XVII. *Contributions towards the History of Zamia Gigas, Lindl. & Hutt.** By W. C. WILLIAMSON, F.R.S., Professor of Natural History in Owens College. Communicated by WILLIAM CARRUTHERS, Esq., F.L.S.

Read June 4th, 1868.

(Plates LII. & LIII.)

THE rich geological district known as the "Yorkshire Coast" has furnished no more interesting subject for investigation than the *Zamia Gigas*, Lindl. & Hutt. The frond of this plant was first figured in Young and Bird's 'Geological Survey of the Yorkshire Coast' (tab. 2. fig. 6). In Prof. Phillips's 'Geology of the Yorkshire Coast' a few leaflets were given under the name of *Cycadites gramineus* (tab. 10. fig. 2). It was afterwards figured, from one of my drawings, in Lindley and Hutton's 'Fossil Flora' (tab. 165), under the name of *Zamia Gigas*, and I learn from M. Adolphe Brongniart that this represents *Zamia Mantelli* of his 'Prodrome' (p. 199).

In Young and Bird's work some curious fossils are represented whose nature was wholly unknown to the authors; but they suggested that they might be related to the frond already referred to. This suggestion was based upon the fact that the two fossils were found in the same stratum, and not upon a study of their structure; nevertheless it is probably correct.

In 1832 my father drew my attention to some fine specimens of these anomalous objects, which he had just discovered at Hawsker. In 1833 I accompanied him to this locality and succeeded in obtaining additional illustrative specimens, so that, in a memoir presented to the Geological Society of London in May 1834, I ventured to suggest that these organisms were "apparently connected with the fructification of a *Cycas*" (Geol. Trans. 2nd series, vol. v. p. 230). Nothing further was published respecting them, except an imperfect example figured in Mantell's 'Medals of Creation,' until 1847, when two brief notices appeared in the 'Proceedings of the Philosophical Society of Yorkshire,'—one by James Yates, Esq., F.R.S., who has laboured diligently in accumulating specimens illustrative of these Cycads, and the other by myself. In the latter communication several points were specified which further inquiry has confirmed; some others were advanced hypothetically, which I have since found to be either wholly erroneous or to require considerable modification.

More recently I have examined additional specimens in the collections of the Yorkshire Philosophical Society, of the late Dr. Murray and Mr. Bean of Scarborough, and Mr. Ripley of Whitby. Through the latter gentleman I received two invaluable specimens belonging to the Philosophical Society of Whitby, the Council of which Society not only allowed me the use of them, but, with praiseworthy liberality, permitted me to exercise

* I have employed, throughout, the name given by Lindley and Hutton, although Mr. Carruthers has, in a memoir published with this, established for this and the allied species a distinct genus, with which he has done me the honour of associating my name.

my chisel upon them for the purpose of making out some obscure points in their structure, a permission which led to important results. From the specimens thus brought under examination, I have selected the most important; and after describing these individually, I will endeavour, so far as the materials admit, to restore the entire plant. But in attempting this I would carefully distinguish between unquestionable facts and dubious inferences. The facts to which I wish to call attention are reliable. How far my interpretation of them may prove correct remains to be seen.

