leaf-surface. In the perfect pitcher the "lateral lines" are distinctly recognisable as ridges, one on either side, running from the junction of the corrugated rim with the base of the lid down towards the extremity of the petiole, where they disappear.

To convert, in idea, one of the funnel-like structures above described into the normal *Cephalotus*-pitcher, we must imagine that side of the funnel nearest to the main axis as remaining comparatively stationary, while the far side of the funnel becomes calceolately pouched to an enormous extent, forming, in fact, almost the entire pitcher. The pitcher-leaf of *Cephalotus*, with its calceolate pouching, whereby the apex of the lamina is curved round so as to become approximated to its base, may not inaptly be compared to the well-known "hammer-headed" upper petals of *Aconitum*, where we have also petiolated leaf-organs with similar pouching of the lamina and approximation of apex to base. The interest of this comparison is further heightened by the circumstance that in both cases the internal surface is developed (although for very different purposes) as a secreting apparatus. In illustration of the parallel, I give an outline figure of the pitcher-leaf of *Cephalotus* (Plate V., fig. 6), placed in such a position—with petiole nearly vertical—as will enable any one at a glance to compare it with the nectariferous petal of *Aconitum* (Plate V., fig. 7), a figure of which I have borrowed from Prof. Asa Gray's "Text Book."

The conclusions to which I have been led may thus briefly be stated:—

1st. That the pitcher results from a calceolate pouching of the leaf-blade from the upper surface.

2d. That the apex of the leaf is on the far side of the pitcher-orifice from the main axis and from the lid, and is probably represented by the tip of the middle dorsal wing.

3d. That the pitcher-lid represents an outgrowth or excrescence from the upper leaf-surface.

In this place I must mention that Dr Masters, in his "Teratology" (p. 314), says that "in *Cephalotus follicularis* rudimentary or imperfect pitchers may be frequently met with in which the stalk of the leaf is tubular, and bears at its extremity a very small rudimentary leaf-blade." Unless

there is some error of description, the cases here referred to must have been exceedingly unlike mine; but whatever they may have been, it is quite certain that they had not been sufficient to enable Dr Masters to come to any very definite opinion on pitcher-morphology. This may be gathered from his immediately following conclusions as to ascidia in general, which run thus:—"It is not in all cases easy to trace the origin and true nature of the ascidium, as the venation is sometimes obscure. If there be a single well-marked midrib the probability is that the case is one of cohesion of the margins of the leaf; but if the veins are all of about equal size, and radiate from a common stalk, the pouch-like formation is probably due to dilatation and hollowing of the petiole.* Again, when the result of a union of the margins of the leaf, the pitcher is generally less regular than when formed from the hollow end of a leaf-stalk. Further information is especially needed as to the mode of development and formation of these tubular organs so as to ascertain clearly when they are the result of a true cupping process, and when of cohesion of the margins of one or more leaves."

In conclusion, I may refer to the principal points for comparison, or contrast, between the pitcher of *Cephalotus*, on the one hand, and those of *Sarracenia* and *Nepenthes*, on the other, in both of which latter the development has been examined—in *Sarracenia* by Professor Baillon,† and in *Nepenthes* by Sir Joseph D. Hooker.‡

As regards *Sarracenia*, Baillon's observations and conclusions are briefly as follows:—In *S. purpurea* the leaf appears at first as a small convex mammilla. A little later the base of the organ becomes somewhat dilated and a little concave towards the inner surface. This dilatation is the sheathing base of the petiole, and at a later period becomes considerably developed. It has nothing to do with the formation of the pitcher. This last appears somewhat later

* To this category Dr Masters would, no doubt, relegate the case of *Cephalotus*. It seems just possible that in the monstrosities of *Cephalotus* referred to by him the rudiment of the pitcher-lid has been mistaken for a "rudimentary leaf-blade."

† "Sur le developpement des feuilles des *Sarracenia*"—(*Comptes Rendus*, lxxi. p. 630).

