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I.—*Parka decipiens.* *Notes on specimens from the collections of James Reid, Esq., of Allan House, Blairgowrie, Scotland,*

By SIR WILLIAM DAWSON, LL.D., F.R.S., and PROF. PENHALLOW, B.Sc.

(Read May 28, 1891.)

PART I.—HISTORICAL AND GEOLOGICAL.

By Sir WM. DAWSON.

Last year I had the pleasure of noticing[1] some fossil plants from the Lower Devonian, kindly submitted to me by Mr. James Reid, of Allan House, Blairgowrie, Scotland. In correspondence with Mr. Reid some questions arose respecting the peculiar organisms from the same formations known as *Parka decipiens*, and Mr. Reid has been so kind as to send from his own collections and those of other friends a large number of specimens of these doubtful objects, which I have studied with much interest, and which I thought it desirable to submit to critical examination by my friend, Professor Penhallow, whose results are given in Part II. It may be useful, however, to give some preliminary account of the history and geological relations of the fossil.

Parka decipiens was originally described by Dr. Fleming in 1831.[2] This sagacious observer noted its circular groups of small rounded or polygonal, flattened, seed-like bodies, the fact of these being in part covered with a membranous involucral organ and their association with grassy-looking leaves. He regarded it as of vegetable nature, and compared it to the fruit of *Juncus* or *Sparganium*.[3] Miller agrees with this view, and in the later editions of the "Old Red Sandstone" he describes it as occurring in the quarries of Carmylie, in association with "riband-like leaves converging into a short stem," and also with "thickish wrinkled stems." These plants he compares to "stalks of sea-grass-weed plucked up by the roots," and elsewhere to "stems producing *Zostera*-like leaves." He quotes, however, the opinion of Lyell that the *Parka* may be eggs of a mollusk, and seems to lean to the belief that it may have possibly been the spawn of some of the large Devonian crustaceans associated with it in the same beds. In the seventh edition, edited by Mrs. Miller, Symonds adds a note to the effect that *Parka* is "now known to be the seeds of a plant," and is "abundant in the Kidderminster beds." In another note to the same edition the same view is given, and a specimen is figured from the collection of Lord Kinnaird, showing a peduncle apparently attached to the mass.

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[1] 'Nature,' April 10th, 1890.

[2] 'Cheek's Edinburgh Journal.'

[3] Miller, "Testimony of the Rocks."

In the sixth edition of "The Elements" Lyell figures two specimens, one of them lying in a mass of the *Zostera*-like leaves described by Fleming and Miller. He compares them with the eggs of *Natica*, and also with dried-up eggs of frogs, as observed by Mantell, but inclines to the view that they may have been ova of some species of *Pterygotus*, and states that they seem to have constituted "a single layer of ova enclosed in a sack." Mr. Powrie is referred to as holding this opinion. In "The Students' Manual," 4th edition, revised by Duncan, the same views are stated. Lyell distinguishes from *Parka* certain larger round discs, found separately and in small clusters, without any envelope, and in a letter from Mr. Powrie, kindly communicated to me, that gentleman refers to these as different from *Parka*, and also from the globular smooth objects described as *Pachytheca* by Hooker and referred to in my former note. Mr. Powrie has described the beds in Forfarshire holding these specimens, in two excellent papers in the 'Journal of the Geological Society of London,'[1] and in the latter of these he states his views as to the probable nature of *Parka*, more especially referring to the fact that numerous remains of *Pterygotus* and other crustaceans occur in the beds. It is to be observed, however, that in some of the beds vegetable remains are much more abundant than those of crustaceans.

Murchison notices the Forfarshire beds holding *Parka*, in Siluria (239 and 250 *et seq.*), referring them to the base of the Devonian, agreeing in this with Mr. Powrie in the papers above referred to. The characteristic fossiliferous beds are those known as the Arbroath flagstones. As shown in "The Geological Map of Scotland," the outcrop of these Lower Devonian beds extends in an oblique band through Forfarshire and Perthshire, and it is from this belt that most of the specimens referred to in the following pages were collected.

Page, in his "Advanced Text-book,"[2] notices *Parka*, and endeavours to solve the difficulty by figuring three specimens as respectively "vegetable," "molluscan spawn," and "crustacean spawn." The first figure represents a small specimen with remains of an indusium. The second is a larger specimen destitute of any covering. The third is a group of a few larger rounded bodies with central dot, and probably different from *Parka decipiens*, or at least from the ordinary type. He adds that he is inclined to regard many of the very numerous specimens he has studied as vegetable, but others may have been the spawn of mollusca or more probably of crustacea.

In Geikie's "Text-book of Geology" these objects are referred to as "clusters of crustacean egg-packets." A similar view is adopted by Woodward in his memoirs on *Merostomata* in the publications of the Palæontographical Society.

As stated above, the credit of directing renewed attention to these fossils belongs primarily to Mr. Reid of Allan House, Blairgowrie, and to Mr. Graham of Rescobie,[3] both of whom have collected large suites of specimens, and both were strongly impressed with their vegetable nature and with their possible affinities with rhizocarpean forms of vegetation similar to those which I had described in "The Geological History of Plants," from Ohio and from Brazil. To Mr. Reid I am indebted for placing at my disposal his large collections, and for many valuable notes as to localities, mode of occurrence and probable nature of the fossils, and to Mr. Graham for similar notes and for specimens sent through Mr. Reid.