Amongst the broken débris which falls from the cliffs of Hawsker and Runswick are numerous masses of hard ferruginous sandstone belonging to the "Lower Sandstone and Shale" of Phillips. These masses appear to fall from a stratum about 20 feet thick, which is only separated from the Inferior Oolite by a few feet of carbonaceous shale. The ferruginous blocks furnish the specimens under consideration, associated with Cycadean fronds, fragments of coniferous wood, some ferns, and occasionally an undescribed jointed stem, having the outward aspect of a Calamite; of these, the Cycadean fronds are by much the most abundant; this naturally attracted my attention when endeavouring to discover the complementary parts of the anomalous fossils. To suppose that the latter belonged to a plant of which no other traces had been preserved, was an improbable idea, negatived by their comparative abundance and the small amount of mutilation they had undergone. Such traces could be found only amongst the vegetable remains of the same rocks; of these I have already enumerated the chief. With the ferns they could have no relationship, and with the jointed stem they appeared to have as little. Nothing remained, therefore, but to seek for the missing portions either amongst the coniferous fragments or amongst the Cycadean fronds. All circumstances pointed to the latter as the foliage; but a stem was wanted on which to reunite the detached parts. In 1834 I found, on a huge block of sandstone at Hawsker, the cast of a stem between 1 and 2 feet long and nearly 4 inches in diameter. Its surface was covered with scars resembling those of a Cycad. It had evidently been moulded upon the bark of a tall arborescent plant. The rock was too large for removal, and being unprovided with materials for taking a cast, I could only take a hasty sketch of the specimen and leave it to its fate. Some years afterwards I found in my cabinet a specimen of the sandstone containing a large mass of mingled carbonaceous matter and Scarbroite, and on removing these I found that it had been part of a stem similar to that of which I had so often deplored the loss. Its outer surface exhibited, with great clearness, the rhomboidal scars already referred to, and which closely resembled those of many living Cycadean stems. Having thus obtained two examples of these stems (of which, I may add, Mr. Carruthers informs me he found a third example in the Cambridge Museum), I deemed it probable that they had belonged to the same plant as the Cycadean fronds. On forwarding my specimen to M. Adolphe Brongniart, he replied, "L'empreinte contenue dans cet échantillon me paraît une tige, ou plutôt l'impression d'une petite portion de l'écorce de la tige d'un *Zamia Gigas*. C'est une faite de plus pour compléter l'histoire de cette plante si problématique." This confirmatory opinion, I need scarcely say, left me little room for doubting the correctness of my previous conclusions. From this brief sketch of the history of the subject, I may proceed to describe the specimens.

The Stem.—The exterior exhibited numerous rhomboidal cicatrices left by the fallen fronds. The drawing (Plate LIII. fig. 6) represents a portion of the specimen referred to. The cavity was filled with brown pulverulent carbonaceous matter, mixed with a white aluminous substance (Scarbroite), these being the remains of the solid tissues of the stems, from which all traces of minute structure had disappeared. The surface is divided by a network of elevated ridges into a number of irregular lozenge-shaped spaces, marking the existence, in the original bark, of deep clefts or fissures, separating the base of each petiole from those of its neighbours. Within each area thus circumscribed is a raised oval or diamond-shaped cicatrix, surrounded by a deep depression. This was, of course, reversed in the original, and hence the cicatrix was really one with elevated margins and a depressed centre. On the surface of each cicatrix the cast exhibits, with a considerable degree of uniformity, a deep longitudinal fissure, as well as some oblique but less sharply defined ones towards the upper part. These represent corresponding projections in the stem; but whether they indicate the arrangement of the fibro-vascular bundles or irregularities resulting from accidental contraction, I am doubtful. There are also some other minor but less uniform rugosities on the surface of each cicatrix. In the large example at Hawsker the scars were somewhat larger and further apart than in the specimen figured; its diameter was uniform throughout, like the general habit of *Cycas circinalis* or *C. media*.

In the collection of Mr. Ripley there is a specimen which is obviously the apex of a stem with portions of seven or eight diverging fronds. As these fronds are *in situ*, we have no traces of the cicatrices seen on the lower part of the stem. Its compressed condition, also, has almost obliterated all superficial characters. It confirms, however, what has been already said respecting the elongated contour of the original stem.

Mr. Ripley's cabinet also contains a cylindrical specimen, 4 inches in length, and having a diameter of $1\frac{1}{2}$ inch at one extremity and $1\frac{1}{4}$ at the other, which represents, I believe, the interior of the vascular cylinder. Its surface is marked with numerous interrupted longitudinal grooves and ridges, from half an inch to an inch long, formed by the openings through which the vascular bundles passed to the leaves.

The Fronds.—Soon after leaving the stem the dilated base of each rachis contracts to from $\frac{1}{4}$ to $\frac{1}{3}$ inch, and at a short distance from its origin gives off the small leaflets as in most living Cycads; these rapidly increase in length until they reach from 2 to 4 inches. Each foliole is acuminate and slightly falcate; its slightly contracted base is fixed somewhat obliquely upon the upper surface of the rachis; the greatest diameter of the leaflet is a little beyond its sessile base. The latter is usually concave, and has either been planted upon an enlargement of the rachis, or has been distended with parenchyma, as is common amongst living species of *Encephalartos*. Each foliole exhibits numerous slightly divergent nervures radiating from the constricted base; of these, about two-thirds are distributed to the upper margin of each leaflet, a few reach the apex, and the remainder disappear along its inferior margin*. In this arrangement

* On this point Brongniart's description of *Zamites* does not agree with the Yorkshire specimens. He says, amongst other characteristics, that they have, "nervures parallèles entre elles et au bord de la foliole, et par conséquent convergentes vers le sommet; fines et égales entre elles, très-rarement bifurquées lorsque la foliole est élargie

they differ from *Dion edule*, and approach *Encephalartos Caffer*, to the leaflets of which latter species, as well as to those of *Encephalartos lanuginosus*, those of *Zamia Gigas* bear a close resemblance. Both Miquel and Brongniart have pointed out that the fronds exhibit a much closer affinity with the African and East-Indian forms than with the true *Zamia* of the American continent. The fronds vary in size, but have often attained a length of 3 feet.

