Key to Quiz Questions #3
The Fungal Kingdom -- Fall 2006

1. *Evolutionarily speaking, it is generally accepted that crustose lichens are the most primitive and fruticose are the most advanced, with foliose in between. What sort of evolutionary pressures do you think account for this evolution? Construct a plausible scenario to explain this evolutionary trend. Begin with the most primitive crusts. Be sure to mention specific structures/features that evolved and how they resulted in increased fitness for the individuals possessing them. (20 pt)*

The answer to this question could cover a lot of ground. In order to receive full credit, you needed to address the evolution of the different growth forms and the trade-offs, with at least five specific adaptations/structures and the potential advantages they conferred. One of the specific adaptations you needed to address was the appearance of vegetative reproductive structures. A complete answer needed to specifically outline the resulting increase in fitness to individuals with the adaptation. Many of you listed changes that resulted in lichens receiving more sunlight or nutrients without making the connection that these would result in more and perhaps faster growth…bigger lichens cover more area and out-compete their neighbors.

Here's an answer that covers many of the possibilities that you might have included.

The most primitive crustose lichens are the powdery leprose crusts, which form a loose, non-differentiated thallus. These probably evolved from a parasitic fungus/algae relationship where the fungus penetrated the algal cell membrane. The evolutionary pressures (EP) on the mycobionts in these early protolichens were to develop the ability to access algal sugars without penetrating the cell membrane (don't kill the algae), influence the algae to release more sugars (which might result in the ability to recognize specific algae), completely encase the algal cells in fungal tissue, and to grow slower so as not to outpace the algae's growth. EP on the algae might result in a higher rate of photosynthesis (modified pyrenoids in chloroplasts). All of these adaptations would result in greater access to nutrients by the fungus which could then result in a larger thallus and/or more production of reproductive propagules.

In the more organized crustose lichens, EP resulted in the production of an upper cortex and pigments that allowed these lichens to survive in more exposed situations. EP also favored tough lichens that were tightly attached to the substrate (rocks) or even within the substrate (endolithic lichens) to survive harsh environmental conditions. EP resulted in evolution of hydrophobins by the mycobiont to insure that the precipitation event was sufficient to make back the metabolic cost of starting up. Hydrophobins would also reduce the possibility of oversaturation and the resulting decrease in photosynthesis due to slower diffusion/dissolution of CO_2 in water, as well as minimize loss of algal sugars to the environment. EP also resulted in favorable conditions within the lichen thallus for the algae, causing a selection for algal characteristics that optimized growth within the thallus. One possibility could be the release of polyols by the fungus to the algae upon rehydration, thus giving a selective advantage to the algae within the lichen.

As lichens moved from dry, exposed niches into areas where moisture wasn't so limiting, EP favored faster fungal and algal growth rates and the evolution of a thallus shape with a higher surface area to volume ratio to maximize nutrient uptake, gas exchange, and photosynthesis rates (expose more algal cells). These adaptations would result in more rapid lichen growth rates which would allow these lichens to increase their relative dominance and leave more offspring. Increased thallus surface area/volume ratio (SA/V) probably happened first in crustose lichens that formed squamules, which evolved into foliose lichens and eventually fruticose lichens. Lichens with higher SA/V would have an advantage in more protected areas where moisture wasn't limiting, but would not do as well in harsh, exposed environments. Along with the evolution of a lower cortex came outgrowths of the cortex that anchored the lichen to the substrate, eventually resulting in rhizines. In addition to anchoring the lichen and increase absorptive surfaces (increasing growth), rhizines or other localized attachments permitted the lichen to grow over other lichens, shading them out.

The earliest vegetative propagules, soredia (which were probably due to rapidly growing algal cells bursting through the cortex), conferred an adaptive advantage to those lichens by allowing them to rapidly colonize relatively stable niches in the local environment. Additional growth patterns that increased surface area/volume ratios and also served as vegetative propagules (isidia and lobules) increased the fitness of lichens in less severe environments.

Competition for space on substrate surfaces generated EP that favored the fruticose growth form. These lichens have a high surface area/volume ratio, but only occupy a small space on the substrate (the rest of the thallus is either erect or pendulous). Competition with low-growing plants could also have generated EP that favored fruticose lichens.

EP on algae in more rapidly growing lichens might have resulted in the loss of metabolically expensive characteristics that weren't needed to survive within the lichen, but resulted in decreased fitness outside of the lichen association. This resulted in algal species that are only found within lichens.

Nitrogen limitation was/is a significant EP in many ecosystems and the incorporation of cyanobacteria as the primary or secondary photobiont in cephalodia allowed lichens with this adaptation to flourish in nutrient-poor environments.

