Quiz Questions #2 Key
The Fungal Kingdom -- Fall 2006

1. *You are looking at some brownish blobs on a specimen of Sphaerophorus globosus and a trying to determine if they are cephalodia or apothecia. How are you going to definitely tell the difference? Be specific, including drawings of any features you might use to make your determination.*

The general shape of the structure and location will give you a bit of a clue. You could check the description of the lichen and determine that the apothecia are black and ball-like, but you might not be able to rule out an immature apothecium. You might also notice that this species doesn't have cephalodia, but you still not sure of the identification. In order to be definitive, you must prepare a cross-section of the structure (use KOH and phloxine) and use a compound microscope to examine it. If it is an apothecium, you should find a hymenial layer with asci and perhaps some ascospores (have appropriate drawings showing the layer of asci). If it a cephalodium, you will not find a hymenium, but blue-green cyanobacterial cells (5 pt total).

2. *What do Lobaria pulmonaria, Pilophorus acicularis, and Peltigera leucophlebia have in common? What is purpose of this common trait?*

All three of these lichens consist of three bionts—one mycobiont and two photobionts. The dominant photobiont is a green alga and the cyanobacteria are housed in cephalodia (internal in *Lobaria* and external in the other two). The cyanobacteria fix nitrogen, making it available to the lichen and allowing it to colonize N-poor sites (5 pt).

3. *Including as many features as you can, compare the three major types of mycorrhiza -- arbuscular, ecto-, and ericoid. Give some possible reasons why one might be more common in a given area than the others.*

See following table for summary of key features. Also refer to summary notes for Week 2 lecture (these follow). Note that I have updated some species numbers since the notes were handed out (EcM plants for instance) -- so points were not deducted for citing somewhat different numbers. (8 pt)

Factors leading to commonness in an area: CLIMATE is probably the most important, along with historical factors (random quirks of fate would be part of this). Could also mention types of plants available, types of fungi available (both of which are affected by history), and prevailing parent material and soil type. All these factors are interrelated to a high degree, so some appreciation of that should be apparent in the answer. Could also mention human activity (planting lawns or crops in EcM forest areas, EcM truffle trees in meadows, *etc*.). (2 pt)

	Arbuscular Mycorrhiza (AM)	Ectomycorrhiza (EcM)	Ericoid Mycorrhiza (ErM)
Key Anatomical and Morphological Features:	Intercellular hyphae + or – Intracellular hyphae and structures + Arbuscules + Vesicles + or – External phase of individual large-diameter hyphae, close to root, high biomass Very large asexual spores produced primarily in the soil	Sheath or mantle + Intercellular Hartig net + External phase of extensive mycelium, often organized into strands, high biomass Many species form large sporocarps such as mushrooms and truffles	Intracellular hyphal coils External phase of fine individual hyphae near root surface, low biomass
Mycobionts:	Approximately 160 species of glomeromycetes ("Glomalean" fungi -- *Glomus* is a large genus)	At least 6000 species of basidiomycetes (mainly), ascomycetes, and zygomycetes (very rarely)	Small number of ascomycetes, perhaps 25 or fewer species
Phytobionts:	Perhaps more than 250,000 species from nearly all families, including angiosperms, gymnosperms, pteridophytes, bryophytes, and lycopods	7000-8000, mostly woody, species of angiosperms and gymnosperms; especially common in the families Pinaceae, Fagaceae, Betulaceae, Salicaceae, Myrtaceae, Dipterocarpaceae, and Caesalpinaceae	Up to a few hundred species in the order Ericales, especially in the families Ericaceae, Epacridaceae, and Empetraceae (the latter two families often included in Ericaceae)
General Ecological Occurrence:	Dominant type in tropical forests and savannas, grasslands, and deserts Contribute to overstory and understory of temperate forests	Dominant type in temperate and boreal forests Important component of tundra Locally dominant in tropical forests	Dominant type in heathlands Important component of tundra Contribute to understory of temperate and boreal forests
Typical Soil Conditions:	Mineral soils with little development of organic horizons Mineralization generally rapid so NO_3^- often abundant P main limiting nutrient	Forest soils with thin to thick organic horizons Mineralization slow so N occurs in organic forms and as NH_4^+ N or P main limiting nutrient	Soils such as peats with very thick organic horizons Mineralization extremely slow so N primarily in organic forms N main limiting nutrient

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Summary Notes -- Introduction to Mycorrhizas

What are mycorrhizas?