The Peduncle.—Several examples have occurred of a stem or axis covered with large acuminate scales arranged in ascending spiral lines. One of these, in the Scarborough Museum, first satisfied me that they were the squamous peduncles which had supported the singular organisms already referred to, and which I believe to be the organs of fructification. Each peduncle appears to have been from 6 inches to a foot, or even more, in height, sometimes simple, at others branched.

A bifurcated specimen, belonging to Mr. Ripley, is about 2 inches in diameter. After ascending vertically for 7 inches, it dichotomizes, each branch being between 4 and 5 inches in length, and about $1\frac{1}{2}$ inch in diameter immediately above the divergence, but expanding to about 3 inches at its upper extremity. The scales with which it is covered are arranged in a spiral manner, a distribution still better shown in some other fragments which I have seen. Each scale is about 3 inches long, and marked with numerous linear striæ. It is very much dilated at its base, where it clasps the stem, but contracts towards its obtusely acuminate apex. Its upper portion exhibits a slight tendency to the development of a dorsal ridge or keel, but which bears no resemblance to a true midrib. At the extremity of the branch, the spiral arrangement of the scales is less obvious, giving place apparently to a more circular one at the place where the terminal organism has been attached. In this specimen many of the scales have disappeared, owing partly to their accidental fracture, leaving little more than the mass of carbonaceous matter found by their compressed bases; but at the apex, especially of one of the branches and at the point of divergence, they are more perfect.

Organs of Fructification.—The portions of *Zamia Gigas* which, next to the fronds, are most frequently met with are the organisms already referred to, consisting ordinarily of one or more circles of long lanceolate incurved scales, which, when complete, enclose and are surmounted by other appendages. In the examples commonly seen, there is nothing preserved but the whorl of scales, as in Plate LII. figs. 6 & 7. Fig. 6 is the base of a specimen in my own cabinet; the lanceolate scales spring from a central axis, rising first outwards and upwards, then curving inwards at their upper half. I would designate this part of the plant the *involucrum*, regarding the scales as bracts. The figure shows that there are frequently two or more overlapping layers of scales. This specimen is valuable because it is the only one I have seen in which the base of the organism is perfect, indicating the small size of the woody axis of the peduncle. This portion usually appears as represented in figs. 5 & 7, where, owing to their extreme thinness at this part, the bases of the scales have been broken off, revealing a concave

dans sa partie moyenne." I find, on the contrary, that about two-thirds of the nervures disappear at the upper margin of the leaf, and that, by their branching, the leaf contains fully one-third more nervures than start from the sessile base.

annular area of radiating cells. Since the drawing fig. 5 was made, the specimen represented has been accidentally reduced to the common form, the central portion having fallen out. It now, like figs. 5 & 7, shows a central cavity, bounded inferiorly by the concave annular area.

The central cavity swells out into a pyriform space once occupied by an expansion of the axis, contracting again towards its upper part, its greatest diameter being at about its lower third. The interior of this cavity is perfectly smooth in the specimen in question. Above the contracted upper extremity it develops into a structure which a second casual fracture revealed after the drawing was made, and to which I shall call attention in connexion with another specimen.

Fig. 7 represents a specimen in which the inferior central portion has become detached. The frequency of this occurrence would have misled me respecting the thickness of the axis at this point, but for the solitary example described; I should have considered that part of the axis to have had, not only a diameter several times greater than has actually been the case, but that it had a convex extremity fitting into the concavity formed by the radiating structures represented in fig. 7. The base of fig. 7 exhibits two concentric circles, the intervening concave area being occupied by numerous small radiating elongated cells* arranged vertically upon the axis; the inner circular margin forms the margin of a large pyriform cavity left by the removal of the axis. I would designate this latter portion of the structure the *pyriform axis*. As in the case of the previous specimen, this cavity contracts superiorly, terminating in a narrow circular aperture; this example, from the Scarborough Museum, also indicates that the outer surface of the pyriform axis has been perfectly smooth.

