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FUNGAL SYMBIOSES

ERZSÉBET JAKUCS

Department of Plant Anatomy, Eötvös Loránd University Budapest, Hungary

Demonstrating different types of biotrophy fungi are outstanding within eukaryotes. All types of symbioses sensu deBary [1] (parasitism, mutualism, amensalism, commensalism, neutralism, antagonism) and all possible transient forms of these are represented by them. Furtherly the word "symbiosis" will be used, as commonly, in the strict concept as mutualistic symbiosis.

It has been long debated on whether biotrophic or saprophytic forms could be the ancestors of terrestrial fungi. Evolutionary evidences show that both types existed already within the first fungi conquesting land in the same period as plants and animals. Finds of the first vascular plants (e.g. the ancient fern Rhynia) of the early Devonian period certify that VA-type mycorrhizal symbiosis had already been evolved up to that time [2] and spreading of plants provided further expansion for symbiotic endophytes. Production of large amounts of terrestrial organic debris (e.g. cellulose, lignin, keratin) must have been a great evolutionary challenge for saprophytic fungi at the same time. Therefore fungal life had to evolve parallelly with plant and animal evolution on land. It is coevolution of symbiotic fungi and their hosts which has created the now existing fungal symbioses. Understanding the diversity, structure and function of modern symbiotic relationships is only possible on the basis of their evolutionary history [3].

Symbioses of fungi are highly diverse. Coevolution with different groups of animals resulted in such strange relationships like the symbiosis between fungus-growing ants and their fungi [4], some truffles and truffle-flies or groups of hypogeous basidiomycetes (e.g. *Rhizopogon*) with some mammals (e.g. mice) [5] dispersing their spores by mycophagy. Thus, fungus-plant symbioses based on the mutualistic metabolic cooperation between the photobiont and mycobiont are of greater ecological importance than fungus-animal symbioses.

One of the main types of plant-fungus symbioses is lichenes, which are terrestrial thallophytes composed by fungi with algae. The about 14,000 lichen types are formed by 21 genera of green and blue algae with a wide variety of obligatory biotrophic fungi (mainly ascomycetes) [6]. Symbiotic partnership between algae and fungi are known also from marine environments involving some red algae and ascomycetes. A series of more or less strict to loose symbiotic associations existing between algae and fungi in the upper

ERZSÉBET JAKUCS
Department of Plant Anatomy, Eötvös Loránd University
Puskin u. 11–13, H–1088 Budapest, Hungary

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intertidal zone (the so-called "littoral lichenes") are more resistant io desiccation than algae alone.

The most widespread and diverse plant-fungus symbioses are mycorrhizae. At about 240,000 species, 90% of terrestrial plants (livermosses, ferns, gymnosperms and angiosperms) take part in mycorrhizal associations with more than 6,000 fungal species [7]. Enhancing fitness of both partners, mycorrhizal state can be regarded as the normal physiological condition of plants and fungi in natural environments.

Different morphological and functional forms of mycorrhizae with distinct fungus-host specificity have been evolved. The most widespread is the vesicular-arbuscular type (VAM) formed by about 130 species of the *Gomales* (*Zygomycota*) with about 80% of the plant species [8]. Ectomycorrhizal relationships involving mainly basidiomycetes are characteristic to gymnosperms and angiosperm trees in moderate climates [9]. Ericoid, arbutoid and orchid mycorrhizae are more specific than the former ones restricted to a few families of plants and a smaller group of fungal partners [10].

Symbiotic fungal associations are widespread and frequent on Earth. Tundra-vegetation dominated by lichens occupies about 8% of the continental area. Ubiquitous VAM-associations are of special importance in grasslands and tropical woods. Coniferous and deciduous forests of moderate climates are highly dominated by ectomycorrhizal associations. In the heatherlands of alpine and subarctic regions ericoid mycorrhizae play an important role in element and energy transfer [11]. The function of the common but up-to now weekly known so-called "dark septate endophytes" must also be significant in the northern temperate zone [12].

As the result of more than 400 million year's evolution fungal symbioses play a basic role in maintaining the balance of natural ecosystems in the biosphere [13].

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