‡ "On the Origin and Development of the Pitchers of *Nepenthes*, with an Account of some new Bornean Plants of that Genus"—(*Trans. Linn. Soc.* vol. xxii. p. 415).

as a small depression or fossa a little to the inner side of the extremity of the cone which represents the young leaf. This fossa—the result of inequality of development in the different portions of the extremity of a leaf whose petiolar and vaginal portions already exist—he holds to be formed on the upper surface of the lamina. The fully-developed pitcher he views as corresponding morphologically to a peltate leaf like that of *Nelumbium*. The large but shallow inverted cone which forms the leaf-blade in *Nelumbium* becomes in *Sarracenia* deeper and narrower, so as ultimately to present the form of a long obconical horn. The pitcher-lid he considers as merely the terminal lobe of the peltate limb.

If Baillon is right—as probably he is—in viewing the pitcher of *Sarracenia* as a modification of a peltate leaf, it would, in this respect, seem to differ considerably from that of *Cephalotus*. In *Sarracenia* the whole outer surface of the pitcher, on the near as well as on the far side from the main axis, would represent *lower* leaf-surface; whereas in *Cephalotus* the upper surface of the pitcher-lid and the portion of the outer surface of the pitcher-wall intervening between it and the extremity of the petiole, and bounded laterally by the "lateral lines" above referred to, belong to *upper* leaf-surface.

As regards *Nepenthes*, Hooker's observations conclusively show that the pitcher-cavity is the result of a pouching from the upper leaf-surface, and that the leaf-apex is represented by the "styliform process" which projects from behind the junction of the lid and pitcher. The lid here must be viewed as an outgrowth or excrescence from the upper leaf-surface, just as in *Cephalotus:* with this difference, however, that while in *Cephalotus* the lid springs from the side of the pitcher orifice *nearest* to the main axis, the lid in *Nepenthes* springs from the side *farthest* from it.

The pitcher-leaf of *Nepenthes* presents, as is well known, very considerable difficulties to the morphologist who wishes to reduce its parts to the terms of "petiole" and "lamina." The flatly expanded portion, sometimes sessile and sometimes supported by what closely resembles a petiole, is considered by Hooker as the lamina, whose midrib is produced

as a tendril-like structure somewhat after the fashion of the cirrhose prolongation of the leaf-apex in *Gloriosa*. The pitcher he views as a glandular excavation on the internal aspect of this "excurrent midrib" somewhat below its extremity.

With regard to this determination a few remarks may not be out of place.

If Hooker's representation of the early development of the leaf of *Nepenthes* be examined, and especially his figure of the first appearance of the pitcher-excavation (*loc. cit.*, Tab. lxxiv., fig. 1 *b*), one cannot but be struck with its exact correspondence with Baillon's description of the development of the *Sarracenia* leaf, where the excavation representing the future pitcher appears as a small fossa a little to the inner side of the cone which represents the young leaf, the base of which is already somewhat dilated and a little concave towards the inner surface. If the pitcher of *Sarracenia* represents a leaf-blade, it seems scarcely possible to resist the conclusion that the same must hold good for *Nepenthes*.

An apparent difficulty, however, arises as to the signification of the flat expansion below the cirrhose support of the pitcher.

At first I was disposed to look upon all the parts below the pitcher—including the flat expansion—as representing the petiole; but an examination of the remarkable leaf-forms occurring in certain *Crotons* now inclines me to adopt a view virtually identical with that of Hooker, although perhaps not exactly in the shape contemplated by him.

In the plants called *Croton interruptus* and *C. picturatus* —probably both of them monstrous forms of *C. angustifolius* —we have, in many of the leaves, the phenomenon of an interruption, or more or less sudden narrowing in the course of the lamina, which for some distance becomes reduced to the slender filamentary midrib. It happens, moreover, that in the greater number of the interrupted leaves the distal portion of the lamina—borne upon the "excurrent midrib" —is developed, peltate-fashion, into an oblique funnel of varying depth.* (Plate VI. figs. 1 and 2).

* Especially in *C. picturatus*.