Fig. 3, a specimen in my own cabinet, carries us a step further, showing the superior constricted part of the pyriform axis expanding into a funnel-shaped appendage, the surface of which has been strongly marked with parallel longitudinal lines. These lines are due, as other specimens demonstrate, to "cells" like those seen at the base of the involucre (fig. 7), but differently arranged, being parallel to the surface of the axis and not vertical. This new arrangement will be demonstrated from other examples.

In nearly all the specimens hitherto discovered, the central axis terminates at the margin of this funnel, which is sharply defined, and at which the diverging grooves end abruptly. That this structure had supported some additional appendage appeared obvious to me; but years of research passed by before I obtained the slightest clue to the missing parts. That it had been deciduous, or at all events very liable to be broken off at this point, was sufficiently obvious, since of the dozens that I examined none exhibited a trace of the terminal organ. A specimen represented in fig. 4 gives additional information respecting the axis. Being in a hard compact stone, the fracture has split the involucre and its pyriform axis through its centre, showing that the latter was a *solid* and not a *hollow* structure; all its vegetable carbon is preserved *in situ*, in an amorphous condition, intersected with bands of the Scarbroite so commonly found amongst the vegetable remains of these Yorkshire sandstones. This specimen admirably

* I shall use this word to represent these curious cavities, because I can find no better, but without any evidence that the expression is applicable here in its physiological sense.

demonstrates the shape of the pyriform axis, and also the abrupt way in which it terminates superiorly on the detachment of the organ which it sustained.

Fig. 5 represents a specimen closely resembling fig. 7, but giving us additional facts; it exhibits, in the interior of the pyriform peduncle, a cylinder of carbonaceous matter having well-defined boundaries. This cylinder appears to have been separated from the surrounding cortical cells by a narrow interval, which may have been occupied by some different kind of tissue; its inner surface exhibits strongly marked longitudinal parallel grooves, which extend upwards into the constricted part of the axis. This cylinder bears the aspect of a woody zone, of which the longitudinal ridges represent vascular bundles; but if so, the vessels have been much more densely packed, as well as more regularly parallel to each other, than in recent Cycads.

This specimen, belonging to Mr. Ripley, also affords indications of the extension of the pyriform axis beyond the usually terminal funnel, and shows that the latter became suddenly contracted by a curious inflexion of the tissues composing it, and further indicates that the centre of the lenticular disk thus formed has been extended upwards into a central prolongation. Two invaluable specimens in my own cabinet confirm and further illustrate this part of the structure. One of these contains the pyriform axis detached from the involucre; on splitting the specimen, in order to trace its upward prolongation, I obtained the conclusive results indicated (double the natural size) in figs. 7, 8, and 9 (Plate LIII.), demonstrating the actual termination of the axis. The last two figures represent the two halves of the specimen, showing the upper extremity of the axis: the pyriform dilatation does not appear in the drawings, being on the reverse side of the fragment indicated by fig. 8; but fig. 9 exhibits the appearance this specimen would have presented had the fracture happened to pass through the central plane of the specimen. In fig. 8, as just stated, the pyriform axis is imbedded in the stone. It differs from all the other examples I have seen in having the interior surface of the hollow cast marked by numerous irregular longitudinal rugæ. As the specimen has no traces of the involucre attached to it, and as it is the only one in which I have found the surface of this part of the axis otherwise than smooth, I think we may attribute these rugæ to the partial shrivelling of the organism prior to its fossilization. At the base of fig. 10 we see a small portion of the grooved funnel, the striated surface of which only extends about half the distance between its outer margin and the constricted part of the pyriform axis below. From this margin the axis rapidly contracts superiorly, in the way represented in fig. 7, demonstrating that the funnel-shaped structure was the inferior part of a disk, to which I would apply the name of the lenticular disk. Inferiorly, the surface of this disk has been concave, and convex on its upper surface, the central portion of the latter being further prolonged into a pyramidal structure about an inch in length. This structure may be designated the pyramidal axis; its surface is indented with numerous longitudinal grooves and striæ, very similar to those on the inferior surface of the lenticular disk, but not quite so strongly defined. In fig. 10, some of these longitudinal grooves are more deeply indented than others, and this difference is not seen on the opposite side of the pyramid represented by fig. 8. Near its upper extremity the pyramidal axis again expands into a cup-shaped enlargement about one-

fourth of an inch in diameter (fig. 7), and from the centre of this there arises a small terminal mamillary projection, rather more than the eighth of an inch in height and breadth; to this cup and its terminal mamilla I would give the provisional name of the *corona*.

