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## THE EVOLUTION OF THE CRYPTOGAMS

*L'Évolution du Règne Végétale.* Les Cryptogames.

Par MM. Saprota et Marion. Bibliothèque Scientifique Internationale, xxxi. (1881.)

THIS exceedingly valuable contribution to the history of the evolution of the vegetable kingdom, to be followed by a second volume dealing with the Phanerogams, is fully illustrated by 85 figures.

It is almost superfluous to remark on the exceptional qualifications with which the authors enter upon the task, for they have already produced some of the ablest works, particularly upon fossil plants. Although much of the material they have had to deal with has not been more than usually satisfactory, their work has been singularly free from the arrogance of other writers on the subject of fossil plants, who pretend to a clairvoyance enabling them to determine unhesitatingly even fragments of leaves of extinct trees when every organ necessary for botanical determination is absent. When, as in the great majority of cases, subsequent discoveries prove these gentlemen to be wrong, we hear nothing from them, but when their guesses prove right, they are exceedingly jubilant.

At the outset the authors lay some stress on the fact that a less complex organisation does not necessarily imply relative antiquity. Circumstances exceptionally favourable to certain series of plants have forced their development to a state never afterwards surpassed, but which, on the contrary, has retrogressed by the elimination of hastily-developed or prematurely-adopted types. New series or new branches given off by the same series have constantly replaced, in all ages, the series or the branches which have died out or declined, and the vegetable kingdom, taken as a whole, has constantly progressed. The book, moreover, is not written for those who totally disbelieve in the principles of evolution, for no proof that it contains will convince them; but those who wish to understand the successive modifications that have led to the comparatively recent group of Angiosperms, will find it full of interest.

Commencing with the Protista, the authors lead us through the Protophytes to the Lower Metaphytes, which together constitute the artificial group of Cryptogams. These represent an elder branch of the vegetable kingdom, and lead, by perfectly natural transitions, to the Phanerogams, the younger branch, of which the latter offshoots appeared only at long posterior dates.

The origin of all plants is in protoplasm, and those of the Protista which are amorphous, yet possess the essential attributes of life, may well be thought to reproduce the probable characteristics of the earliest primordial plants. On the southern shores of France creatures several centimetres in length are dredged from depths of five to ten fathoms, whose substance is entirely penetrated with fine particles of the sea bottom. They would pass unnoticed did they not shift their position with extreme slowness and extend short prolongations. Placed in a glass of sea-water they attach themselves to the sides, and free themselves gradually of sand, when a slightly yellow hyaline jelly, absolutely deprived of nucleary elements,

is disclosed. They are allied to the Protamœba, Protobathybius, and Pelobius, and from these starting points all the progressive stages of development are traced.

In certain organisms among the Protista the protoplasmic mass secretes a rigid envelope, and when, further, a portion of the protoplasm becomes converted into another substance, "chlorophyll," all the characters of vegetable life are realised. In the interior of these cells the protoplasm remains truly amœbous, and acts and is acted upon in precisely the same manner as in animal amœbæ, but this special substance chlorophyll gives rise to a whole series of new physiological functions, and its presence alone marks off animal from vegetable life. The only distinction that can be drawn between the two kingdoms is thus entirely due at the commencement to a transformation of part of the elementary protoplasm.

Leaving the Protista, the authors treat at some length the embryogeny and methods of reproduction of Protophytes, especially the Algæ, tracing these through the primitive and single-celled diatoms and desmids, with soft or hard envelopes containing protoplasm charged with chlorophyll, to the higher forms in which special organs are developed, as the Floridæ, Fucaceæ, &c., and the Characeæ. Setting aside the Fungi and Lichens as groups whose development has been arrested by parasitic habit, the authors proceed to consider the manner in which aquatic vegetation became first adapted to terrestrial life.

