valued friend, Mr. Graham Bell, to authorize the publication of a general statement of the results thus far obtained.

Let me add, in explanation, that the scale of the construction did not admit of any apparatus for condensing the steam or economizing the water, which, therefore, could only be carried in sufficient quantity for a very short flight. This difficulty is peculiar to the scale on which the experiment is conducted, and does not present itself in a larger construction.

Professor Bell has shown me his letter, which follows.

Very respectfully yours,
S. P. LANGLEY.

WASHINGTON, D. C., May 12, 1896.

THE EDITOR OF SCIENCE—*Dear Sir:* Last Wednesday, May 6th, I witnessed a very remarkable experiment with Prof. Langley's aerodrome on the Potomac River; indeed, it seemed to me that the experiment was of such historical importance that it should be made public.

I am not at liberty to give an account of all the details, but the main facts I have Professor Langley's consent for giving you, and they are as follows:

The aerodrome or 'flying machine' in question, was of steel, driven by a steam engine. It resembled an enormous bird, soaring in the air with extreme regularity in large curves, sweeping steadily upward in a spiral path, the spirals with a diameter of perhaps 100 yards, until it reached a height of about 100 feet in the air at the end of a course of about half a mile, when the steam gave out, the propellors which had moved it stopped, and then, to my further surprise, the whole, instead of tumbling down, settled as slowly and gracefully as it is possible for any bird to do, touched the water without any damage, and was immediately picked out and ready to be tried again.

A second trial was like the first, except that the machine went in a different direction, moving in one continuous gentle ascent as it swung around in circles, like a great soaring bird. At one time it seemed to be in danger as its course carried it over a neighboring wooded promontory, but apprehension was immediately allayed as it passed 25 or 30 feet above the tops of the highest trees there, and ascending still further its steam finally gave out again, and it settled into the waters of the river, not quite a quarter of a mile from the point at which it arose.

No one could have witnessed these experiments without being convinced that the practicability of mechanical flight had been demonstrated.

Yours very truly,
ALEXANDER GRAHAM BELL.

1331 CONNECTICUT AVENUE,
WASHINGTON, D. C., May 12, 1896.

THE DEVELOPMENT OF EXOGENOUS STRUCTURE IN THE PALEOZOIC LYCOPODS—A SUMMARY OF THE RESEARCHES OF WILLIAMSON AND RENAULT.

THE fact of the occurrence of exogenous structure in the Lycopodineæ, Equisetineæ and some of the ferns of the Carboniferous age is in itself hardly less remarkable and interesting than is the variety of phases under which this structure makes its appearance. It would seem that during the rapid differentiation and modification of vascular plants at the time of the great coal formation, plants of these lower classes played fast and loose with exogeny, shaping in fantastic and capricious designs a structure that is now the garb of the most exalted classes. Even within the boundaries of the *Lepidodendra* and the *Sigillariæ* the diversity is so great that while some species show no secondary growth at all, others, especially among the *Sigillariæ*, are so highly organized that the followers of the Brongniartian school still range them by the side of the Gymnosperms.

As representing the latest stage in the progress of knowledge concerning exogenous development in the Paleozoic Lycopods, as well as expressing the views of the foremost authorities in Paleozoic plant histology in both the Brongniartian and the English schools, I venture to summarize, in brief, without pretense of adding anything original to the subject myself, the contents of two lately published papers.

The first, by the late Prof. W. C. Williamson, of Owens College, England, his last independent publication, I believe, is entitled, *On the light thrown upon the question of the Growth and Development of the Carboniferous Arborescent Lepidodendra by a study of the details of their Organization.**

At the outset it may be well, and of interest to the reader, to briefly review the general structural characters of the Lepidodendron type, in describing which I shall quote in part from Prof. Williamson's own publications: "In the youngest Lepidodendroid twigs the conspicuous central tissue is a small vascular bundle known as the primary xylem strand. It extends, under varied modifications of form and size, from near the apex of the youngest twig to the base of the oldest stem. In its downward course it gives off a large number of small vascular bundles, known as leaf traces, each one of which passes outwards to a leaf, supplying it with its vascular tissues. In many cases we discover a few cells in the center of its component tracheids, which, on passing downward towards the lower members of the tree, enlarge into a more or less conspicuous medulla. In a few cases the smaller shoots exhibit no traces of these cells, which are only discoverable in branches of somewhat larger size; but in all, the larger the twig, the larger, also, is the central cellular tissue in varying degrees and in different types. This is a true medulla, which generally exhibits its maximum diameter only at the base of the oldest stems."