Two specimens in my cabinet exhibit the lenticular disk, with its pyramidal axis and corona, in a much less completely developed state. One of these is in the example fig. 5. A vertical section is shown in fig. 9. In this state the corona is well developed; the mamilla is more acute than in fig. 6; but the pyramidal axis is almost wholly wanting, the corona being nearly sessile upon the depressed centre of the lenticular disk. This obviously appears to be a less developed condition of the organ than the other specimen (figs. 6-8) indicates; and the general aspect of the involucre (fig. 7) suggests the same idea, it being much less globular than is the case with fig. 6. These younger specimens afford almost absolute proof that the corona is the terminal portion of the central axis. I have now seen four of these rare examples, and they all bear the strongest marks of terminal completeness. It may be worthy of note that the specimen (figs. 10, 11, 12), the only one I have seen in which the pyramidal axis is fully developed, is the only one also in which the surface of the pyriform axis is shrivelled and corrugated, instead of smooth, as if the organ had fulfilled its mission and was drying up.

Having thus ascertained the form of the axis, we may now turn to some anomalous features in its structure. Attention has been drawn to the ring of radiating cells at the base. These are arranged like the cells of the honeycomb, each one being in turn the centre of a surrounding group of six others (fig. 10); but they are often so compressed that it is only under favourable conditions that this arrangement can be determined; nevertheless it is an unquestionable fact. These cells appear to have formed a cortical layer, arranged vertically upon and extending over the entire surface of the pyramidal axis, having a probable thickness of from half to three-quarters of an inch at the lower and central portions, and becoming thinner on approaching the constricted part of the axis, and most probably disappearing before reaching the funnel-shaped base of the lenticular disk. I infer that it was coextensive with that part of the pyriform axis of which the cast in the specimen, fig. 7, exhibits an uninterruptedly smooth surface. That it invested a great part of that surface, was shown by a specimen formerly in the possession of Mr. James Yates, and now, I believe, in the collection of the Jardin des Plantes at Paris, as also in one in Mr. Ripley's cabinet; and as all the specimens demonstrate a change in the tissues forming the surface of the axis, where the radiating grooves appear on the funnel-shaped base of the lenticular disk, I conclude that at this point this layer of cells thinned out, so far as the vertical series was concerned. Each cell was in close contact, at its inner extremity (fig. 11), with the smooth surface of the pyramidal axis. Externally it seems to have presented a rounded contour, giving a crenulated outline to the vertical section of this tissue.

This structure is invariably seen at the base of each involucre, as represented in figs. 3 & 6 (Plate LII.). I conclude that these cortical cells formed a layer that was deciduous, being very easily detached from the smooth surface of the peduncle, and that the ring which is so invariably preserved round the base of the involucre is only the

lowermost margin of the layer retained *in situ* because wedged in that position, externally by the bases of the bracts of the involucre, and internally by the substance of the pyriform peduncle. The smoothness of the surface of the peduncle, demonstrated by several examples, clearly indicates that the connexion between it and the investing cells has been very slight; the detachment of the latter may have resulted either from maceration in water readily severing this connexion, or from the tissue having been truly deciduous, and destined to be thrown off like many recent antheriferous structures.

Attention has been directed to the radiating striæ marking the outer surface of the funnel-shaped base of the lenticular disk (Plate LII. fig. 5): I have several specimens demonstrating that at least the exterior of this part of the axis has been composed of elongated cells similar *in appearance* to those of the cortical layer; but they appear to have formed a permanent part of the axis, being almost invariably found *in situ* when the carbonaceous matter is preserved. Whether they occupied the whole diameter of the peduncle, or only formed an external layer, I cannot determine*. Instead of being arranged vertically to the surface of the axis, they are disposed longitudinally and in symmetrical parallel lines, following the curves of the exterior of the axis; their terminations are seen on the upper surface of the lenticular disk, especially at its peripheral portion (fig. 6). The exact relation of these cells to those of the outer layer is uncertain, but there is always a remarkable break in the continuity of the tissues here, showing some important change in their arrangement. In the undeveloped examples (Plate LIII. fig. 9) a thin series of the most superficial of these cells appear on the surface of the lenticular disk, converging towards the base of the pyramidal axis, which they then ascend, and are continued in the same manner to the extremity of the central mammillary apex of the corona. It thus appears that at least the surface of the axis above the narrow base of the lenticular disk has been composed of a series of elongated cells or tubes, arranged longitudinally and following the curves of the surface, and that a number of them terminated abruptly at or immediately beneath the upper surface of the lenticular disk. As seen in fig. 7, many of the superficial grooves caused by these tissues are more strongly marked than the rest, recurring at regular intervals. The undeveloped specimens indicate a similar external contour.

