as the mandible and the hyoid and scapulary arches. From a study of the skull, it becomes apparent at once why in fossil teeth of *Ceratodus* nothing or very little of the bone attached to them has been preserved. Those teeth rest on cartilage as well as on bone, the latter being a very thin and porous layer which could not be preserved, unless the progress of stratification had been going on with as little disturbance as in the Solenhofen Schiefers; but the matrix in which fossil Ceratodont teeth are found shows that it was formed under very different conditions, and it is certainly not of a nature to permit the supposition that thin porous lamellæ of bone would have been preserved entire.

The structure of the skeleton reminds us much of that of the sturgeons, Chimæra, and especially of *Lepidosiren;* and of all the modifications by which it differs from these types, perhaps none is of greater interest than that observed in the paddles. The central part of the paddle, which we have found externally to be covered with scales, is supported by a jointed axis of cartilage extending from the root to the extremity of the paddle; each joint bears a pair of three- or two- or one-jointed branches. This is the case in the hind as well as fore paddles, and we are justified in supposing that those extinct Ganoids of which impressions of paddles with scaly centres have been preserved, were provided with a similar internal skeleton. Professor Huxley, some years ago, drew attention to the analogy existing between the filamentary limbs of *Lepidosiren* and the lobate fins of certain extinct Ganoids, and the correctness of this view is fully borne out by the discovery of *Ceratodus*, inasmuch as the *Lepidosiren*-limb proves to be typically the same as that of *Ceratodus*, but reduced to the jointed central axis.

The gills are perfectly developed, four on each side. They are broad lamellated membranes, free from each other, but attached to the outer walls of the gill-cavity. One can hardly doubt that, in water of normal composition, they are sufficient for the purpose of breathing. A lung, however, is superadded to them, a true lung, which receives blood from a branch of the aorta, and returns it directly to the heart by a separate vein. Whilst the Barramunda is in water sufficiently pure to yield the necessary supply of oxygen, the function of breathing rests with the gills alone, and the lung receives arterial blood, returning venous blood, like all the other organs of the body; under this condition it does not differ from the air-bladder of other fishes. But when the fish is compelled to sojourn in thick muddy water, charged with noxious gases, which must be the case very frequently during the droughts which annually exhaust the creeks of tropical Australia, it commences to breathe air in the way indicated above; under this condition the pulmonary vein carries purely arterial blood to the heart, where it is mixed with venous blood and distributed to the various organs of the body. If the medium in which the fish happens to be is perfectly unfit for breathing, the gills cease to have any function; if only in a less degree, the gills may still continue to assist in respiration. In short, the organisation of the Barramunda is such as to justify us in the assertion that it can breathe by either gills or lung alone, or by both simultaneously.

With regard to the structure of the lung, it shows a nearer approach to the air-bladder of other living Ganoid fishes than that of *Lepidosiren;* it is not paired, but consists of a single long sac extending nearly to the end of the abdominal cavity. Yet the interior of the sac shows a symmetrical arrangement of the right and left side, being subdivided into numerous cellular compartments, by which the respiratory surface is much increased in extent.

The next organ of importance for determining the systematic affinities of the Barramunda is the heart. Considering the great resemblance this fish has shown in other respects to *Lepidosiren*, I fully expected to find this organ agree also with the Dipnoous type; but this is not the case. Instead of the two longitudinal valves of the Dipnoous heart, the *bulbus arteriosus* is provided with two or three transverse series, of which one only is fully developed; or, in other words, *Ceratodus* proved to be a Ganoid fish. But, as *Ceratodus* and *Lepidosiren* are in all other points too closely allied to be separated in two distinct sub-classes or even sub-orders, we must arrive at the conclusion to drop the *Dipnoi* as a sub-class, and to refer *Lepidosiren* also to the Ganoids, which will then be characterised, not by transverse series of valves, but by the presence of a muscular, contractile *bulbus arteriosus* with valves, transverse or longitudinal, in its interior—a structure which they have in common with the sharks and rays (*Plagiostomata*).

The intestinal tract is a large straight sac with an internal spiral valve, as in the Ganoids and Plagiostomes. The kidneys are paired, the ureters enter a very small urine bladder or cloaca at the back of, and partly confluent with, the rectum.