While the more highly organised and complex Algæ have preserved those aquatic habits necessitated by physiological functions, numerous species of Nostochineæ, Palmelleæ, and Vaucheria have quitted the water from time to time to vegetate in humid places on land. These furnish the earliest indication of adaptability to aerial life, and it is curious to find that this proceeds from lower forms of Algæ but slightly differentiated from each other morphologically, and not from the more completely evolutionised types. Some, with flat cellular fronds, such as Ulva, crept, it is supposed, face to the ground and became ancestors of the Hepaticæ. Others, more confervoid, produced a thallus whose growth, necessarily apical, became complex by simple vegetative multiplication. Foliary appendices were given off, and a sort of plantlet with rootlets, stem, and leaves, all strictly cellular, came into existence, capable, like the Mosses at the present day, of agamous reproduction. In the earliest stage of growth of the Equisetaceæ, of Ferns, and of Ophioglosseæ, we see a similar primordial cellular plant, called a Prothallus, develop from the spore, and resembling in every respect the lower Algæ. This prothallus bears the sexual organs, and it may here be noticed that it is impossible to insist too strongly on the influence exercised by the act of reproduction on the differentiation of primordial plants.

In lowly developed types the act of reproduction arrests what may be termed their nutritive life. This act may be "precocious" or "tardy," the variations in the time of sexuality exerting a dominant influence on the morphologic differentiation of life. In the well-known case of the Axolotl the embryos of the same birth may either have well developed or only rudimentary sexual glands. In the former case the fry reproduce precociously before losing their branchiæ, while those which reproduce more

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tardily become transformed into "Amblystomes," their morphologic differentiation being unchecked by the act of reproduction. Similarly among primitive terrestrial Algæ, those in which sexuality was deferred until late had a longer period of purely vegetative life, and therefore not only felt more strongly the influence of new conditions, but had a longer time in which to adapt themselves and thus become diversified in type. The resultants of this elaboration are represented now by the Mosses and Hepaticæ. In the Mosses the spore gives birth to a confervoid thallus called "protonema," a reversion apparently to the primitive ancestral Alga. This elementary thallus, not being arrested by the appearance of sexual organs, is susceptible to subsequent differentiation; foliary buds are given off in places from its ramifications, the multiplication of cells at these points becomes regular, and little by little small laminæ assume the form of leaflets on a stem supported by radicles. These radicles are capable of producing new plants, and mosses propagate so energetically that extensive carpets may be formed without the aid of reproductive organs, and in some species fruiting plants are rarely met with. This great vegetative power seems entirely due to the absence or rarity of sexual function. The reproductive organs when present are however of the greatest morphological importance. These are distinguished as "antheridia," or male, and "archegone," or female. At maturity antherozoids escape from the antheridia and impregnate the archegone. The "oospore" contained in the archegone produces a new cellular plant, which develops more or less within the archegone in which it is born, and finally becomes the organ called "fruit" in the Mosses. This so-called fruit is in reality a distinct plantlet, called a "sporogone," which by asexual generation or simple multiplication gives birth to the spores, and these spores, falling in damp places, again give rise to new thalli or moss plants. This alternate generation is unknown among Algæ. We have thus in the Mosses a new point of departure, the more important generation, being analogous to Algæ and tardily sexual, take on very complete morphological characters; the other generation, agamous, subordinate, and incapable of disengagement from the archegone in which it is formed, yet fundamentally an independent plant. The Hepaticæ are similar in growth, and both together present a stationary group which have elaborated a special kind of organic differentiation, but in a direction limited by biologic conditions. Derived from cellular thalli with "tardy sexuality," evolution has acted exclusively on the first generation; while the second, of newer origin and free from heredity, would have been susceptible of far more complete differentiation. The truth of this hypothesis becomes apparent when Ferns, Equisetaceæ, and Ophioglossæ are studied.