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[1] Vol. xvii, pp. 534 *et seq.*: vol. xx, pp. 413 *et seq.*

[2] 1856, page 127.

[3] Mr. Reid in his letters also refers to Mr. MacNair as having assisted in working out stratigraphical details.

The specimens sent to me by Mr. Reid are from various parts of the Devonian belt of Perth and Forfar, ranging from Callander in the south-west to Rescobie in the north-east as well as some slabs from the Caithness flags, which Murchison regarded as of the same age with the Arbroath flags. All the specimens hold fossil plants of similar kinds; but so far as *Parka* is concerned the most important are from Myreton quarries, near Dundee and from Rescobie; the latter I believe from the collections of Mr. W. Graham of that place.

The specimens from Myreton quarries are in part gray flags containing carbonized plants; in part dark gray, hard, arenaceous shale, with flattened rugose stems, one as much as four inches in diameter, branchlets of *Psilophyton*, linear leaves and patches of *Parka*. These last are carbonized and often well preserved. They have afforded the best specimens for microscopic examination.

The specimens from Rescobie are gray and sometimes micaceous flaggy sandstone, similar to the last, with fragments of plants and patches of *Parka*, the whole flattened and carbonized or replaced by red oxide of iron. The plant remains consist of thick rugose stems, sometimes branching, and elongated leaves (*Cordaites augustifolia*), and fragments of *Psilophyton*.

Some specimens from Blairgowrie, consisting of similar gray flaggy sandstones, contain many fragments of plants, also certain seed-like and fruit-like bodies, one of which has the markings of *Parka*.

The only animal remains detected in the collection were a few fragments which may have belonged to large Merostomatous crustaceans or to placoganoid fishes. Some of these present an irregular or scaly reticulation, which might at first sight be confounded with *Parka*, but is readily distinguished on closer inspection.

The specimens of *Parka decipiens* are scattered over the surfaces of the slabs and intermixed with and sometimes apparently attached to the fragments of plants, especially the branches of the rugose stems above referred to. They are of various sizes, from half an inch to nearly two inches in diameter, and either rounded or of reniform or irregular shapes. They consist of aggregations of flattened circular or hexagonal bodies, all nearly of the same size, so that the smaller patches contain few granules and the larger a greater number. In many cases there are evident remains of a membranous indusium or covering, and several are so situated at the ends of stems as to appear to be connected with them. The covering was either originally incomplete or liable to open by dehiscence or decay, and in some cases it has disappeared altogether. In the carbonaceous specimens from Myreton the individual circular granules can be easily separated from the stone as thin pellicles of carbon, and can be mounted for microscopic study, though they are perfectly opaque. The appearance of hexagonal meshes would seem to be produced either by mutual pressure in flattening or by the compression between them of some soft substance filling their interstices. They were probably originally globular, but must have been soft and compressible, and probably only in one layer, and not in a globular mass or berry-like form. The apparent indusium may either have been a sac-like covering or a frond to which a layer of globules was attached. The greater part of the flattened discs are, to the naked eye, perfectly smooth; but a few show slight prominences or pustules, which may indicate small and dense globules enclosed in the individual disc or granule.

With reference to the disputed question as to the nature of these bodies, it is evident

that they may either have been ova or spawn of some animal deposited in patches on fronds or stems of aquatic plants, and with or without an investing sac, or they may have been groups of sporocarps, covered or partially covered with an indusium, and borne on somewhat thick, fleshy stems.

In the former case they could not have been deposited in sand, like the eggs of *Natica*, or in masses like the spawn of frogs ; but they may have been the ova either of gastropod mollusks or of crustaceans depositing their eggs in flat patches on vegetable or other bodies in water. The variable size and form of the patches may be regarded as so far corresponding with this view of their origin.

If of vegetable origin they would probably be the sporocarps of some cryptogamous plant of aquatic habitat rather than seeds of phaenogamous plants. On this supposition the various forms and sizes might be explained by supposing different species or varieties or accidental differences of preservation.

It was evident that these questions could be best settled by microscopic examination, which I could not learn had been undertaken, except by Mr. Powrie, who states in a letter communicated to me that he has examined specimens microscopically without any result. None of the specimens on the flags seemed in a condition to afford structure, but those on the shales from Myreton seemed more promising. Having removed some of the flat pellicles of these specimens, I found that, though extremely thin, they were perfectly opaque, and by attempting to rub them down I merely succeeded in finding that they consisted of three extremely thin layers, the two outer black and carbonaceous, the inner amber-coloured and translucent. As opaque objects, however, the best specimens showed a *hexagonal cellular areolation*, and on comparing this with the surface of sporocarps of *Protosalvinia* from Ohio and Brazil, I found the structures perfectly similar. This was so far an indication of vegetable affinity, as I know of no crustacean or molluscan ova showing such cellular areolation. Finally, having removed a few of the discs from the matrix, these were boiled for some time in nitric acid, by which the outer coat was in part removed, and the interior was softened and caused to swell. In this condition, when broken up and examined in water, the middle layer resolved itself into what seemed to be a mass of microspores, which were easily separated, though some of them seemed inclined to adhere in stellar groups, or, as Prof. Penhallow subsequently made out, to be connected with groups of thin-walled cells. These microspores are of a delicate yellow colour, thin-walled, and in some cases showing a triangular mark similar to that on spores of *Isoetes*, etc. These results seemed sufficiently to settle the vegetable nature of *Parka* and its probable relation to the sporocarps of *Protosalvinia* of the Erian of America.