Along with the specimens described some others are found having a very different aspect, but apparently belonging to the same plant. Fig. 2, Plate LII., represents one of them in the Scarborough Museum, of the natural size; it is a cast showing the inferior surface of the organism. It is a funnel-shaped body; the hollow interior is about an inch in depth, and rather more than half an inch wide at its fundus, enlarging to about an inch at its upper part, where it suddenly expands into a broad disk, having a diameter of nearly 4 inches, exclusive of a circle of radiating appendages. The latter exhibits a slight tendency to be recurved downwards. The entire surface is marked by numerous irregular radiating striæ, and also by several grooves and corrugations, which are strongest in the tubular portion of the specimen. Round its peripheral margin are the remains of a number of radiating appendages, each being about an inch in length,

* Since the above was written, I have ascertained that they form a *well-defined* external cylinder about $\frac{1}{8}$ inch in thickness.

and from $\frac{1}{4}$ to $\frac{3}{8}$ inch in diameter at the base, tapering to a point, whilst curving outwards and upwards.

Fig. 1, Plate LII., represents another specimen which exhibits additional points of the greatest interest. In tab. 1. fig. 2 of Young and Bird's 'Geological Survey,' there is given a representation of a fossil from the collection of the Whitby Philosophical Society, which the Council has permitted me to examine, along with its reverse, also in their possession. The specimen is well preserved in the centre of a block of compact sandstone; but, as is so often the case with these fossils, especially where the vegetable structure has been of some thickness, the friable carbonaceous matter has fallen away on the fracture of the matrix, exposing the superior and inferior aspects of the organism. The lower surface is figured by Young and Bird; generally it resembles the one described (fig. 2), but is somewhat smaller, the disk exclusive of the rays being only about 2 inches in diameter. The central cavity is at the same time wider and shallower, being more saucer-like. Its diameter, superiorly, is about $1\frac{1}{4}$ inch, whilst its depth is barely $\frac{3}{8}$ inch. At its fundus there is an irregular but well-defined circle, $\frac{3}{8}$ inch wide, which I believe marks the thickness of the peduncle which supported it; and from the margin of this small circular space, as from the fundus of fig. 2, numerous strongly marked rugæ radiate towards the margin of the depressed cavity, and become less definite as they ascend towards its brim, where they are almost wholly lost. These of course represent corresponding corrugations on the *exterior* of the organism. The peripheral radii are truncated at their extremities, as represented by Young and Bird; but this is accidental, arising from their apices being imbedded in the matrix. The Council allowed me to employ my chisel as stated above, and the result was the display of the magnificent specimen represented by fig. 1, being the cast of the *superior* surface of the organism.

Its centre is occupied by a large projecting truncated boss, on the upper surface of which is a slight depression, indicating a corresponding elevation on the surface. Though a few faintly developed folds are seen running down the sides of this projecting boss, there is nothing like the numerous striæ seen in fig. 2. There are, however, some circular markings of another kind, to which I shall have to refer by-and-by. At the base of the boss the organism spreads out into a disk, the margin of which supports fifteen pointed rays; each of these is about an inch in length and $\frac{3}{8}$ inch wide; they are somewhat constricted at their origin, but bulge out a little before reaching their centre, and then gradually taper off to their outer apex. Their direction is first outwards and then upwards, the whole structure having the appearance of a starfish in which the extremities of the rays have been curled up. Different portions of the specimen exhibit the form of both the upper and lower surfaces of these rays, from the carbon of some of them being retained *in situ*. The inferior surface has originally been a little concave from side to side, the margins curling slightly downwards. The superior surface, on the other hand, has a strong central longitudinal projection (figs. 3 & 4, Plate LIII.), extending from the apex to about the middle of the ray, its position being shown in the cast by a corresponding depression. On each side of this ridge, the surface of the ray has been concave. Where the large *central* depression, *d*, terminates *in the fossil cast*,