Fungi usually are referred to as the "great decomposers." However, without the mycorrhizal fungi, there would be very little of anything to decompose. Mycorrhizas are mutualistic symbiotic associations between fungi and the roots (or root-like organs) of plants. The fungi receive photosynthates from the plant, and, at a minimum, the plant receives nutrients (such as N, P, and K), water, and in some cases protection against pathogens, from the fungus.

Importance of mycorrhizas

Mycorrhizas are diverse, ubiquitous, ancient, and absolutely essential to all terrestrial ecosystems (and, therefore, to us -- "no fungi, no plants; no plants, no animals").

Diversity of mycorrhizas

There are 7-8 main types of mycorrhiza -- arbuscular mycorrhiza (AM), ectomycorrhiza (EcM), and ericoid mycorrhiza (ErM) are by far the most important ecologically. Involved in each type are many different fungi and many different plants, and there are very many different fungus-plant combinations. Some of the associations are very specific; others seem to be not so specific.

Arbuscular mycorrhizas (AM)

AM cannot be distinguished macroscopically. Roots must be chemically treated, stained, and then examined under a microscope in order to visualize the fungal structures. The fungi involved are known as the Glomeromycota, a monophyletic group now recognized as distinct from the Zygomycota. There are ~150 species of "Glomalean" (AM) fungi. They produce extremely large spores, but not mushrooms.

The plant partners in AM are extraordinarily diverse. Perhaps 80-90% of the more than 300,000 species of plants form them. Redwoods, maples, tropical rainforest trees, strawberries, corn, grasses, ferns, mosses, and liverworts are examples of the diversity of AM plants.

In a series of field and lab experiments, it was found that the productivity and plant diversity of experimental grassland communities were controlled by the diversity of AM fungi added to them. Besides grasslands, AM is the dominant form of mycorrhiza in tropical forests, some temperate forests, and deserts. They are thought to be involved primarily in phosphorus uptake, but it is likely their roles extend beyond that.

An important role of AM fungi is the production and exudation of glycoproteins that serve to bind soil particles together, thereby improving the structure of the soil, and making water and mineral nutrients more readily accessible to the plants.

Ectomycorrhizas (EcM)

EcM have distinctive morphologies that can be distinguished (in some cases, only after a bit of practice) with the naked eye or under slight magnification. They are formed by fungi in the Basidiomycota (many) and Ascomycota (not so many) and many are mushroom-formers. In fact, a large percentage of the larger mushrooms you see in our PNW forests in the fall are formed by EcM fungi. There may be over 10,000 species of EcM fungi.

In comparison, there are about 7000-8000 species of EcM plants. Most of these are trees in the pine, oak/beech, birch, and willow families, plus the genus *Eucalyptus*. These are the dominant trees of the temperate and boreal forests, such as Douglas-fir, western hemlock, pines, true firs, spruces, oaks, beech, aspen, birch, and willow. The EcM fungi are thought to be primarily involved in nitrogen uptake, although they have many other roles as well.

Ericoid mycorrhizas (ErM)

ErM are formed by a relatively small number of fungi (~25 species of Ascomycota) and plants (~500-1000 species in the heath family and other families closely related to it). ErM plants you might know are rhododendrons, blueberries, cranberries, and salal. Despite the low diversity, ErM are very important understory plants in temperate and boreal forests and in non-forest habitats at high latitudes where soils are very cold, wet, and acidic.

World distribution of mycorrhizas

The world distribution of AM, EcM, and ErM correlates very closely with climate and soil type, and these patterns probably reflect cause and effect.

History of mycorrhizas

Mycorrhizas are ancient. The oldest land plant fossils (~400-450 Mya) contain typical AM structures such as arbuscules. The history of plant evolution seems to be closely intertwined with that of the fungi.