2. *You are sound asleep when the phone rings. The caller is a veterinarian whose patient (a large dog) was found eating a mushroom and has since been experiencing seizures, vomiting, and other symptoms. The vet wants to know what sort of treatment to prescribe and hopes that you, as a well known mushroom expert, can help. She comments that the dog's owner is sure the mushroom was an amanita. You know of several* Amanita *species in the area, and that they vary widely in the presence and type of toxins they contain. What specific questions would you ask the owner to determine (over the phone) whether the mushroom was* Amanita phalloides*,* A. muscaria*,* A. pantherina*, or* A. vaginata *(assume it is one of those four and that you need to figure out which one)? (10 pt)*

Note that you are a mushroom expert (not vet or toxicologist) and are asking the OWNER about the MUSHROOMS, not asking the vet about the symptoms. Database of dog symptoms is not large enough for them to be definitive species indicators, but they could be helpful if mushrooms are not available. Although the question says to assume the mushroom is one of the four amanitas listed, it actually would be best to first make sure that it really is an amanita. Don't assume the dog's owner really knows her mushrooms. To establish its identity as an amanita, you should confirm it has white spores, free (or nearly free) gills, partial veil (may or may not persist as a ring), and universal veil (remnants on stipe base, often as a cup, and possibly on cap). So your questions might be:

- On a mature mushroom, what color are the gills? (The dog's owner is not likely to have made a spore print, but amanitas usually have white gills. Gills that are white when mature indicate that the spores are white or at least very light colored.)
- Are the mushroom's gills attached to the stem?
- Does the mushroom have a skirt-like ring on its stem?
- Are there warts or a patch of material on the cap?
- Did you dig up the whole mushroom, including the base of the stem? Is there a cup at the base of the stem? If not, is there any other type of material there?

Once you're reasonably sure that the mushroom is an amanita, you can proceed to determine which one. A character matrix illustrating some key differences among the four species in question follows.

Thus, you should ask questions to determine the cap color, nature of volval remnants on the cap, nature of volva, presence of a ring, and striation of the cap margin. Ask about each type of feature one-by-one rather than species-by-species. Habitat (or at least nearby trees) might also provide some information, although none of the four species is confined to any single tree species. The question was graded on the basis of this information, not the "is it really an amanita" part.

Species	**Cap color**	**Veil remnants on cap**	**Volva**	**Ring**	**Cap margin**
A. phalloides	Yellowish green, bronze, rarely white	Usually none, sometimes a small patch	Ample, sac-like, shape nearly globose	Usually disappears early	Smooth
A. muscaria	Orange to red, sometimes yellow, rarely white	Warts	Concentric rings of tissue	Usually present	Striate
A. pantherina	Light to dark brown	Warts	Collar-like rim on bulbous base	Usually present	Striate
A. vaginata	Light to dark gray	Small patch or none	Sac-like, often tight against stipe, upper portion often flares	Absent	Strongly striate

3. *(a) Describe the main stages in a life cycle.*

Refer to Week 3 lecture notes and the handout with different life cycles. The main stages include the haploid (n) and diploid (2n) phases, meiosis (reduction division), and syngamy (fertilization). These stages comprise the sexual reproduction cycle. In many organisms, the haploid and/or diploid phases also can undergo vegetative reproduction. This is the life cycle concept we covered at length in lecture during Week 3.

(b) Compare the life cycle of a typical wood-rotting basidiomycete with those of a flowering plant and a mammal. In what ways are they similar? Different?

All have the main stages. Animals are diploid dominant; fungi haploid dominant (with some including an n + n phase); plants have a more balanced life cycle, termed alternation of generations. Few animals have asexual reproduction in addition to sexual reproduction; many fungi and plants do. Fungi alone have an n + n phase (dikaryophase).

(c) What advantages and disadvantages are there in the basidiomycete life cycle compared to those of a flowering plant and a mammal?

All three groups of organisms are very successful which suggests that no one life cycle type is greatly "better" than the others. A difference in the fungal life cycle that could be beneficial is the common presence of both sexual and asexual phases. This could provide greater flexibility -- putting energy into spreading vegetatively when conditions are good and shifting to sexual reproduction when resources are in short supply, which could provide for dispersal to new areas or possibly produce new genotypes better suited to the existing conditions.

Despite being considered haploid, fungi with a dikaryophase function as diploids and this also provides them with great flexibility.

It's difficult to see disadvantages in the fungal life cycle.

PS: I did say "mammal." Ignore "animal" comments -- they were caused by a brain cramp.

(10 pt)