The origin of these three groups is similar to that of the Mosses and Hepaticæ. Their spores give birth to a cellular thallus or "prothallus," which "precociously" produces numerous archegones and antheridia. The same process takes place as in the case of Mosses, except that the resulting "sporogone" is vigorous and speedily effaces the ephemeral life of the sexual plant. It promptly frees itself and takes root, its tissues become extremely diversified, and fibres and vessels, histological elements previously unknown, appear, and plants known as ferns,

horsetails, &c., result. On the leaves of this highly-developed sporogone the sporangia are born which produce the spores, whose germination gives birth to the sexual prothallus. The precocious and abundant development of sexual organs almost immediately arrests the differentiation of the prothallus, and the primordial aerial Alga becomes completely subordinate. On the other hand the sporogone which succeeds became more and more developed and commenced a series which step by step has led finally to the most highly organised and most recent group of plants, the Angiosperms. The evolution which has given us those plants, which seem to an inattentive observer to form nearly the entire vegetation of the earth, is in the authors' opinion the result of a circumstance, doubtless almost insignificant in its commencement, and of which the first effects were to arrest by a precocious sexuality the organic differentiation of some of the primordial terrestrial plants. While everything seemed to unite to favour the evolution of those types with permanent thalli, and which produced Mosses and the Hepaticæ, other thalli of lower development found in the very causes which limited their differentiation, the starting point of a new vegetative system, that of the sporogone, the preponderance of which soon became manifest. In the Rhizocarps we see this species of development in a more advanced stage than in the Ferns. The sporogone has become more and more preponderating, and the prothallus scarcely disengages itself from the envelopes of the spore.

Ferns occasionally exhibit a tendency to a separation of the sexes, for the prothallus may be either male or female, but in the Rhizocarps dioecy is more nearly realised, for the spores themselves are of two sexes—microspores and macrospores. The germination of the microspores consists simply in the production of tubes scarcely divided into cells, in one of which the antherozoids are produced. In the macrospore, though a rudimentary prothallus is at first more or less apparent, this is quickly concealed by the extension of the sporogone developed within one of the archegones. With the disappearance of the rudimentary prothallus almost the last trace of the primordial cellular Alga disappears.

The prothallus is thus seen to be so reduced in the Rhizocarps that it seems almost as if the sporogone were disengaged directly from the macrospore. This sporogone follows otherwise the same histological development as in Ferns, but gives birth morphologically to a further departure. Certain fronds become differentiated into "sporocarps," a kind of fruit comprising both micro- and macrosporangia, and which in *Marsilia* attain remarkable complexity. This is the highest point of evolution seen in existing Cryptogams, for the Lycopods are rather a parallel development than an actual advance beyond the Rhizocarps. They are divided into Isospores, or true Lycopods, in which the sporogones bear but one kind of spore, producing monœcious prothalli only; and the Heterospores (*Selaginellæ* and *Isoetes*), in which the sporogone bears both microspores and macrospores.

In the microspores of heterosporous Lycopods a single cellule represents the male thallus, and appears a useless appendicle to the antherozoid-producing cellules. The macrospore germinates into two cellular masses, corresponding to the female thallus, which, although never



entirely disengaged from the envelopes of the spore, still produces true archegones destined to receive the impregnation of the antherozoids.

In these, as in all the Metaphytes of which we have been speaking, the spores become detached before germination. While this caducity always characterises the microspore, the macrospore separates less readily from the sporogone, and the method in which the sexes in primordial plants became separated is doubtless indicated by this tendency. The microspore always represents the male and the macrospore the female thallus, the physiological functions which they have to effect being very different. Activity characterises the male element, which always seeks the female element, necessarily more complex, voluminous, and charged with plastic substances. It is easy to conceive the possibility of the existence of a stage, a little above the existing heterosporous Lycopods, in which the microspores alone become detached before germination, and seek the macrospores while still attached to the fronds of the sporogone, which would then germinate on the plant and receive impregnation before their fall. It is true that we can say nothing definitely as yet respecting the extinct allies of the Lycopodiaceæ, which may have possessed this character, but the course of evolution requires this stage to have existed, and it is recognisable in the Gymnosperms and Angiosperms.