The organs of propagation show some noteworthy peculiarities. They are paired, in long bands. The male organs have no visible outlet, although a seminiferous duct has been found traversing the substance of the testicle through nearly its whole length; no outward opening could be discovered, and it is not known how the semen is discharged. The ova are small, very numerous, and attached to transverse laminæ of the ovaries; when mature, they fall into the abdominal cavity, as in the salmon tribe, and would appear to be expelled through two wide slits behind the vent. Yet each ovary is accompanied by a long oviduct, as in the sturgeon or *Lepidosiren*, though it probably has no function, and is only indicative of an approximation of this remarkable fish to higher types. Such are some of the principle features of the organisation of the Barramunda; and it remains now to add some remarks on its affinities and its place in the system.

A. GÜNTHER

(*To be continued.*)

ON EXOGENOUS STRUCTURES AMONGST THE STEMS OF THE COAL-MEASURES

IN a memoir recently read before the Royal Society, I propounded a new classification of the vascular cryptogams, and at the late meeting of the British Association at Edinburgh I brought the same subject forward, when my views were opposed by Mr. Carruthers, Dr. M'Nab, and Prof. Dyer, as reported in the columns of NATURE for Aug. 31. I was well aware that when I disturbed existing and time-honoured systems of classification I should meet with such opposition; but, being thoroughly convinced that my views are sound, and that they will ultimately be adopted, it only remains for me to face the conflict, and persevere with my demonstrations of what I believe to be true. My present object is to do what was impossible in the hurried and unsatisfactory discussions that frequently arose at the meetings of the British Association to accomplish, viz.: to take care that there shall be no misunderstanding as to the real points at issue. My opponents seek to interpret the gigantic arborescent stems of the coal-measures by the light of the dwarfed and degraded examples of vascular cryptogams which constitute their living representatives. I, on the other hand, claim to interpret the latter by the former, some of which, the Lycopods, for example, instead of being feeble things trailing in the grass, had stems three feet in diameter, and rising a hundred feet into the air. Instead of merely constituting a verdant carpet for forests of noble exogens and endogens, they were the forest; here, consequently, we might expect that whatever characteristic features they possessed would be developed and displayed in their utmost perfection.

Mr. Carruthers' fundamental argument is, that I, in my classification, elevate the vegetative organs at the cost of the reproductive ones. I reply I am merely applying principles already adopted by botanists throughout the world. They are those of DeCandolle, of Endlicher, of Lindley, of Brongniart, and of Balfour. These writers, in common with most others, recognise primary distinctions that are purely vegetative. Not only are those which separate vascular from cellular plants of this character, but the further ones of exogens, endogens, acrogens, and thallogens are of the same nature. The fact of the closest resemblance of the inflorescence, and of the formation of the embryo in the embryo-sac in the two groups, does not prevent the separation of the flowering plants into exogens and endogens. Turning from the phanerogamous to the cryptogamic plants, we find that nearly every writer of importance adopts vegetative features as the basis of his classification. DeCandolle divides his *Acrogens* into those which have and those which have not vascular tissues. Endlicher's primary term *Cormaphyta* refers to a vegetative feature, viz., the possession of a stem, whilst his secondary divisions of *Acrobrya*, *Amphibrya*, and *Acramphibrya* all refer to the mode of growth and not to fructification. Lindley again distinguishes his flowerless plants according as they are acrogens or thallogens; whilst Balfour characterises them primarily as acrogens or cormogens and thallogens. In thus dwelling upon the vegetative element of the cryptogams, I am merely treading in the steps of nearly every writer of note who has written on these subjects. So much, therefore, for the primary point.