At this stage of the investigation I thought it well to call in the technical skill and experience of my friend, Prof. Penhallow, that I might have his independent judgment in the matter. Prof. Penhallow was so kind as to submit the specimens to careful microscopical examination, and has furnished me with the results so fully and clearly detailed in the second part of this paper,

Two questions still remain. Are all the organisms referred to *Parka* of the same nature ; and to which, if any, of the plants associated with it does it belong ?

As to the first question, the specimens experimented upon were of the ordinary form, in a hexagonal areolation, and constitute patches enclosed wholly or partially in an indusium. They are perfectly similar to all the numerous specimens in the Rescobie and

Myreton collections. They differ, however, entirely in structure from *Pachytheca*, which is found in the same beds, but retaining its rotundity of form (while *Parka* is flattened), and showing no cellular areolation. Nor is there anything to connect *Parka* with certain rounded and ovate vesicles of larger size found detached in the same beds, and which have been noticed by Mr. Powrie and Mr. Reid. These are not improbably vegetable, and possibly sporocarps or indusia, but I have not found them to show any structure.

With reference to the second question, we cannot connect these bodies with *Psilophyton*, whose fructification is well known, and the only other plants on the slabs are the rugose stems above referred to and the narrow *Zostera*-like leaves which would seem to have constituted their foliage. These plants occur both in the Rescobie and Myreton specimens on the same slabs with *Parka*. In carefully examining the slabs I find a number of masses of *Parka* placed at the extremities of branches or fragments of branches of these rugose stems. This apposition may be accidental, but it occurs so frequently as to give some probability that it indicates an organic connection.

Putting the parts together in accordance with these facts, we may suppose *Parka decipiens* to be the fruit of an aquatic plant having strong rugose but not woody stems or rhozomes, producing numerous branches, those which were fertile, and perhaps nearer the base, supporting clusters of *Parka*, those which were barren producing long grass-like floating leaves like those of *Zostera*. The affinities of such a plant would be with modern rhizocarps, though a peculiar and exaggerated form.

In the meantime *Parka decipiens* may be accepted as an addition to the vastly profuse rhizocarpean flora, which we know from American examples to have been present in the waters of the Devonian period, as the author has shown in previous publications.[1] It seems possible that the plant formerly described by the author as *Cordaites augustifolia*,[2] from the Erian of Gaspé may be allied to *Parka*, though only its leaves and stems are known. Many rugose stems similar to the Scottish specimens have been noticed in both the Lower and Upper Erian of Gaspé and the Baie des Chaleurs, and in both localities patches of compressed vesicles larger than those of *Parka*, and in dense, closely packed masses, have been found associated with these; and at Gaspé I found, in 1868, a group of vesicles similar to the Scottish specimens, but smaller. It is, therefore, probable that forms of this kind existed on both sides of the Atlantic in the early Devonian.

It is further to be observed that as we know the sporocarps of *Protosalvinia* of Ohio and of Brazil only as detached individuals, we cannot be certain that these may not originally have been attached together in groups like *Parka*, and we do not yet know with certainty the nature of their vegetative organs. In the meantime the facts above stated should serve to guide investigation with respect to these interesting plants on both sides of the Atlantic.

It is proper to state that these new developments add to the evidence to which I have referred in my papers on *Protosalvinia*,[3] and in "The Geological History of Plants,"[4] in favour of the great development of the rhizocarpean type in Palæozoic times. The enormous quantities of sporocarps and macrospores in the Upper Erian shales of Ohio and

[1] "Geological History of Plants," p. 48 *et seq.*; 'Transactions Chicago Academy,' vol. i, No. 9, 1886.

[2] I do not now regard the Gaspé plant as of this species.

[3] 'Canadian Record of Science,' 1883; 'Bul. Chicago Academy,' 1886, p. 105.

[4] 1888, London and New York.

Western Canada testify to this in the later Devonian of America, and the Lower Devonian *Parka* affords similar evidence. There is, as I have elsewhere maintained, the best reason to believe that organisms of this kind were also very important in the Carboniferous period, and that many of the sporocarps and macrospores found in the shales, cannels and bituminous coals will prove to be rhizocarpean. In this connection I may also refer to such organisms as *Sporocystis* and *Lepidocystis* of Lesquereux, from the coal-formation of Pennsylvania, and which, on the evidence of specimens kindly sent to me by Mr. Lacoe of Pittston, Pa., I am inclined to regard as near allies of *Parka*.

The probable relation of *Parka* with the obscure rugose stems, *Zostera*-like leaves, etc., associated with it in Scotland, also serves to afford at least a conjectural explanation of the quantities of vegetable *débris* of this kind found in the Erian in Europe and America, and also in some still older formations, and which have variously been referred to *Algæ*, stipes of ferns, fragments of Lycopodaceous plants, etc. *Parka* and *Protosalvinia* also come into connection with *Psilophyton*, *Ptilophyton*, *Arthrostigma* and other plants of the Erian, which have been regarded as intermediate between *Rhizocarps* and *Lycopods*.

All these facts place us in presence of a vast development of rhizocarpean forms as forerunners of the abundant and gigantic lycopodiaceous plants and ferns of the latter Palæozoic, and show that these humble aquatic plants once played a much more important part in nature than one could have inferred from their degraded position in modern times.

