A Closer Look at Fungi in the Arnold Arboretum

Kathryn Richardson

Walk into the Arnold Arboretum and you'll see a beautiful and historically important collection of trees and shrubs. With a closer look, other organisms become visible, including fungi. The world of fungi is vast, and many members of this diverse kingdom are found throughout the Arboretum. In an informal survey from spring through fall of 2008, Arboretum staff reported over 100 fungal sightings, and positive identifications were made for 40 species. A dozen species noted in the survey are profiled starting on page 15.

Plants + Fungi

The association between plants and fungi is sometimes beneficial, sometimes harmful, and sometimes a bit of both. Fungi can be indicators of a tree's declining health, but in other cases—such as mycorrhizae which aid roots with nutrient uptake—they are physiologically beneficial to plants. Identifying fungi and understanding their physiology is an important aspect of interpreting the health of the Arboretum's collections.

The Arnold Arboretum hosts an unknown number of fungi, many of which have specific relationships with certain plants. When a fungus is found growing on an accessioned tree, horticultural staff attempt to make an accurate identification, and often those known relationships aid in the identification process. For example, a shiny bracket fungus growing on eastern hemlock (*Tsuga canadensis*) is probably the hemlock varnish shelf (*Ganoderma tsugae*), and an oak tree with a massive cluster of sulphur-yellow mushrooms growing from its roots is likely to be chicken of the woods (*Laetiporus sulphureus*).

These fungi may live in their hosts for several years. As they feed, these fungi cause wood decay and often weaken the

Fungi ID

PRECISELY identifying fungi can be challenging even for experts. Many morphological features from growth habit to the size and color of spores provide clues for identification. Often minute details are needed to confirm species identity.

Correct identification is critical when considering fungi as food, since the fungi kingdom contains species that are deliciously edible and others that are deadly poisonous. Though often stated, it's worth repeating: Never consume any mushroom without being absolutely sure of its identity.

SUSAN HARDY BROWN

The distinctive lamellae (gills) of this mushroom mark it as a member of the phylum Basidiomycota, but much more information is needed to determine its exact species.

structural integrity of the tree. Damage from fungi also weakens the tree's defenses and may enable entry for other pests and diseases which cause further injury. Arboretum trees flagged with potentially fatal fungi are carefully observed and notes are kept within the Arboretum's collections database. If the tree begins to decline, this information is useful in making a decision on its treatment or removal.

The Fungal Life

Fungi are neither plant nor animal and are placed in their own kingdom, though historically this was not always the case. Taxonomists initially placed fungi in the plant kingdom (Plantae) because, plants and fungi are both sessile (not free-moving) and have cell walls. However, fungi lack chlorophyll (and thus cannot make their own food via photosynthesis) and have walls made of chitin, not cellulose as seen in plants. Fungi are closely related to animals and bacteria and were once placed in the animal kingdom (Animalae), but fungi are not motile. Fungi proved to be unique life forms deserving their own kingdom.

Fungi cannot produce their own food and thus must acquire the nutrients they need from their hosts or substrates. Based upon their nutritional needs, fungi fall into three categories: saprobes, parasites, and mutualists. Saprobic fungi feed on dead organic materials and serve as the scavengers of the kingdom by recycling carbon, nitrogen, and other essential elements back into the soil. Parasitic fungi feed on living organisms and often harm them in some way. "Parasitize" sounds threatening, but the reality is that fungal parasites do not typically destroy their host quickly and may be present for some time before the host shows decline. Mutualistic fungi have a beneficial relationship with other living organisms. Examples of mutualists include lichens (fungi plus algae or cyanobacteria) and mychorrhizae (fungi and plant roots). Around 90% of all living trees have a mycorrhizal relationship with fungi.

The presence of fungal fruiting bodies on trees indicates that the fungus has reached the spore production stage of its life cycle. When released spores land on a substrate and germinate, threadlike hyphae grow and combine to form mycelia, the vegetative growth of fungi. Mycelia grow underground (sometimes spreading for miles), or within wood or other hosts. Mycelia grow even when no fruiting bodies are present, so the extent of damage caused by a fungus in the tree before the emergence of the fruiting body is sometimes unclear.

Fungi to Know

The largest groups of fungi are found in the phylum Basiodiomycota, often inclusively called the basidiomycetes. Many familiar fungi such as cap-and-stipe (stalk) mushrooms (including the cultivated "white button mushroom" [*Agaricus bisporus*] found in grocery stores), brackets, and puffballs are placed in this group. It is safe to say that if you are looking at a fungus that has either rib-like gills (lamella) or tiny pores on the underside of the cap, it's a basidiomycete. The microscopic rust and smut fungi are also basidiomycetes.