The closeness of the parallel which may be drawn between this structure and the ascidium-leaf of *Nepenthes* will be at once apparent; and, although analogical reasoning of this kind must be employed with caution, it seems highly probable that in *Nepenthes* we have to deal with a leaf the lamina of which is interrupted in the middle of its course by becoming reduced to its midrib, and that, while the proximal portion of the lamina retains its typical form of a flat expansion, the distal portion becomes peltately expanded into a funnel or pitcher.

In the *Croton* leaves just referred to, it is to be noted that the proximal expansion, while sometimes simply narrowed into the attenuated portion, as in Plate VI. fig. 1, is more frequently developed towards its extremity in a peltate manner, so that the midrib appears as excurrent from the lower leaf-surface, as in Plate VI. fig. 2. This latter case is of special interest inasmuch as a similar peltation towards the extremity of the proximal expansion occurs in many of the leaves of *Nepenthes phyllamphora*, and forms one of the specific characters of Hooker's magnificent *N. Rajah*.

EXPLANATION OF PLATES.

Plate V.—*a* = Leaf-apex. *l* = Pitcher-lid. *ll* = "Lateral line." *mdw* = Middle dorsal wing. *lw* = Lateral wing. *mdt* = Middle dorsal tooth of corrugated rim.

Fig. 1. Normal foliage leaf of *Cephalotus*.

Fig. 2. Specimen A. Leaf with spoon-like excavation on upper leaf-surface.

Fig. 3. Specimen B. Leaf funnel shaped, with small tooth-like rudiment of pitcher-lid on the near side of the orifice of the funnel.

Fig. 4. Specimen C. Leaf funnel-shaped. Rudiment of pitcher-lid 3-lobed.

Fig. 5. Specimen D. Leaf funnel-shaped. Rudiment of pitcher-lid 2-lobed. Nearly side view.

Fig. 5 (*a*). Nearly dorsal view of same specimen. Middle dorsal wing seen with its tip coincident with the leaf-apex.

Fig. 6. Normal Ascidium-leaf, placed, with petiole nearly vertical, for comparison with the funnel-shaped abnormalities and with the accompanying figure of the petal of *Aconitum*. If the ascidium-leaf be compared with the funnel-shaped specimens, and the position of the "lateral lines" (*ll*) be noted, it will be evident that the

pitcher virtually consists of a calceolate expansion of the far side of the funnel from the main axis.

Fig. 7. Nectariferous petal of *Aconitum* (after Asa Gray), showing petiolar portion (claw) and calceolately pouched lamina.

Plate VI.—Fig. 1. Interrupted leaf of *Croton picturatus*. Distal portion of lamina peltate, forming an oblique funnel. Proximal expansion simply narrowed into the attenuated portion.

Fig. 2. Another of the same. Here, however, the upper part of the proximal expansion is peltate, so that the filamentary midrib appears as "excurrent" from the lower leaf-surface.

In Plate V. the figures are all more or less magnified. In Plate VI. they are of natural size.

On Lepidophloios, a genus of Carboniferous Plants. By John M. Macfarlane, B.Sc. (Plates VII. and VIII.)

The genus Lepidophloios was formed by Sternberg * for the reception of certain Carboniferous plant remains, which, while conforming in many respects to Lepidodendron and allied genera, were distinguishable from these by well-marked peculiarities. These specimens he described as *Lepidophloios laricinum*. To the elucidation of the life-history of this species I propose devoting the present paper. The following is a short *resumé* of the literature on the subject. Corda † described and figured parts of the stem of a species of Lepidophloios as *Lomatophloios crassicaulis*. He wrought out the minute structure of it in great detail. Though able to ascertain its internal anatomy, he erred as to its true affinities, since he regarded it as being allied to Sempervirens and Cactus.

When Goldenberg published his "Flora Saræpontæ Fossilis," he—as far as I can learn—enumerated three species of Lomatophloios and two of Lepidophloios, the differences between these two genera, in the opinion of this observer, consisting in the greater size of the foliar cushions and leaf scars in the former. In a paper "On

* Tableau des genres de végétaux Fossiles, p. 43.