every ray exhibits two small parallel oval protuberances, each being about $\frac{1}{4}$ inch long, and about $\frac{1}{8}$ inch wide. In the fossil itself these mark the position of two depressions (Plate LIII. fig. 3) in each ray, separated from each other by a slight prolongation of the central ridge. The further prolongation of the mesial line can be detected in the direction of the centre of the entire organism, *f*, and on either side of it, especially when it traverses the disk, are traces of a row of small circular pits (Plate LII. fig. 1), each being about $\frac{1}{16}$ inch in diameter. The depth of these little pits is very slight, and their outline often wants definition; but they are sometimes so distinct as to establish the fact that they formed a characteristic feature of the organism. I propose to call this structure by the provisional name of the carpellary disk.

Thus far I have confined myself to describing the specimens, without attempting to draw from them any inferences. These have shown that we have an arborescent stem marked with the rhomboidal scars of fallen leaves, as in *Cycadeæ*. We have leaves, the Cycadean affinities of which no one disputes, springing from the summit of the stem; then we have a peduncle (Plate LIII. fig. 13) clothed with scales, identical with the *squamæ foliaries* of Link, the uppermost ones having been more elongated than the rest. This peduncle sustained the involucre, composed of verticils of similar but much longer scales or bracts, within which there arose a pyriform axis with a smooth exterior, supporting a superficial layer of oblong cells arranged vertically on its outer surface. Superiorly the axis contracted, and again expanding to form the lenticular disk, then shot up into the pyramidal axis, and terminated in the corona.

We find associated with the above fossils the radiating organism provisionally designated the carpellary disk, and of which a restored figure is given in Plate LIII. fig. 2, a structure having many indications that it was the female reproductive organ of a gymnospermous plant. All the remarkable objects enumerated occur in the same blocks of sandstone, unassociated with any other plants to which they can be referred with any show of probability. The inference that they are parts of one plant, though incapable of proof, is forcibly suggested. Adopting this interpretation, I will venture on a few hypothetical conclusions, such as may guide future observers either to their confirmation or to a correction of my errors. At all events such suggestions will raise definite points for further investigation.

Remembering the dioecious character of living Cycads, it is probable that the fossil forms were also dioecious. The two different organisms, restored in figs. 2 & 13 (Plate LIII.), may be the male and female reproductive organs of *Zamia Gigas*. Remembering further the frequency with which the male organs are deciduous amongst living plants, we note with interest the significant probability that the pyriform axis of fig. 6 was invested by a deciduous antheriferous tissue. The examples from which the restored diagram (fig. 2) was constructed, afford more positive evidence that they were female organs. They recall the bracts of the female cones of living Cycads, with their pairs of ovules symmetrically disposed, and make it more than probable that the two oblong depressions on the surface of fig. 3 supported ovules, as indicated in figs. 2 & 4, while the two parallel centripetal rows of small depressions (fig. 2) may mark the position of corresponding pairs of *abortive* ovules.

If this be a correct interpretation of the organism, it has been a verticil of altered leaves which have coalesced below into a funnel-shaped disk, but yet show in the free peripheral rays the number of leaves entering into its composition. This interpretation has been strengthened by the discovery of a small seed represented in figs. 14 & 15 (Plate LIII.). I found this seed imbedded among the bracts of a scaly peduncle when breaking it. It exactly corresponds in size to the depressions in fig. 3, where it was, I believe, borne. Its upper extremity is rounded (fig. 15), somewhat depressed, and nearly smooth; its opposite end is more prominent and rougher. When originally found it was covered by a thin film of carbonaceous matter, and its matrix still exhibits a faint brownish stain surrounding the nut. Its surface is very slightly marked with longitudinal lines resembling those of the putamen of *Encephalartos Caffer*.