It is due to that gifted observer, the late Sir W. E. Logan, to recall the fact that his recognition in 1863 of the occurrence of shales filled with "microscopic orbicular bodies" in the Upper Erian of Kettle Point, Lake Huron, described by me, in 1871, as *Sporangites Huronensis*, was the first intimation given to the world of the vast deposits of this kind in the Erian of interior America. Another sagacious and acute observer, the late Dr. Fleming, discovered and described *Parka decipiens* in the Devonian of Scotland, and suggested its vegetable nature, as far back as 1831; while Miller in later years followed up the research and kept these obscure fossils before men's minds as probably aquatic plants. In geology it is the men who note and record small and apparently obscure facts who often open the door to wide and important generalizations. Fleming I knew as an aged man when I was a student. Logan and Miller were friends in later years. It is a pleasure to be able to continue and extend their work.

Parka decipiens. Notes on specimens of collections, etc.—(Continued.)

Part II.—Microscopical and Botanical Results.

(With Plate I)

By D. P. Penhallow, B.Sc.

Early in the winter of 1890-91, Sir William Dawson placed in my hands certain specimens of *Parka decipiens*, with the request that I should make a microscopical examintion of it. The material was originally obtained from Mr. James Reid of Blairgowrie, Scotland, and consisted of gray and micaceous sandstone bearing impressions of *Parka*, together with a number of the *Parka* discs which had been boiled out in nitric acid. After careful examination and comparison, the conclusion was reached that *Parka* was an aquatic rhizocarp, probably allied to *Pilularia*. Since then a large amount of correspondence on the subject has passed between Mr. Reid, Mr. Graham and Sir William Dawson, and we have also received from the first named gentleman a large amount of fresh material, together with the results of more recent observations made at the various localities where *Parka* is found in abundance. Some of this additional material throws light upon hitherto obscure points, while many of the suggestions offered by Mr. Reid and Mr. Graham are of considerable importance as bearing upon the views entertained by Sir William Dawson and myself.

In consideration of these facts, it has seemed desirable to carefully review the whole subject from the double standpoint of the data furnished by the two gentlemen referred to and the evidence of the specimens as brought under my own inspection. It seems the more important to do this since the question of the animal origin of these fossils, raised some years since, has not, up to the present time, been wholly disposed of.

The origin of the specimens, their geology and history have been fully considered by Sir William Dawson in the preceding pages, and it therefore devolves upon me to consider them botanically, upon the basis of microscopical examination of the various parts.

Preliminary to such an enquiry, it has been found desirable to classify the material in a general way, without reference to locality. All the specimens so far examined thus naturally fall into the following groups:

1. Rugose stems, in which the organic matter has been wholly replaced by red oxide of iron. Many fragments of these show little in detail, though all agree in general characteristics. The most perfect is 36 cm. long, 45 cm. wide at the lower end and 3 cm. broad at the upper end. Three branches, alternate and opposite (?), are distant from one a tuft

another about 11 cm., and are for the most part 1 to 2 cm. broad. No superficial structure is apparent. The plant represented by this fossil was evidently not highly vascular, and readily compressible.

2. Rugose stems represented by a specimen about 16 cm. long, 4 mm. in diameter, and showing leaves apparently attached, 2 mm. broad.

3. Fragments of linear leaves (*Cordaites augustifolia?*). These are 1 cm. broad, and show somewhat rounding terminations. Carbonaceous residue is somewhat conspicuous.

4. Linear leaves or branches. These are usually represented by mere impressions, and measure from 1 to 3 mm. in width, the average width being 2 mm. They usually show no structure, but in a few cases fine, parallel lines like the nerves of a linear leaf are to be seen.

5. Oval impressions showing distinct reticulations. Three such impressions have been observed. The most perfect is an oval body 13 × 20 mm. and devoid of *Parka* discs, but showing a reticulated and somewhat radiating structure, evidently composed of elongated parenchymatous cells. The form of this specimen appears to be quite complete. The second impression is that of a body similar in size, form and structural markings, but only one-half is in view. The third is of the same nature, but the structural markings are more obscure.

6. Discoid impressions of bodies represented by a somewhat carbonaceous residue, but showing no structure. Apparently solid, spore-like spheres flattened by pressure. Three such discs have been observed, one measuring 6 mm. broad, and the other two 5 mm. each.

7. Various fragments of *Parka* of different dimensions and various degrees of perfection. These all show the characteristic discs or hexagonal markings, which are sometimes carbonized, so that they may be separated. They are more generally mere impressions. For convenience they may be separated, according to variations in size, into groups A, B and C.

Group A.—Bodies of usually regular outline, and oval or round, with distinct discoid markings. They measure from 6 to 11 mm. in breadth. These are associated with stems, to which they sometimes appear united.

Group B.—Oval bodies with *Parka* markings distinct, and not in any way connected with stems. The outline is generally perfect. They measure about 13 × 20 mm.

Group C.—A large oval body of ferruginous character, with fairly well preserved outline and impressions of *Parka* discs. It measures 3·5 cm. by 5·3 cm.

Numerous fragments showing well-defined *Parka* discs occur, and, from their size, appear to be parts of bodies of the above dimensions. To properly understand the relations of these various bodies a detailed consideration of each is essential.