Basidiomycota produce basidiospores which have a single haploid nucleus. When these spores germinate they produce long, branching hyphae with a single nucleus in each compartment (area between cell walls). When two compatible hyphal strands come into contact with each other they unite to form a hyphal strand that now houses two nuclei in each compartment. A basidiomycete will spend most of its life in the vegetative mycelial stage until environmental cues, such as rain or temperature change, cause the growth of fruiting bodies (basidiocarps). Many basidiomycetes are decomposers, but others have a mycorrhizal partnership with forest trees.

Another fungal phylum, Ascomycota, includes the sac fungi or spore shooters. Unlike basidiomycetes that have structures (basidiophores) that drop spores from their fruiting bodies, ascomycetes have spores in sacs located within a structure called an ascocarp or ascomata. The spores are "shot" out of their sacs and dispersed into the air. Sac fungi are also decomposers and recyclers of organic matter. Many ascomycetes are parasitic including those that cause Dutch elm disease and chestnut blight. Ascomycetes include yeasts, which are used to make beer and wine, as well as mycelial fungi such as morels and black knot. Another interesting example of an ascomycete is the fungus that causes ergot, a damaging disease of grain crops. Ergot fungus contains a compound

that is a precursor to the hallucinogen LSD. Though not proven, it has been suggested that ergot poisoning was a potential cause of the hysteria that led to the Salem witchcraft trials in the late 1600s.

Although no longer classified in the fungi kingdom, Myxomycetes (slime molds) are also mentioned here since they resemble fungi, are common at the Arboretum, and elicit many questions from visitors (see page 21).

A Sampler of Arboretum Fungi

Here are a dozen interesting fungi—plus one slime mold—that were found in last year's informal survey of fungi at the Arnold Arboretum

COURTESY OF PAULA DESANTO

Pheasant's-back Polypore or Dryad's Saddle (*Polyporus squamosus*)

In the spring of 2008, a very large pheasant's-back polypore appeared on a venerable cucumbertree magnolia (*Magnolia acuminata*, accession 15154-E) near the main entrance of the Arnold Arboretum. This magnolia has survived for over 100 years, but time has taken its toll and the doors are now open for various organisms, including fungi, to invade.

Growing out of an old limb-removal wound on the magnolia's trunk was an impressive bracket with a uniquely patterned cap. This species, the pheasant's-back polypore, can grow to 24 inches (61 centimeters) in diameter. It appears growing on stumps and dead hardwood trees in spring in the northeastern United States. It is easily recognized by its fan-shaped, tan to creamy yellowish cap with an array of brown scales that look like pheasant feathers—thus the species' common name. (Another common name, dryad's saddle, refers to its potential use by the tree-dwelling nymphs known as dryads in Greek mythology.) The white underside of the cap is dotted with thousands of small pores (*polyporus* means "many pores").

It was sad to see this particular polypore because it indicates that this magnolia's life is coming to an end. The Arboretum's horticultural staff had noted the tree's decline before the emergence of this polypore, but its presence told us more about the health of this tree. The pheasant's-back polypore is typically saprobic on dead trees but it can also parasitize the heartwood of living trees such as this magnolia. This polypore fungus had been living in this tree for an unknown period of time before it produced this fruiting body; the extent of internal rot is uncertain but the tree will continue to be monitored closely.

HARUTA OVIDIU, UNIVERSITY OF ORADEA, BUGWOOD.ORG

Witch's Butter (*Tremella mesenterica*)

Witch's butter is a member of the phylum Basidiomycota, but does not have the traditional cap and stem as do some other fungi in this group. This fungus is yellow to orange in color and appears as wavy, gelatinous folds. It can dry out to the point of appearing dead, but will rehydrate readily with rainfall or other applied water. Another interesting fact about witch's butter is that it feeds on other fungi, not on wood. It is often seen growing on downed logs or dead branches, where it parasitizes wood-decaying fungi. Witch's butter is widely distributed in temperate regions in North America, Europe, Asia, and Australia.

