

LICHENS AND SYMBIOSIS

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When Schwendener announced in 1867 that the gonidia of lichens are algae and that a lichen is, therefore, not a single plant but a group of plants, the idea met with instant and prolonged opposition. Nylander, who was the foremost lichenologist of the time, never accepted the theory and wrote very bitterly against it. One of the chief reasons for the opposition seems to have been that the systematists were afraid that the components of lichens would be distributed among the fungi and algae and the group of lichens as a systematic subdivision of the plant kingdom would disappear.

The distribution of lichen-fungi among the other fungi is, of course, perfectly logical from the systematic point of view, and at present, after more than half a century has elapsed since the announcement of the dual nature of lichens, a few workers in this country are attempting to accomplish it. The lichen-fungi differ so greatly in vegetative characters from the other fungi, however, that a classification which maintains them as a distinct group is much more convenient and usable than one which distributes them among the already enormous numbers of other fungi. For this reason, for most botanists there will probably always be a distinct lichen group, however illogical it may seem to the systematists.

Some of the workers who have considered it advisable to classify the lichen-fungi among other fungi have contended that a lichen is simply a fungus and that they are classifying lichens among the fungi. It will be profitable, therefore, to consider for a moment the use of the term lichen. When the word lichen was first used, of course, it was thought that the lichens were single plants like liverworts. In fact they were at one time classed with the liverworts in one family. The discovery of the dual nature of lichens by Schwendener, however, demonstrated that the things called lichens are comparable to insect galls, mycorrhizas, root tubercles, and other sorts of galls, in that they are produced only through the intimate parasitic association of unlike organisms. This being the case,

it is not logical to apply the term lichen to either of the organisms concerned. A fungus is a fungus and an alga is an alga, and it takes the two together to make a lichen. A lichen-fungus without an alga will never grow up to be a lichen. Usually it will not grow up at all. In any case, however, it is entirely possible to have a lichen-fungus without algae, but we can no more have a lichen without algae than we can have a mycorrhiza without a root. (One exception to this statement has recently come to light in the case of *Rhodobacteriophora* in which there are purple bacteria in place of algal symbionts. The principle involved is the same here as in other lichens, however, and the force of the argument is not diminished by this exception.¹)

The objection has been made that unless we consider the lichen-fungus to be the lichen it will be necessary to invent new names for all of the lichen-fungi in order to distinguish them from the names used for the lichens. Probably certain systematists who are overly fond of publishing new species names, with their own names following them, would be delighted with such a task. There is no need, however, for any such action. If we recognize, as we must, that lichens are comparable in many respects to the various kinds of galls, we can readily see that there is no need of a name for a lichen as distinct from that of the lichen-fungus. The algae that are concerned in the make-up of a lichen ordinarily belong to well-known species which already have names, and there is no reason why the names by which the lichens are known should not be used for the other components. This in fact is what has been done, consciously or unconsciously, for the last half century. We do a similar thing in the case of many insect and fungus galls. We collect a gall from a poplar tree and we say it is *Pemphigus vagabundus* on poplar. We understand perfectly that *Pemphigus vagabundus* is the name of the gall-forming insect but we use it also to designate the gall. Or we collect a black "knot" from a plum tree and we call it *Dibotryum morbosum*, although this is merely the name of the parasitic fungus. No confusion results from this usage nor is there any reason

(1) Uphof, J. C. Th. Purple bacteria as symbionts of a lichen. *Science* 61: 67-1925.

for confusion from a similar usage of names in the case of lichens. It cannot be argued that the galls mentioned are very different from a lichen in that the entire host plant is not involved, for the difference is only one of degree. If an entire oak tree were greatly modified by a parasitic insect or fungus we would still call it a gall and would designate it in the same way that we do other galls. It should be reiterated that there can be no logical objection, unless it be that of convenience, against classifying the lichen-fungi along with other fungi, but we cannot call a lichen-fungus a lichen any more than we can call a mycorrhizal-fungus a mycorrhiza or a gall-insect a gall; we cannot say that lichen is a fungus any more than we can say that a mycorrhiza is a fungus or that a gall is an insect.

The exact physiological relationship between the two components of a lichen is still very imperfectly known, although it has been studied and discussed for a very long time. Some writers have thought that a lichen represents a sort of partnership between the fungus and the alga, each partner supplying to the other certain necessities of life in a spirit of neighborly regard. Others have taken a somewhat opposite view and have painted the fungus as a culprit which has made a slave of the poor alga. Still others, getting back to a botanical way of looking at things, have in some cases considered the fungus as an ordinary parasite on the alga, or, on the other hand, have said that the fungus is diseased by the alga.

It is improbable that the physiological relationship between lichen-fungus and alga is exactly the same in all cases. It is reasonably certain, however, that in the majority of lichens the fungus obtains organic food from the alga, either as a parasite on the living gonidia or as a saprophyte on dead ones. Similarly, it is certain that the alga obtains water, at least, from the fungus, either directly or indirectly. The relationship has apparently reached such a balance that it is more or less normal for both fungus and alga and both can endure it, therefore, without suffering. This, however, must not be taken to imply a sort of reciprocity agreement under which each

party supplies something to the other. Rather each party takes all it can get from the other. In other words the lichen represents a case of double, or reciprocal, parasitism.

This rather nicely balanced relationship is not vitally different from the social relationship between the green plants and the fungus flora of a forest, in which the fungi use organic food that has been elaborated by the green plants and the green plants use food materials that have been made available through the activities of the fungi. In this case, however, the organisms concerned are not in actual, intimate contact and they derive materials only indirectly, rather than directly, from one another.

Now symbiosis means the living together of two or more unlike organisms. It includes all such cases regardless of their physiological relationship.² There can be no question, then, of a lichen not representing a case of symbiosis. When the organisms concerned are in actual contact, as in a lichen, the symbiosis is said to be *conjunctive*, while those cases in which the symbionts are not in actual contact, as the green plants and fungi of a forest community, represent *disjunctive* symbiosis. When there is no food relationship between symbionts, as in the case of an epiphyte on a tree, the symbiosis is *social*, while if there is a food relationship it is *nutritive*. Nutritive symbiosis is further subdivided into *antagonistic*, to include cases in which only one symbiont, or at least not all of them, derives benefit, such as ordinary parasitism or disease, and *reciprocal*, to include cases in which more than one symbiont derives benefit from the relationship. From these remarks it will be readily seen that if the physiological relationship between lichen-fungi and algae (gonidia) is substantially as described above, a lichen represents a case of reciprocal nutritive conjunctive symbiosis.

(²) For a more detailed discussion of the use of the term symbiosis see McDougall, W. B. The Classification of Symbiotic Phenomena. Plant World 21: 250-256, 1918.