In these, the culminating development of the vegetable kingdom, the sporogone masks completely the primordial vegetative system, of which however there still remain traces. The sporogone, which has become differentiated into the most varied and complex plants with organs of the utmost delicacy and efficacy, invariably produces spores of two sorts. The microspores (or pollen grains) quit their sporangia (anthers) before germination, to fecundate the female spore, but impregnation no longer depends on the action of vibratile corpuscles; leaving an antheridium. The entire ancient life of the male prothallus with its cellular tissue and its antheridia is represented by a tube piercing the exospore or external membrane of the pollen grain and coming into contact with the female element. The male protoplasm is no longer in corpuscles, but in order to impregnate, directly traverses by endosmose the membrane of the pollinic tube. The gradations by which this reduction of the male prothallus has taken place are not preserved in any existing plant.

The manner in which the development of the female macrospore has been arrested is even more remarkable. A special macrosporangium or "ovule" is born in Phanerogams, on branches of the sporogone in which the leaves are transformed into what is called a flower, an organ not differing morphologically from the sporangium-bearing spikes of Cryptogams. That no complete interruption or hiatus really exists between these different types of vegetation is demonstrated by a study of the macrosporangia of Gymnosperms.

In these the macrospore or embryonic sac contained in the macrosporangium (ovule) germinates on the spot and gives birth to a true prothallus or primordial cellular vegetative system, which fills the entire ovule. On this inclosed prothallus of the Gymnosperms (Conifers and Cycads), called an "endosperm," archegones appear (the "corpuscles"), which are fecundated by the last rudiment

of the male prothallus (the pollinic tube). This is accomplished while the macrosporangium is still attached to the sporogone, and results in the production of an embryo in place of the oospore of the archegone. This rudiment of the new sporogone is already well developed when the macrosporangium or seed becomes detached. The sporogone only apparently succeeds directly to another sporogone, for actually the primordial vegetative system has preserved its sexual function; concealed and reduced as it is, it has still presided over the earliest developments of the agamous phase of the plant.

In certain Gymnosperms (*Salisburia*), and as if to better demonstrate the successive stages which have led from the Cryptogams to Phanerogams, the pollinic tube has inaugurated its movement, and the seed, apparently ripened, falls from the tree before the formation of any corpuscles or archegones. These are scarcely developed in the ovule, before the penetration of the male organ operates fecundation and gives birth to the phenomena which result in the formation of the embryo.

In the Angiosperms these processes are further reduced and the macrosporangium still more concealed by the production of an ovary. In tracing the homology of the complex and delicate processes involved in the reproduction of Angiosperms the climax of plant-evolution is reached.

Enough has been said to show the scope and value of the work which Saporta and Marion have laboriously produced. That part which attempts to bridge the gap, hitherto perhaps the most complete break in the natural system, is of such great importance that I have almost quoted the authors' own words. The interpretations and ideas set forth may perhaps be insufficient to carry complete conviction, but it will be seen that the remainder of this work, which treats principally of palæontology, confirms the theories derived from study of existing plants.

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(To be continued.)

#### PROF. ROBERTSON SMITH ON THE OLD TESTAMENT

*The Old Testament in the Jewish Church.* By Prof. W. Robertson Smith. (Edinburgh: A. and C. Black, 1881.)

THE only result of the "baiting" to which Prof. Robertson Smith has been subjected seems to have been the exact reverse of what his assailants intended. Forbidden to lecture upon Hebrew philology at Aberdeen, he has been invited to Edinburgh and Glasgow, there to detail to crowded audiences the method and conclusions of biblical criticism.

No one could be more fitted for the task he has undertaken than Prof. Robertson Smith. Clear-headed, acute, and learned, he had been a devoted student of natural science before he suddenly turned his attention to the Semitic languages and Old Testament criticism. The scientific habit of mind he had acquired was carried by him into his new studies, and it was inevitable that he should attach himself to that modern school of philologists and historians which by the application of the scientific method has revolutionised the study both of language and of history. He believed that the prin-