The name "witch's butter" comes from several European legends. One states that if the fungus was found growing near a home's entrance or front gate, then the homeowner had been hexed by a witch. The spell could be broken by plunging a pin into the fungus, causing the witch to feel the pinpricks, which in turn would cause her to return to remove the spell and the fungus. A legend of Swedish origin blames this fungus on a witch's cat. The cat, sent out to steal food from the neighbors, would gorge itself and then vomit "witch's butter" on the gardens, fences, gates, and homes of unsuspecting people. The name "witch's butter" is sometimes applied to any of a number of jelly-like fungi.

NIMA SAMIMI

The Stinky Squid (*Pseudocolus fusiformis*)

The stinky squid is a basidiomycete belonging to the Phallaceae, a family of fungi commonly known as stinkhorns. The stinky squid certainly lives up to its name both in scent and appearance—in late August 2008 this stinkhorn created quite a horrible smell in the Arnold Arboretum when it appeared in a few beds in the Leventritt Shrub and Vine Garden as well as in densely planted areas on Peters Hill.

Common to eastern North America, this species of stinkhorn has a fantastic appearance. Beginning its reproductive life as an egglike structure with white rhizomorphs attached to the base, its fruiting body quickly emerges, displaying three to five tapering arms. The arms may be free-standing or fused together at the tips, and are yellow towards the base and reddish orange towards the apex. It stands 1 to 3 inches (3 to 7 centimeters) in height with dark green spores lining the inner sides of its arms. (A broken-off fruiting structure is seen here.)

There's no question about how this fungus received its common name: it looks like a squid and has the odor of rotting flesh. Stinkhorns, including stinky squid,

disperse their spores by attracting flies and other insects which land on the fungus and feed on the stinky slime. In the process, the insects collect spores on their bodies as well as ingesting them, then spread the spores to new locations.

Common Oyster Mushroom (*Pleurotus ostreatus*)

NANCY ROSE

The common oyster mushroom—a familiar edible mushroom that can be found in grocery stores—is common in the Arboretum and appeared in large numbers last spring. Oyster mushroom species are typically found in the fall, winter, and early spring, though they are also sometimes seen in the summer under the right conditions. They grow on dead hardwoods and, less often, on conifers, and also on some living trees. Oyster mushrooms grow in dense clusters, have light brown to off-white caps, and display prominent, elongated white gills.

An interesting fact about species in this mushroom genus is that they are carnivorous; they trap, kill, and eat living organisms such as nematodes and bacteria in addition to the more typical fungus function of decomposing wood.

JOSEPH O'BRIEN, USDA FOREST SERVICE, BUGWOOD.ORG

Chicken of the Woods (*Laetiporus sulphureus*)

Chicken of the woods belongs to the genus *Laetiporus,* which fairly recently has been separated into several species based on DNA analysis. When I first began identifying chicken of the woods in the Arboretum I assumed it was *Laetiporus sulphureus,* but most turned out to be the very similar-looking species *Laetiporus cincinnatus.* Both species have the common name "chicken of the woods" and are popular edibles for mushroom hunters. They are readily identified because of their bright yellow to orange color and appearance as masses or rosettes of wavy, blunt-rimmed plates. They are widely distributed east of the Rocky Mountains and often grow as parasites or saprobes on oaks (*Quercus* spp.). The main difference between the two species is the location of their fruiting bodies; *Laetiporus sulphureus* usually grows on tree stumps while *L. cincinnatus* grows from the roots of the infected host, giving the appearance that it is growing terrestrially.

The common name is appropriate for several reasons. The flesh of the caps is yellowish in color, almost like raw chicken. Also, the taste and texture of this fungus, when cooked, reportedly are similar to cooked chicken.


ROBERT MAYER

Turkey Tail Fungus (*Trametes versicolor*)

The turkey tail fungus is one of the most commonly seen bracket fungi, occurring on dead trees in temperate zone forests all over the world. Turkey tail fungus is saprobic on dead hardwoods and can sometimes completely cover trunks and branches. A decomposer of wood, this fungus will sometimes work away for hundreds of years on a single host.

Turkey tail fungus is a polypore, having pores instead of gills, and has a hard exterior instead of the fleshy ones seen in traditional mushrooms. It is aptly named, displaying concentric colored bands that resemble a fanned turkey's tail. The colors of turkey tail fungus can vary, but the bands commonly appear in shades of white, brown, and tan, sometimes with more colorful bands in orange, cinnamon, or bluish tones. A close look reveals dense, downy hairs on the bracket's upper surface.