The Rugose Stems, 1 and 2.—Of the rugose stems only two fairly perfect specimens have been brought under my notice; the one relatively large, and the other relatively small. All the other stem specimens are mere fragments which exhibit no special details. The larger stem is completely flattened, and all the organic matter has been replaced by red oxide of iron. One end—the inferior—is distinctly broader than the other—the superior—the diameter of each being 4·5 cm. and 3 cm. respectively. Three branches, as

represented by their short stumps, are given off at intervals of about 11 cm. Apparently they are alternate and opposite in arrangement, but this may be the result of displacement. The union of these branches with the main axis is not abrupt—*i.e.*, at right angles—but the separation is gradual, as we find in the lateral members of many aquatic plants having horizontal stems, thus suggesting possible similarity of organisms. And if this idea were extended, it would be quite possible to show a somewhat well defined general resemblance to such horizontal stems as are found in *Marsilia* and *Pilularia*.

No leaves *in situ* have been found, and it is therefore impossible to decide, except so far as the very limited value of association may afford testimony, as to the character of the foliage produced by this stem. A careful search has also failed to disclose any attachments having the nature of inflorescence or fruit.

That the stem was not highly vascular would seem to be indicated by the extreme compression which it has suffered, and, so far as it goes in connection with what has already been stated, this might also be taken as evidence of the possibly aquatic character of the plant. In a recent communication from Mr. Reid he expresses a similar view.

Fragments of Leaves, Nos. 3 and 4.—Associated with the large stems are portions of linear leaves. They are generally about 4 to 6 cm. long, and have a uniform width of 1 cm. They show one end broken off, and the other somewhat rounded. The carbonaceous substance is sometimes conspicuous, sometimes replaced by red oxide of iron. No superficial markings are to be seen. These remains are referred to in the present paper by Sir William Dawson as *Cordaites augustifolia*, from their general resemblance to the leaves of that plant, but without any intention of establishing identity between the two. There is no direct evidence to show what these leaves were derived from.

The greater number of the specimens examined show impressions or carbonaceous remains of long, linear bodies, either slender stems or narrow leaves. They vary in width from 1 to 3 mm., but show a general tendency towards an average width of 2 mm. As a rule no structure is apparent, though in a few cases fine parallel markings have been observed, suggesting similarity to the nerves of a linear leaf. No terminations of these organs have been found, though in the smaller stem—No. 2—the two lateral members appear to be the same as these organs. It would, therefore, seem highly probable that these remains represent linear leaves belonging to horizontal stems of the dimensions and character of the smaller stems already described.

The larger leaves (*Cordaites*) cannot be definitely connected with any stem, but the constancy of their association with the large rugose stems, with which the narrower leaves do not appear to be found, and their close similarity to the latter, would seem to suggest that they are in reality the foliage of those stems. In this connection it may also be well to point out the fact that in his visits to the quarries where *Parka* is found, Mr. Graham "got bits of riband-leaves, narrow stalks and associated *Parka*, the latter in comparative abundance, and *nothing else*."

As pointed out by Sir William Dawson, remains of *Psilophyton* are very numerous in connection with *Parka*, being represented both by stems and fragments of leaves. It is, therefore, quite possible that some of the narrow leaves referred to above as belonging to *Parka* may in reality belong to *Psilophyton*, though I think it hardly probable. On the other hand, one specimen from Caithness, Scotland, received from Mr. Reid, shows a tuft

of long narrow leaves apparently attached to a creeping stem. The whole tuft is 16 cm. long, 6 cm. broad at the upper extremity, and 5 cm. broad at the lower end, where all the leaves appear to be attached to a horizontal stem about 1 cm. in diameter. This part of the specimen is rather obscure, however, and too much importance must not be attached to it. The leaves in width and other characteristics closely approach those of the narrower form described above.

Oval Bodies, No. 5.—Three impressions—one tolerably complete and the other two fragmentary—have been found, showing oval bodies with a reticulated and radiating structure. They show no trace of organic matter, and are as a rule devoid of *Parka* discs. In the complete form they measure 13 × 20 mm., and show evidence of a cellular structure, which is distinctly radiating and composed of elongated cells. The general structure is similar to that observed in the sporangia of rhizocarps. In one case impressions of *Parka* discs were found near the edge and clearly *within* the limits of the body. This may, of course, be a purely accidental association. In the same case a discoid body, 5 mm. in diameter (Plate I, fig. 6), but devoid of structural markings, was found near the margin, and in all three specimens *Parka* discs were found scattered through the matrix in various directions.

In the case of the most perfect one there were also associated with it in close proximity two oval bodies; one (fig. 3) containing eleven *Parka* discs, and the other and smaller five discs.

The impression gained by the size, form and structure of these bodies is that they probably represent the entire (or portions of) sporocarps in which the *Parka* discs were contained, a view which gains a certain measure of support from the peculiar association of these bodies with one another.

Discoid Bodies, No 6.—In three instances I observed round discoid bodies having a diameter of 6 mm. in one case and of 5 mm. in each of the others. These objects are more or less carbonized, but less so than many of the *Parka* discs. They are usually of well-preserved outline, somewhat more strongly elevated at the centre, as if there were a harder body enclosed, which more fully resisted the action of pressure. They show no structural markings. (Plate I, fig. 6.) The concentric lines shown in the figure are probably the result of compression. These bodies are so distinctly different from anything else found in the material under consideration, that it is not possible at present to establish their connection. It might be urged that they are young sporocarps of the same nature as those so commonly found in *Parka*, but if we grant this view we must admit a remarkable uniformity in the state of development of all that have so far been found. On the other hand, they are most certainly not isolated *Parka* discs, from which they are conspicuously different both in form and size. These bodies have been noted by both Mr. Powrie and Mr. Reid. The only other fossils with which they are more or less comparable is *Pachytheca*, which occurs in the same beds, but the differences are such that it seems hardly possible to connect the two.