In the closest external contact to this primary xylem system is a second vascular zone, the 'secondary xylem,' which is developed from a peripheral cambium layer much like the growth of ordinary trees. This secondary xylem is composed of vertically prolonged radiating vascular laminæ, which are separated by intervening medullary rays. These two systems form the 'stele,' and the Carboniferous Lycopods are 'monostelic.' The remaining external zones of tissue constitute the leaf-bearing cortex. "In its youngest state this tissue consists almost wholly either of rounded cells, parenchyma, or vertically elongated ones with pointed ends, prosenchyma." At a later period of growth, varying in different types, a thin meristemic zone appears in the outermost parenchyma of the cortex. A ring of its rounded cells, as seen in transverse section, undergoes divisions, the more internal developing into prosenchymatous ones to form a layer of periderm. This periderm constantly thickens by similarly produced exterior additions so long as the plant lives, constituting the great bulk of the tree trunks, which may attain a diameter of four feet or more. The outermost cells resulting from the above-described meristemic action experience a succession of similar metamorphoses, always preserving a thin layer of parenchyma between the surface of the periderm and the bases of the leaves. The leaves, which are variable in form and size, are attached by rhomboidal bases to the bolsters or leaf cushions, which, though square and hardly larger than the leaf base when young, continue to grow after the true leaf falls off, and their diamond-shaped, often fusiform protuberant bolsters, arranged in quincunx, form the

*Mem. Proc. Manchester Lit. and Phil. Soc., 1894–95, pp. 31–65, 1895.

usual netted impressions characteristic and familiar in the fossil remains. The leaf scar bears three well-marked points. The Lepidodendra always branch dichotomously.

Concerning the mode of development of the primary xylem or central part of the stele there has been lack of evidence and consequent radical difference of opinion. To the solution of this problem Prof. Williamson devoted the six summer months of 1894 examining the slides in his extraordinary collection numbering several thousand specimens, and counting or calculating with great precision the number of cells in the primary and secondary xylem systems.

The study of the dichotomies of the branches has thrown great light upon this important question, for "It is to the ascending series of these dichotomies that the Lepidodendra owe their characteristic structure and modes of development."

The first change in the normally cylindrical ordinary branch is the splitting of the central vascular cylinder of primary xylem and its contained cellular medulla. The cylinder splits vertically for a short distance into two crescentic, diverging halves, while the external form of the branch becomes oval, the difference between the longer and shorter axes being greater as we ascend to the dichotomy. Before reaching this the two horns of each crescent of primary xylem approach each other. At this stage the cells of the two medullæ are in direct contact with those of the inner cortex. Several of Prof. Williamson's sections show that the crescentic condition is permanent for a short space at least, approximating what DuBary calls the 'foliar gap' in ferns. Higher in the dichotomy, however, the horns of each crescent rapidly converge to form two new cylinders, 'differing in no respects, save size and number of internal parts, from that of the parent stem.' The same phenomena occur with each successive dichotomy, each pair of resulting branches, though diminished in diameter, having exactly the same type of organization as the one from which they sprang. Thus, however numerous the dichotomies they are all produced alike and no structural changes are introduced 'from the base of the parent branch up to the smallest twig of the full-grown tree,' save certain secondary ones produced by growth processes which begin to manifest themselves at the base of that trunk. It will at once be seen that the number of cells and vessels of the cortex, primary xylem and medulla is one-half as great in each of the two branches as in the parent below the bifurcation. A similar ratio obtains in the number of leaves. Such dichotomies occur only when the twigs are terminal with a growing point.

Besides these equal dichotomies there are two sorts of unequal dichotomies different in structure and purpose. In the first only a small segment is cut out of the primary xylem cylinder and passes outward, carrying with it a small portion of the medulla to form a branch. This unsymmetrical segment becomes a solid strand with or without any trace of a medulla, though usually on reaching the axis of the cone, which it usually supports, a central medulla is shown. In the second form of unequal dichotomy the medulla is unaffected, a limited number of tracheids being detached from the periphery of the primary xylem cylinder. These strands may also go to reproductive organs.

In answer to the hitherto open problem as to how far the ordinary growth of a branch has exerted any influence upon or borne any relation to the varying dimensions of the primary xylem cylinder of the stele and upon the number of its component tracheids, the author's examination leads to this conclusion: "Unlike what occurs amongst the living Lycopods, amongst the Carboniferous Lepidodendra we find as we descend from the uppermost and youngest shoots, that there is a regular progressive enlargement of the branches below each succeeding dichotomy; * * * and these enlargements are accompanied by a similar though less conspicuous enlargement of the cylinder of the primary xylem, and also in the number of its component tracheids."