† Beiträge zur Flora der Vorwelt, Prague, 1845.

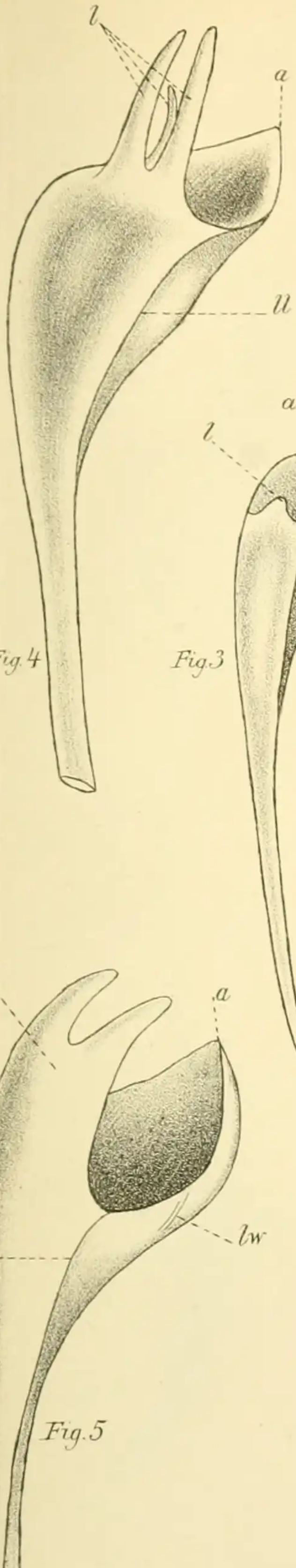

Fig. 4

Fig. 3

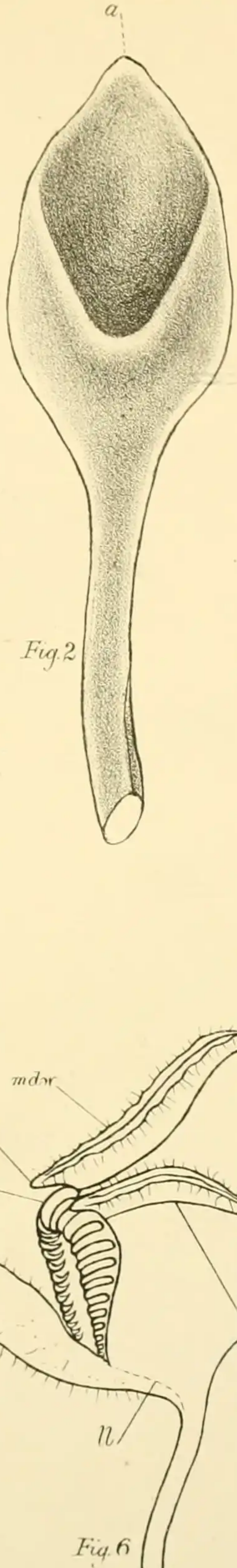

Fig. 2

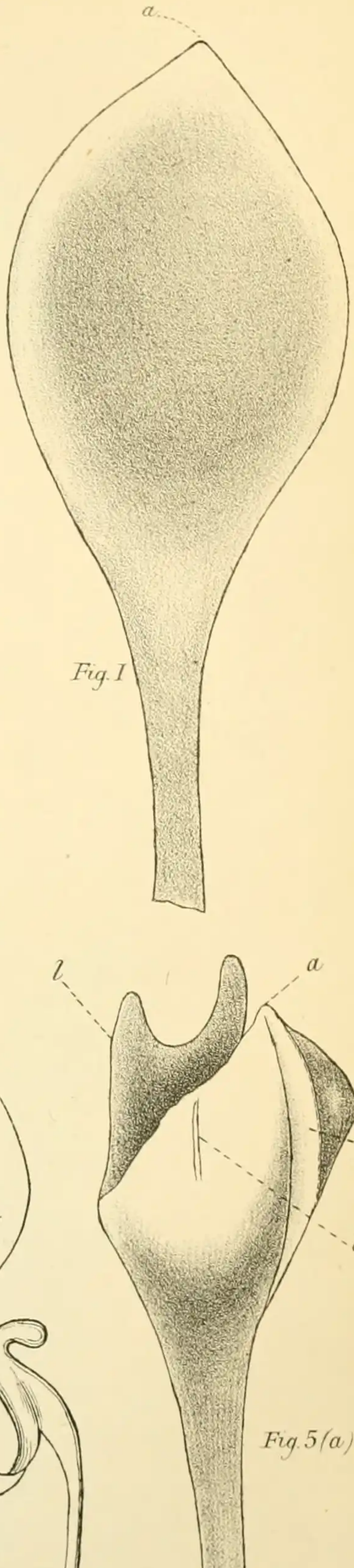

Fig. 1

Fig. 5

Fig. 6

