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THE MARINE BIOLOGICAL LABORATORY
OF WOODS HOLL

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FIRST LECTURE.

THE EVOLUTION OF THE SPOROPHYTE IN THE HIGHER PLANTS.

DOUGLAS HOUGHTON CAMPBELL.

The questions relating to the origin of organic structures must always possess great interest for the biologist, and when I was asked to speak before the students at Woods Holl, it seemed to me that a discussion of recent views bearing on the development of the spore-producing structures of the higher plants, *i.e.*, the Archegoniates and seed-bearing plants, would not be inappropriate.

There is good reason to suppose that among plants, as among animals, the most primitive forms were aquatic; and it is highly probable that many existing fresh-water algæ are but slightly modified descendants of these ancestral types. This is evinced by the great uniformity shown by existing green algæ all over the world. Most genera and many species are cosmopolitan, and they exhibit far less variety than is shown by their larger and more specialized marine relations. Presumably the conditions in fresh water have changed but little, and as the more specialized forms have taken to the land, or have developed in the sea, the few that remained in their primitive environment have been subjected to much less competition, and have probably persisted with but little change from very remote times.

Leaving aside certain forms of doubtful affinities, like the bacteria and blue-green algæ, the existing forms which represent most nearly the ancestors of the higher plants are the Volvocineæ and Protococcaceæ. The former are, as all botanists know, free-swimming green organisms which show resemblances on the one hand to low animals, and on the other are very like the free-swimming reproductive cells, or zoöspores, of many of the higher algæ. The latter probably originated from forms like the simpler Volvocineæ by the loss of motility associated with the development of a continuous cellulose membrane about the vegetative cells. This stage in the evolution of the green algæ is represented by some of the simpler Protococcaceæ. Above these unicellular forms are a number of filamentous plants, single rows of nearly uniform cells. Such plants are Œdogonium or Conferva, which well represent the next step in the evolution of the plant body.

The differentiation of the reproductive cells in the algæ, while it offers one of the most interesting and instructive examples of the evolution of plant structures, must be passed over here. It may be mentioned, however, that the differentiation of the sexual cells has evidently taken place quite independently in several groups of algæ.

In the further development of plant types two very important factors are to be considered. First, the adaptation to a marine existence, and, second, the exchange of an aquatic for a terrestrial life.

The conditions in the ocean are markedly different from those in fresh water, and most plants which have adapted themselves to life in the sea have become decidedly changed. The salinity of the water has no doubt been one of the factors in these changes, but more important is probably the question of light. The two most characteristic groups of sea plants, the red and brown seaweeds, are provided with special pigments in addition to the chlorophyll, and there is little question that these pigments are developed, in part at least, in response to changed light conditions.

As the conditions of light and temperature in a marine environment are far more constant than those in fresh water, we find, as a rule, that marine algæ, especially those inhabiting the deeper water, are more susceptible to changes of light and temperature than are most fresh-water forms.

While certain seaweeds growing between tide-marks are subject to exposure to the air, it is only for a short time, and we find in most such algæ a development of mucilaginous tissue which prevents their complete desiccation.

These seaweeds have adapted themselves perfectly to their peculiar environment, and such highly specialized forms as the great kelps and many red algæ probably represent the highest types of these marine plants. They have diverged widely from the simpler fresh-water algæ, and there is no reason to suppose that they have given rise to any higher types.

The simple fresh-water green algæ, which, so far as we know, most nearly represent the ancestors of the terrestrial green plants, differ much in their conditions of life from the seaweeds. Most bodies of fresh water are subject to great fluctuations of depth, often drying up completely for long periods, or sometimes being frozen. It is obvious that plants living under such conditions must be very resistant, and we find that such is the case among most green algæ. Not only, as a rule, are they capable of enduring a great range of temperature, but usually at the end of their vegetative period they produce special cells, "spores," which can endure complete desiccation without injury, and are also uninjured by freezing. By means of these "resting-spores" the plant is carried over from one growing period to the next, and when the conditions are favorable, the spores germinate and give rise to a new generation. This production of resting-spores is one of the most striking differences between these fresh-water algæ and their red and brown relations in the sea, where there is usually no necessity for such resting-spores.

Certain green algæ, like some species of the common genus Vaucheria, may be considered amphibious, as they do not actually grow in the water, but are exposed to the air on the surface of moist earth, from which they absorb the water necessary for their growth. The ability to thus grow with a diminished water supply is an evident advantage, and in some such way as this it is probable that the first strictly terrestrial plants originated from some originally aquatic algal ancestors.

We can imagine some such forms gradually becoming better and better able to vegetate on the mud left by the subsidence of the water, and finally becoming adapted to life on land. The