MYCOLOGY ANSWERS

WHAT ARE FUNGAL CORDS, STRANDS AND RHIZOMORPHS AND HOW ARE THEY OF BENEFIT TO THE FUNGUS?

The fungus *Armillaria mellea* is a common problem in forests, woodlands and parks, where it can cause the death of various species of trees. It takes one of its common names, 'the bootlace fungus', from the tough, darkly pigmented rhizomorphs, looking and feeling just like old bootlaces, which form beneath the bark of infected trees. Structures such as these are quite commonly produced by many species of fungi, most notably wood decomposing species and those growing in close associations with higher plants (e.g. ectomycorrhizal fungi).

Normal vegetative growth in filamentous fungi is achieved by the extension of hyphae across and through the surrounding substrate. Tips of hyphae grow into areas previously unexploited by that fungus and absorb nutrient materials, thus fuelling further extension. During vegetative growth hyphae branch and normally diverge away from neighbouring hyphae. Individual filaments may become joined together by anastomosis, the vegetative fusion of hyphae, which usually occurs by a tip-to-tip fusion of side branches. In this way, branched mycelium becomes interlinked as a network facilitating communication within the mycelium and permitting translocation of nutrients and the migration of nuclei and organelles between hyphae.

On occasion, hyphae in the outer margin of a growing colony converge, to form linear aggregates. All the component hyphae (from a few to several thousand) become intertwined, adhering and extending together in one direction. Cords such as these are formed by the violet root-rot pathogen of carrots *Helicobasidium purpureum*. As these aggregates grow the individual hyphae become more and more intertwined and eventually developing cords may join with others or may divide, extending further over the substrate. In other species, such as the dry-rot fungus *Serpula lacrymans*, aggregates of hyphae form in a slightly different way. In this case main, or leading, hyphae grow out from the vegetative mycelium and are closely surrounded by their own branches. These develop as strands, growing and becoming thicker as more branches form and wrap around the structure. In older regions a more organised structure is formed involving the differentiation of hyphae which have different structures (different morphology). The outer, sheathing hyphae, develop thick walls with little or no central space, and adhere very closely together like a rind. The inner hyphae are wider and have much larger central cavities, forming tubes, or 'vessels', with little, if any, cytoplasmic contents.

Rhizomorphs, such as those of *Armillaria mellea*, are formed as the result of more extensive and coordinated differentiation among aggregates of hyphae growing together in parallel. The development of the main structure occurs behind a growing front of hyphae, all extending apically. The rhizomorph grows out of, and away from, the main body of the vegetative mycelium, extending at a faster rate. At maturity, rhizomorphs are cylindrical, up to 5 mm in diameter and often very long (0.5–3 m). They usually have a central cavitry, or air space. This is surrounded by an inner medulla composed of hyphae with relatively thin walls and of large diameter, akin to the 'vessel' hyphae of strands, many devoid of cytoplasmic contents. There is an outer cortex woven by small diameter hyphae with relatively tough, pigmented (melanin) walls which probably acts as protection for the whole structure. In a woodland it is sometimes difficult to distinguish rhizomorphs from plant roots.

All such structures represent considerable advantage to the fungi concerned in a number of ways. These organs have an important role in the absorption, movement and storage of nutrients and water within the fungus. Initially, growth of such structures is fuelled by the main body of mycelium, nutrients passing towards the growing front. When a new nutrient resource becomes available compounds in the external environment may be taken up, passed back to the main mycelium or stored. It has been shown that nutrients (carbon, phosphorus, potassium) and water can pass both to and from the growing mycelial front. This must be an important attribute allowing some species to extend considerable distances over non-nutrient substrates (e.g. plaster, concrete, stone). Much of the transportation of nutrients occurs by mass flow of solution through the large vessel hyphae, although some probably also occurs through the cytoplasm of smaller hyphae. The central space in rhizomorphs is thought to facilitate the transfer of oxygen to extending hyphae.

Rhizomorphs are often found in the tree canopy in moist tropical rain forests and play an important role in nutrient recycling in the tropical ecosystem. In this situation, leaf litter represents a huge nutrient store. Much of the litter is trapped, as it falls, to be exploited by aerial mycelial connections and rhizomorphs of fungi among the branches of the trees. Extensive cord, strand and rhizomorph systems occur in leaf litter deposits, particularly in woodlands, where these organs are important in migration, allowing the fungus to reach and colonise new food bases.

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