Prof. Williamson's examinations relate in particular to seven species of Lepidodendron.* Of these *L. Selaginoides* differs from other studied Lepidodendra in having the tracheids of the primary xylem, which are crowded at the outer periphery, more open and fewer in approaching the center of the system, where they often mingle with a peculiar barred parenchyma that occupies the place of the medullary cells in other species. In one specimen of this species the primary xylem has reached a diameter of nearly 3 mm., the cortical diameter being nearly 17 mm. before a small crescent of secondary xylem is discerned. At a more advanced stage the diameter of the primary xylem cylinder is 6 mm., the secondary xylem 14.5 mm., while the cortical is 92 mm.

Of *L. brevifolium*, which is remarkable for its frequent dichotomies, of both the equal and unequal types, Prof. Williamson obtained a section, below a dichotomy, in which a secondary xylem of a maximum thickness of 5 mm., invested the two tracheal crescents of primary xylem, the secondary xylem tissue being seen to grow around the horns of each of the primary xylem crescents and to push its way into the interior of their contained medullæ.

Exceptionally favorable conditions of preservation have made it possible to trace the development of the tissue in *L. Wunschianum* from the youngest twigs down to stems six feet in circumference. In this plant specimens in which the primary xylem is 4 mm. in diameter show no medulla, though on reaching a diameter of 5.5 mm. a medulla nearly 2.5 mm. in diameter appears. But the remarkable fact that the smallest stem in which a trace of secondary xylem was found showed the diameter of the cortex, primary xylem and of the medulla to be 23 cm., 36.5 mm. and 24 mm., respectively, while the very thin ring of secondary xylem is but 4 mm. thick on one side and 1 mm. thick on the other, demonstrates that the branches of this species attained a relatively large size before the growth of secondary xylem began.

In *L. Harcourtii*, the study of a section of which led Brongniart astray and began the conflict between the English and the French paleobotanists, the author elucidates several minor disputed points. It is noteworthy that no exogenous or secondary growth has yet been found by any of the investigators of this species, for the possible reason, as Williamson suggests, that the secondary xylem does not appear until a stage more advanced than that represented in any specimens yet examined.

Two of the sections of *L. fuliginosum* give the following diameters: 1st—cortex, 19 mm.; primary xylem, 3.5 mm.; medulla, 2 mm. 2d—cortex, 60 mm.; primary xylem, 7 mm.; medulla, 6 mm. At an advanced stage of growth, among the radial lines or cells of the innermost cortex, are found parallel lines of true tracheids, 'rudimentary representatives of the secondary xylem zone.' These cells pursue an irregular course longitudinally, and are unequally distributed in the cortical ring in which they occur.

* We can refer to but a few of the author's observations. Those who wish further data will find such tabulated in the present paper and illustrated in the magnificent series of memoirs 'On the Organization of the Fossil Plants of the Coal Measures,' published by Prof. Williamson during the last twenty-five years in the Transactions of the Royal Society of London.

The examination of numerous sections, including one only, 1 mm. in cortical diameter, of *L. mundum*, a low species, shows the same habit of development, and, in the descending from the smallest twigs to larger and lower branches, the same enlargement of the primary stele as a whole and of the number of its component tracheids as in the other arborescent forms.

The painstaking and exhaustive study of his remarkable series of sections led Prof. Williamson to abandon his earlier views, while approaching in the main to those set forth by Solms-Laubach in his Fossil Botany. The impossibility of intercalating leaves and leaf traces among the prearranged geometrically disposed spirals and the observed numerical progression of the volume of tracheids in passing downward lead to the inevitable conclusion that, unlike any living type of growth, these enormous developments of primary tissue originate at the base of the primary stem close to a growing point.

Here the chain of corroborative observation ends and the difficulties and further unsettled problems begin. Prof. Williamson adds: "As to the magnitude of the primary xylem strand and the enormous number of tracheids which compose it, these equally reached their largest proportion at the base of each solitary aërial stem. How such numbers of tracheids, varying in the type of *L. Wunschianum* from 4,000 to 15,000, could be produced in that position is difficult to understand. The *young* sporophyte could not possibly have contained them; hence some process of growth, of the nature of which we have as yet no knowledge, but which was capable of producing these marvelous results, must have succeeded, if not been developed out of the sporophyte."

The second paper, entitled *Sur l' utilitê de l'étude des plantes fossiles au point de vue de l'évolution des organes*, is by M. B. Renault,* the leader of the French paleobotanical histologists.