In many of the discussions which have taken place, my opponents have made the mistake of supposing that I was trying to prove these fossil coal-plants to be dicotyledonous exogens. Whereas what I have throughout contended for is that they are true cryptogams with an exogenous woody axis. Mr. Carruthers says, "The plants were true cryptogams, and in their organisation agree in every essential point with the stems of Lycopodiaceæ" (NATURE, p. 337). With this I of course agree, but I contend that we must interpret the lower forms by the higher and not the higher by the lower. In Carboniferous ages, these plants became superb forest trees, and consequently their stems attained their full development, growing year after year, from their almost microscopic condition when they burst from a microscopic spore, until they became stately trees, such as were revealed at Dixon Fold, and such as are illustrated by specimens now in the Manchester Museum. In the course of their magnificent development the stems were gradually fitted to sustain an enormous weight of branch and foliage. This was done by the development, within those stems, of a vascular woody cylinder, which grew thicker year by year; *such thickening being the result of additions to the exterior of the previous growths.* We here come to a definite issue. Do my opponents intend to deny the existence, in these arborescent carboniferous plants, of these thick ligneous cylinders, or to dispute that they grew in the way described? I think they cannot possibly contemplate doing so. Dr. M'Nab says botanists are agreed in this, that "Lepidodendra and their allies are closely related to other Lycopods. Now we know that the Lycopods, *like the Ferns, have closed fibro-vascular bundles; bundles which can only grow for a certain time, and then, all the cambium being converted into permanent tissue, growth must cease.*" The italics in the preceding paragraph are my own. With the above remark, so far as Ferns are concerned, I thoroughly agree. The facts so correctly stated by Dr. M'Nab constitute one of the fundamental bases of my proposed classification. The vascular bundles *are* closed in all the small ferns, and they remain equally so in the Cyatheas and other arborescent ferns which attain to stately dimensions. The development of this type into a lofty tree has not materially modified the structure of the stem which recurs in the most dwarfed species. But when Dr. M'Nab applies the above general statement to the Lycopods, facts do not sustain him. The huge lepidodendroid carboniferous plants give it a direct contradiction. They have *not* closed vascular bundles, and their growth did *not* cease after a limited time, but was obviously continued, being sustained by a cambium layer, until the plants assumed the magnificent dimensions which their fossil remains now exhibit. That the large vascular cylinder of the fossil forms is a development of what is seen, not only in *Lycopodium chamæcyparinus* referred to by Dr. M'Nab, but in every one of the numerous Lycopods of which I have examined sections, I have never denied. Quite the contrary. But I repeat we must interpret the significance of the *least* developed form by that which is *most* developed. Consequently we must regard the irregular vascular bundles which exist, commingled with cellular tissues, in the axis of each living Lycopod, as a degraded wood cylinder, whose nature can only be understood by reference to what it once was when its parent tree was one of the glories of the primæval forest. The race as a whole has become degenerate, and the stem being no longer called upon to sustain a lofty superstructure, its structure has become equally degenerate.

I will not enter in detail into the question of the nomenclature of the various parts of these exogenous cryptogamic stems, but reserve that subject for some other occasion, after my detailed memoirs now in the hands of the Royal Society have been published. I will merely express my conviction that Mr. Carruthers, who differs widely from me on the subject, assumes the very question in debate between us.

He holds that we can draw no parallel between the conditions existing in the stems of Cryptogams and those of Phanerogams. This is precisely what I contend we can do, and I trust to be able, as my self-appointed task proceeds to its conclusion, to demonstrate to the botanical world that I have abundant reason for so doing. This is a question wholly resting upon facts, and until those facts are fairly before the world, I object to the adoption of any *a priori* conclusion on the subject. Consistently with his views Mr. Carruthers objects to my applying to the stems in question such terms as medulla and medullary rays; especially objecting to the application of the term medulla to a structure containing vessels, *i.e.*, a vascular medulla; but Nepenthes has a vascular medulla, as well as some other phanerogamous plants, and no one presumes to deny the medullary character of such a tissue, because it happens to have vessels in it. The medullary character of the structure does not rest upon the basis of its being wholly devoid of vessels, neither does their occasional presence militate against its being a medulla.

In the preceding remarks I have confined myself substantially to the task of making clear the points at issue between my opponents and myself. In adopting my views of the exogenous structure of the stems in question, I am but following in the steps of some of the ablest of living botanists. M. Adolphe Brongniart, than whom no higher authority can be named, not only adopts the exogenous theory, but is so deeply impressed with its force that he denies the probability of many of the plants in question having been cryptogamic. He places them amongst the gymnospermous exogens. Recent events, however, have shown that though exogenous they are true cryptogams. How absurd, then, to apply to such stems the term acrogen or acrobrya! This controversy must be ultimately settled by the logic of facts, not by vague opinions, and to these I confidently appeal. The details of my proposed classification can only be discussed when all the facts are before the public. When this is the case, I hope to show that my proposition not only does no violence to the true affinities of living cryptogams, but that, in bringing the ancient and modern types into a philosophical relationship, it accomplishes what, under existing systems of classification, it is impossible to do.

W. C. WILLIAMSON