I should, therefore, be inclined for the present to regard them as sporangia representing a fruit similar to that which occurs in *Psilotum*, and I find that in his most recent communication to Sir William Dawson Mr. Reid also advances the same idea.

PARKA DECIPIENS, No. 7.—The structures about which the interest of this present inquiry primarily centres, and those to which the name of *Parka decipiens* was in the first instance assigned, are represented by rounded or oval discs in various states of preservation and variously aggregated. Frequently these discs consist of carbonaceous bodies, which may be separated from the matrix and which show definite structure. At other times they appear as mere impressions, the mass showing hexagonal depressions as produced by the closely aggregated bodies originally present.

These discs are in a few cases scattered separately through the matrix, but they are more commonly aggregated in oval masses of variable size, the whole sometimes presenting evidence of having had a special covering. A comparison of these masses shows that there are differences in point of size, which render it desirable to consider them as falling in three distinct groups.

Group A.—The masses included in this group are usually of more or less regular outline, oval in form and with regular discoid markings. They measure 6 to 11 mm. in diameter. There are also similar bodies containing *Parka* discs, but somewhat smaller, measuring 5 mm. in diameter. One of these is shown in fig. 3, from which it appears obvious, as shown by the imperfectly rounded and massed *Parka* discs, that they are imperfectly developed forms of the larger but otherwise similar bodies.

Group B.—In this group may be included similar oval bodies bearing an abundance of *Parka* discs, usually of regular and well-defined outline, and measuring about 13 × 20 mm. They are, therefore, decidedly larger than the preceding. These show occasional evidence of an outer covering, but in no case have I seen a stem to which they are terminal. They are associated with the bodies of the Group A, and therefore with the same leaves and stems. The discs in these masses are usually carbonized, though they are frequently represented by mere impressions.

These bodies are common, and are found associated with the small stems, with the narrow linear leaves, and with the empty sporocraps already described. In two cases there was an apparent stem. (Plate I, fig. 5.) Whether this relation is accidental or normal cannot be fully determined from our specimens. Also, as shown in the same figure, there is very strong evidence that an outer covering has been removed by pressure from the main body, thus allowing the escape of all but five of the enclosed bodies, of which only mere impressions can be seen.

Group C.—This embraces nearly complete oval bodies of large dimensions and fragments of masses evidently of the same or nearly the same size. They are all obviously larger than those included in the preceding group. Taking the most complete specimen as a representative, they are found to measure 3·5 × 5·3 cm. They are associated with the large rugose stems, and, like them, the carbonaceous matter is wholly replaced by red oxide of iron in the more complete specimens. The fragments show carbonized *Parka* discs or else mere impressions. Plate I, fig. 4, shows a portion of a characteristic mass with carbonized discs. Associated with these larger masses are the broad linear leaves (*Cordaites*), and also to some extent the narrow leaves.

From the foregoing comparisons it would appear that we have to deal with bodies of a similar nature structurally, but differing materially in point of size. It might be suggested that such variation represents different conditions of maturity, but a little

reflection will show that such a view can hardly be entertained, and for the following reasons:

1st. In all of the masses, except the smallest and obviously immature ones, the *Parka* discs are well rounded and distinct, showing evident maturity.

2nd. While in any individual mass there is a certain amount of variation in the contained discs, there is constancy of dimension as between the discs of the various masses.

3rd. The difference in size shown to exist between these masses is not a graduated one, but, as is evident from the dimensions given, is a clearly defined one, by reason of which three separate groups are recognizable. This was, in fact, recognized by Mr. Reid, who pointed out in one of his communications the presence of bodies of two dimensions at least, while Mr. Graham suggests that such a plant might have occurred in a number of forms.

It would thus seem clear that in these masses and oval bodies we must recognize sporocarps containing globular sporangia (*Parka* discs). As to the insertion of these sporangia on the main axis, a question is raised here which it is not at all easy to decide. Two at least of our specimens show a stalk to which the sporocarps are terminal, but the relation is not altogether such as to establish the connection beyond reasonable doubt. Mr. Reid adopts the view of a distinct stalk, and makes his restoration of the plant accordingly. This view is justified by comparison with *Marsilia*, but is not justified by comparison with *Pilularia*, though there is no good reason for rejecting the view that an ancient *Pilularia* may have had stalked sporocarps. On the other hand, it must be kept in mind that these bodies appear, for the most part, quite independent of stems of any kind, and even when such association does occur, as pointed out by Mr. Graham, the masses are generally lateral to and sessile upon the stems. The weight of evidence would thus seem to point to the fact that these sporocarps are sessile upon horizontal stems, such as are represented by the associated structures, and in this respect the plant must be regarded as having affinities with *Pilularia*.