M. Renault draws a very suggestive contrast between the present general grouping of living plants and what would be expected if the manifest relations of the fossil species were taken into consideration; for vegetable paleontology shows the existence of vast numbers of individuals presenting in different degrees characters intermediate to those which obtain among the living plants. If the fossils are included in the same classification with the living plants it will be difficult in many cases to establish perceptible demarcations between, and preserve intact the living groups.

As to the appearance of secondary growth and its use as a basis of classification, the author points out that such growth is seen first in the rhizomes, then in the stems, branches, leaves and fructifications respectively. Thus the subterranean stems of the living *Helminthostachys* and *Botrychium* show the secondary xylem while the aërial portions have the structure of the Cryptograms.

Lepidodendron Harcourtii (mentioned in Williamson's paper), *L. rhodumnense* and *L. esnotense* are cited as simple arborescent Lycopods, the trunks of which are without trace of secondary growth. *L. vasculare* and *L. selaginoides* show a secondary xylem cylinder of varying thickness in the stems. The *Stigmariæ* he considers more highly organized than the *Sigillariæ* which, according to the Brongniartian School, they bore. *Diploxylon*, regarded by some as a Lepidodendroid stage, by others as a *Sigillaria*, has a thick primary xylem surrounded by a bed of secondary xylem, the latter growth being found in not only the roots and stems, but in the foliar bundles also, as far as the base of the leaf.

The smooth Sigillarias, differing from *Di-*

* Bull. Soc. d'Hist. Nat. d'Autun, VI., 1893, Pp. 499–504.

ploxylon, especially by the marked diminution in the diameter of the primary xylem, exhibit the secondary growth in roots, stems and leaf bases, but only as an elementary stage in the leaf itself.

Representing the present Brongniartian School, M. Renault cites the somewhat anomalous *Poroxylon* group ('although belonging rather to another series leading to the Conifera') as examples showing the double growth in roots, stems and leaves, predicting that their still unknown fruits will probably be found to be small seeds constructed on the plan already observed in the contemporaneous *Gymnosperms*. If so, the *Poroxylon* will be especially exemplary in combining the characters of *Phanerogams* and *Cryptogams*. The 'libero-ligneous' bundle of the leaf has the double structure in *Colpoxylon*, while the structure is simple in *Medullosa*, a genus allied to the Cycads, though both have lost all traces of their centripetal wood, except some vascular bundles scattered through the pith, the woody element of the stem being composed of tracheids punctate in many rows and medullary rays organized like those of the *Cycads*. He concludes that the Phanerogamic characters became gradually associated with the Cryptogamic, increasing little by little to preponderancy and finally exterminating the latter; that these changes are successively accomplished in the principal organs of the plant and in a definite order, the fruits being last to change. In effect, M. Renault suggests that the difference between the Paleozoic Lycopod group and the living Cycad is hardly more than that between the living Cycad and the typical Phanerogam. David White.

THE EMBANKMENTS OF THE RIVER PO.

There is probably no part of the world in which the action of rivers in carrying and depositing sediment can be better seen and more readily studied than in the plains of Lombardy and along the adjacent shores of the Adriatic, and no district has contributed more to our knowledge of the important subject of river action and delta building than has this portion of Northern Italy.

In this well settled country the very rapid advance of the land upon the sea everywhere has been especially remarked and could not escape the attention of the most unobservant, since, as is well known, the very town of Adria, which gives its name to the Adriatic Sea and which was a sea port in the time of Augustus, now lies 14 miles inland.

One statement concerning the chief of these Lombard Rivers, the Po, taken from chapter eighteen of Lyell's Principles of Geology, has been copied and recopied in one generation of text-books after another, a statement so remarkable that wherever met with it always arrests one's attention. It is that in which, after speaking of the action of the dykes, between which these Lombard rivers are confined in causing a portion of the sediment, which would otherwise be spread over the plains by the annual inundations, to settle in the bottom of the river channel, with the consequent necessity of from time to time increasing the height of the dykes, he says, "Hence it happens that these streams now traverse the plains on the top of high mounds, like the water of aqueducts, and at Ferrara the surface of the Po has become more elevated than the roofs of the houses."

On reading this passage one cannot but tremble for the fate of the city should the river break through its dykes, as it has already done on several occasions, and, being precipitated into the city, tear its way headlong to the sea.

A visit to Ferrara toward the end of May last served, however, to show that this danger is less imminent than might be supposed from Lyell's description.