No example has yet been discovered in which the radiating carpellary disk has retained its connexion with the peduncle. Its vascular tissues seem to be more developed on its inferior than on its superior surface. I infer this from impressions of the former (Plate LII. fig. 2) being always strongly grooved longitudinally, while those of the latter, which I have seen, are smooth. The upper part had probably a thick layer of parenchyma. With such reasons for supposing that this has been the representative of the female cone, we attain to a negative probability that the involucre and its appendages have been the male organ. That the cells on the pyriform axis did not contain ovules, as some have deemed probable, I am convinced. We constantly find them in such excellent preservation, that some traces of ovules would have been retained had they ever existed. Besides their very small diameter precludes the idea. That the expanded lenticular disk performed some important function is most probable. Its upper surface may have been also antheriferous, and this possibility is further sustained by the circumstance that this part of the structure also appears to have been deciduous. Of all the numerous involucre which I have seen, I have only met with three or four in which these uppermost parts of the axis were not wanting. Fig. 4 accurately indicates the way in which this organ has usually been truncated prior to its being imbedded in the matrix. Thus, though the cells in the funnel-shaped part of the peduncle remain, their upper extremities, with whatever they sustained, were almost invariably detached.

Assuming the specimens of stems described to belong to *Zamia Gigas*, the plant must have had the habit of *Cycas circinalis*, and I have accordingly so restored it in Plate LIII. The dichotomous scaly peduncle is adopted on the authority of a specimen in the Scarborough Museum; this may, however, be exceptional, just as a double cone is in recent Cycads.

I must, in conclusion, express my gratitude to the several individuals who have aided me in this inquiry. To my friend Mr. James Yates, of Highgate, I owe many thanks, for the sight of drawings and specimens which he has ever been willing to communicate to others. The kind assistance of the Council of the Philosophical Society of Whitby has already been acknowledged. The Scarborough Philosophical Society also allowed me the same liberal use of specimens from their fine local collection. The nearness of our relationship would not justify my overlooking the diligence with which my veteran father has pursued the search for these Cycadean relics during fifty years of field-work

on the Yorkshire coast, whilst the invaluable and suggestive assistance of M. Adolphe Brongniart has always been available whenever specimens were submitted to his inspection. Would that I could personally thank three other geologists, whose cabinets were freely thrown open to me; but Dr. Murray and Mr. Bean, of Scarborough, and Mr. Ripley, of Whitby, have passed beyond the reach of earthly thanks since most of the preceding pages were written.

EXPLANATION OF THE PLATES.

PLATE LII.

- Fig. 1. Cast of the superior surface of the "carpellary disk."
- Fig. 2. Cast of the inferior surface of ditto.
- Fig. 3. Inferior aspect of an involucre, showing the cylinder of vascular tissue within the pyriform axis.
- Fig. 4. Longitudinal section of an involucre, with the pyriform axis and the inferior half of the lenticular disk.
- Fig. 5. Upper portion of an involucre, with the impression of the inferior surface of the lenticular disk.
- Fig. 6. Basal aspect of a matured involucre, in which the central portion has been broken away, revealing the interior of the pyriform axis.
- Fig. 7. Basal aspect of a young involucre.

PLATE LIII.

- Fig. 1. Restoration of the male plant of *Zamia Gigas*.
- Fig. 2. Restoration of half of the carpellary disk, showing the vascular exterior, the superficial parenchyma, the ovules *in situ*, and the position of the supposed abortive ovules.
- Fig. 3. One of the rays of fig. 1, Plate LII.; double natural size.
- Fig. 4. Ditto, with seeds in position; restored.
- Fig. 5. Impression of a portion of the exterior of the stem.
- Fig. 6. Upper part of the pyriform axis with the pyramidal axis and corona.
- Fig. 7. The pyramidal axis and corona.
- Fig. 8. Ditto, ditto.
- Fig. 9. Section of immature lenticular disk and corona.
- Fig. 10. Transverse section of the cells investing the pyriform axis.
- Fig. 11. Longitudinal section of ditto.
- Fig. 12. Restoration of the involucre.
- Fig. 13. Restored section of ditto.
- Fig. 14. Seed; nat. size.
- Fig. 15. Seed; enlarged.

Note.—Since writing the above Memoir, Mr. Leckenby's cabinet has afforded me proofs that *Pterophyllum pecten* was a *Williamsonia*. He has both forms of fructification. A specimen of *P. pectinoides* shows that this species should also be referred here. I have ascertained that the external layer of elongated cells of the funnel-shaped base of the lenticular disk was about $\frac{1}{8}$ inch in thickness, and that its inner surface was as sharply defined as its outer one.

W. G. Smith, F. L. S. lith. W. C. Williamson, del.

Williamsonia Gigas. (*Zamia Gigas.*)
all nat size.

W. G. Smith F. L. S. lith. W. C. Williamson, del.

Williamsonia Gigas. (*Zamia Gigas.*)