This brings us to a consideration of the character and structure of the discs as sporangia. As already shown, only a few of the masses show carbonized discs which can be removed. Some of these were carefully boiled out in nitric acid by Sir William Dawson, and handed to me for microscopical examination. Most of them were found to be practically unaltered by this treatment, and were totally opaque. A few, however, broke up or had their outer covering so far removed as to render the internal structure apparent. It was obvious from the outset that each disc was invested by a thick carbonaceous layer, in which no structure could be detected, except when examined as an opaque object, when, as Sir William Dawson has pointed out, a reticulation of the surface is to be observed, similar to that which characterizes the membranes of many sporocarps of modern rhizocarpian plants. Internal to this, however, the disc was observed to consist of a distinct tissue, composed of rather thin-walled cells, thus giving direct proof that they were not simple spores, but of the nature of sporangia. In one or two cases they also appeared to contain certain rounded bodies similar to spores, at least distinct from the other parts of the structure, but so involved as to leave their identity somewhat in doubt.

A careful search through the entire material disclosed numerous detached bodies of rounded or oval form, consisting of a transparent or translucent body, to which were attached the carbonized remains of what I took to be an outer and highly differentiated

cell-wall. These bodies are represented in fig. 2 b, the figures given having been taken as fair average examples of all those found. As the result of an examination of the material first submitted to me, I came to the conclusion that these bodies have an average diameter of 34·6 μ., but that sufficient allowance for the thickness of a cell-wall, as represented by the carbonaceous investment, would make their original dimensions approximate to 40 μ. Later and more extended measurements confirm this result. Comparing with modern types, I find these bodies to be a little larger than the spores of *Lycopodium* (34 μ.), much larger than the microspores of *Selaginella* (28 μ.), and small as compared with the macrospores of extinct *Protosalvania* or modern rhizocarps.

There were also found two small oval cells (fig. 2 *a*) possessing the remains of an outer cell-wall as a carbonized crust. They measured 15 μ. in diameter. No other similar bodies were found. This might be due to their more perishable nature. Both of these bodies are evidently of the nature of spores, and it would seem justifiable to regard them as macrospores and microspores, a view justified by their difference in size, state of preservation and relative number. This would therefore show that both kinds of spores were produced in the same sporocarp as in *Marsilia* and *Pilularia*.

An additional fact of very considerable importance seems to be well established by the material examined. In the slides prepared by Sir William Dawson, who specially drew my attention to them, there are found a large number of rather curious, apparently stellate bodies of complex structure. Sir William Dawson seemed inclined to regard them as remnants of spore clusters. My own impression, as I first examined them, was that they represented the walls of empty sporangia. Upon more critical examination, and after an inspection of additional material, it became evident that neither view could be maintained.

It was found that each body (fig. 1) contained a central carbonized mass, probably the remains of a more highly cutinized structure, about which were disposed cells of very variable form and size, often showing a more or less distinctly radial disposition. Careful focussing also showed that the smaller ones (*f*) were spherical, while the larger (*a*) were nearly or quite flat. An examination of all I could find showed that there was a total absence of constancy in size and structural detail; and if sporangia, this variation could only be accounted for on the ground of different degrees of development, a condition most unlikely to be found among sporangia from the same sporocarp. Their diminutive size as compared with the *Parka* discs (sporangia) would also be opposed to this.

In fig. 1, comparing the series of figures, it will be seen that from *f* to *a* there is evident a more or less gradual development. These figures were taken without special selection as examples of the many structures of this kind found, while several similar bodies much larger than *a* were also observed. The possible connection between fig. 1 *f* and fig. 2 *b* is somewhat obvious. If we regard *f* as a developing condition of *b*, and that from *f* to *a* we have different stages of growth in similar bodies, I think the relation is made clear. This would, therefore, make the bodies *a*, *b*, *c*, *d*, *e*, *f* prothalli in different stages of growth, a view which is well supported by their form and structure.

The data thus gathered seems to strongly indicate that *Parka* is an aquatic rhizocarp allied to *Pilularia*. In the earlier part of the correspondence on this subject Mr. Reid inclined to this view, but later thought there were possible affinities with *Marsilia*. I think we may consider, however, that the narrow leaves, the sessile fruit and the composition of the sporocarps make the relation much nearer the former than the latter.

But, as shown by the specimens, there are undoubtedly three forms to be distinguished. As some means of separating them seems desirable, I would suggest that they be referred to one species and two varieties, the latter being converted into species, if found desirable, on the basis of future examinations of such new material as may be available. The larger forms with the rugose stems and large oval fruit would properly constitute the type *Parka decipiens*, Flem. The fruits of the second dimension are the representatives of the first varietal form *α media*, and the smaller fruits and stems, together with the narrow linear leaves, would be *β minor*.

The systematic description of these plants as thus developed might be stated as follows :

GENUS PARKA. Flem.

Aquatic plants with creeping stems, linear leaves, and sessile sporocarps bearing two kinds of sporangia. Sporangia, 2 mm. in diameter ; macrospores, 40 μ; microspores, 15 μ.

These fossils occur in micaceous, slaty or sandy shales. Their most characteristic appearance is that of oval bodies or fragmentary masses showing rounded discs or impressions of such. They are sometimes carbonized, often ferruginous. From the Lower Devonian of Myreton, Rescobie, Blairgowrie, Thurso and Caithness, Scotland. (Reid and Graham)

PARKA DECIPIENS, Flem.—Stems rugose, about 4 cm. in diameter, showing stumps of branches about 11 cm. distant. Leaves linear, 1 cm. broad, with somewhat rounded terminations. Sporocarps oval, 3·5 × 5·5 cm., bearing more or less conspicuous impressions of the contained sporangia.