Fig. 7

Fig. 5(a)

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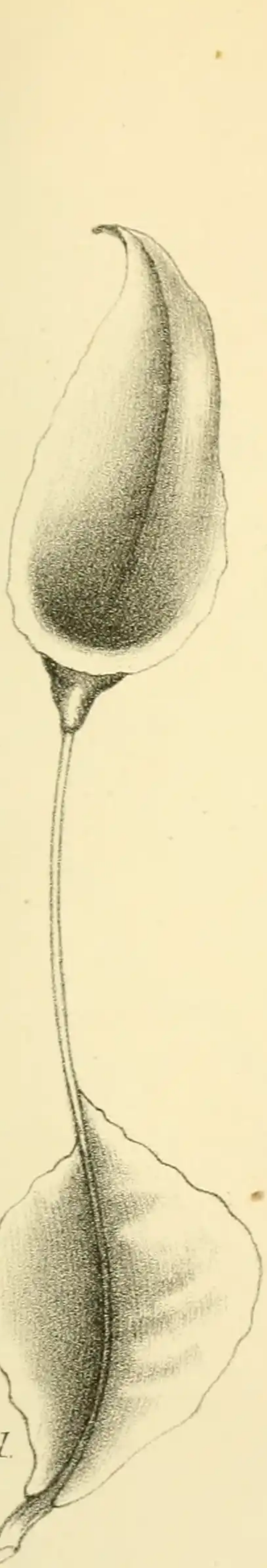

Fig. 1.

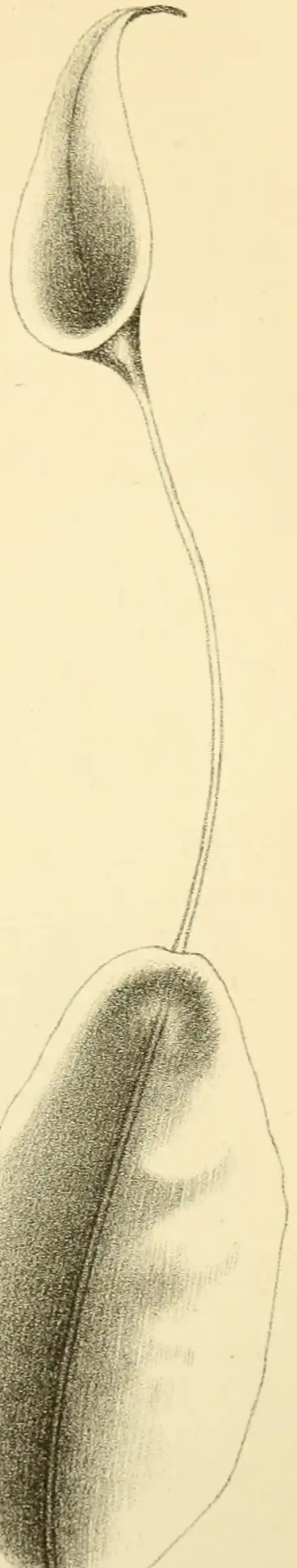

Fig. 2.

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