The sporocarps are sometimes complete, though generally found in fragments, either carbonized or ferruginous.

α media, n. var. Sporocarps oval, nearly entire, 13 × 20 mm. broad. Impressions of sporangia distinct, usually carbonized.

This variety shows no conspicuous leaves or stems.

β minor, n. var. Stems 4 mm. broad. Leaves linear, 1·5 to 2 mm. broad, sometimes finely veined. Sporocarps oval, 6 to 11 mm. broad. Impressions of the sporangia distinct, often carbonized.

EXPLANATION OF PLATE I.

Fig. 1.—Prothalli in various stages of growth. *a* The most complete form, flat and thalloid. *f* In an early stage of growth from the spore and spherical. × 300.

2*a*.—Microspores showing the cell-wall carbonized. × 300.

2*b*.—Macrospores showing the cell-wall carbonized. × 300.

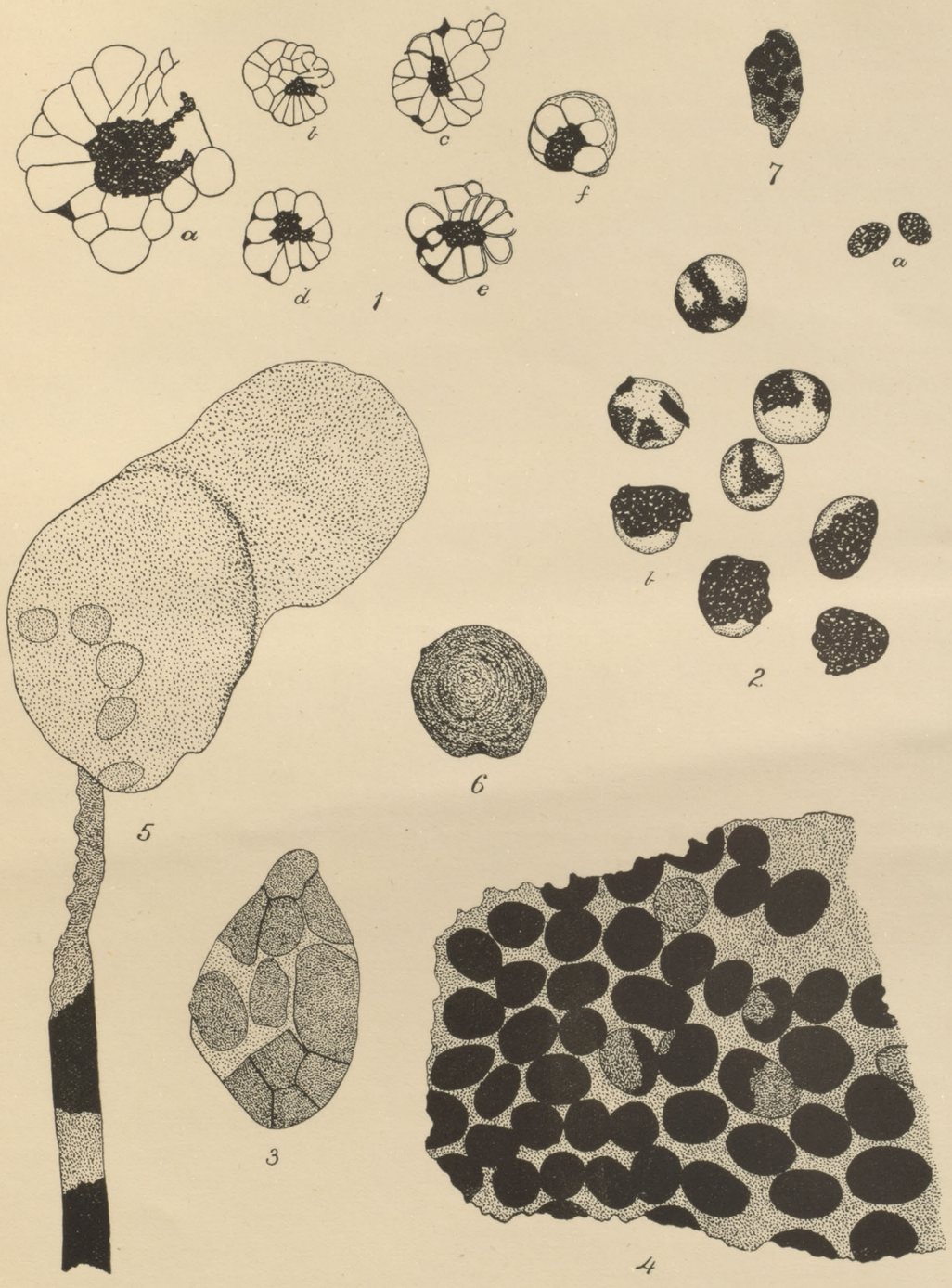
3.—Sporocarp showing the contained sporangia in an undeveloped state. × 4·2.

4.—Portion of a large sporocarp of *Parka decipiens*, showing the characteristic form and aggregation of the sporangia × 5·3.

5.—Sporocarp of variety *α media*, showing the outer membrane crushed off at the top, and five sporangia in the depleted cavity. × 4·2.

6.—Discoid body resembling the fruit of *Psilotum*. × 4.

7.—*Parka decipiens*, Flem., var. *β minor*, Pen. Natural size.



To illustrate Prof. Penhallow's Paper on Parka decipiens.