USDA FOREST SERVICE-NORTH CENTRAL RESEARCH STATION ARCHIVE, BUGWOOD.ORG

Shaggy Mane Mushroom (*Coprinus comatus*)

The shaggy mane—a type of inky cap mushroom—is readily observed from mid-spring to late summer. Found on lawns, in mulched beds, and in forests, the shaggy mane performs as one of nature's recyclers, feeding on soil, forest litter, decaying wood, and even dung. It slowly decomposes the organic matter on which it feeds.

One characteristic that makes this mushroom interesting is its method of spore dispersal. When the spores begin to mature, the shaggy oval cap begins to curl, becoming bell-shaped, as the gills deliquesce (liquefy). This gives the spores maximum exposure to the wind, which then transports the spores to new locations. The gills will continue to liquefy until they are virtually gone, leaving a flat, almost transparent cap. True to the name, the liquefied gills of this and other inky caps can be used as a semi-permanent ink.


NANCY ROSE

Bark Mycena (*Mycena* spp.)

There are many tiny, often-overlooked mushrooms growing in the Arboretum including several in the genus *Mycena*. This genus contains hundreds of species distributed worldwide. Most Mycena species are very small and have bell-shaped caps on slender stipes.

Walking along Meadow Road I came across an old painted maple (*Acer mono*) covered with these tiny mushrooms. Gray-brown in color with caps no larger than a few millimeters in diameter they covered the bark of this

maple along with moss and lichens. At first it seemed sad to see such a fantastic old tree covered with mushrooms, but these fungi do not harm the tree. Bark *Mycena* live on the outer layer of a tree, feeding on the dead bark. They never move to the living layers of the tree and thus do no harm.

NANCY ROSE

Bird's-Nest Fungi (species in several genera including *Crucibulum* and *Cyathus*)

Bird's-nest fungi are a group of unusual fungi in the order Nidulariales ("nidula" means small nest). They are very common in the Arboretum and can be found growing in almost every mulched bed as well as on debris in natural woodland areas. These harmless fungi are saprobic on substrates such as dead wood (including woodchips), leaves, and dung. They often grow in large expanses.

The common name describes these fungi perfectly. The mature peridia (fruiting bodies) resemble tiny nests. These nests contain tiny egglike peridioles which contain spores. Several species of bird's-nest fungi grow at the Arboretum and can be differentiated by the color, size, shape, and texture of their peridia as well as by the color of their peridioles which can vary from white to black with several shades of gray and brown in between.

Bird's-nest fungi exhibit an interesting spore dispersal method. When it rains, water droplets splash the "eggs" (peridioles) out of the nest and into the air. When this happens, a cord which attaches the egg to the nest breaks free and elongates. When the egg lands on nearby substrates the cord sticks and secures the egg to its new site.

ROBERT MAYER

Hen of the Woods (*Grifola frondosa*)

Hen of the woods is a popular edible mushroom with sweet-tasting flesh. The clustered caps of this fungus resemble the ruffled feathers of a hen, and a full-grown specimen can reach a foot or more in diameter and weigh as much as 40 pounds (18 kilograms). Hen of the woods is commonly found growing on oak (*Quercus* spp.) trees from either the trunk or roots.

This mushroom is a parasite and will cause damage over time. It causes white rot which can compromises the structural integrity of the roots. A weakened root system can prove disasterous for a tree in wind storms, since lack of solid anchorage may allow the tree to topple over.


NANCY ROSE

Black Knot Fungus (*Apiosporina morbosa*)

Black knot fungus is visible on several cherry trees by the Arboretum's Forest Hills gate. Black knot can infect a number of cherry and plum species (*Prunus* spp.). This ascomycete is a harmful fungus that damages both the health and appearance of its host. The visible part of this fungus, a black gall, is the result of the fungus disrupting the normal growth of the twig. Galls form at the site of infection. Black knot galls look something like burned marshmallows on a stick and may eventually grow to a foot in length if left unchecked.

Inside the galls are perithecia which produce ascospores, which, after overwintering in the gall, are ejected in the spring when warmer temperatures and adequate moisture arrive. The ascospores are then carried by wind and water to new host sites. Infection occurs on new plant growth and wounded tissues. These ascospores are able to penetrate through the green tissue of new growth and quickly begin to grow. New galls are brown, and can easily go unnoticed until the following year when they continue to grow and turn black. The galls continue to grow every year and the infection continues to spread further down the branch. Older galls often harbor borers which can cause even more problems for infected trees.

All trees at the Arnold Arboretum with black knot galls present are monitored. When a gall is found the infected branch is removed while the fungus is still dormant. This slows further spread on the host tree and also reduces the spread of infection to other trees.

Hemlock Varnish Shelf (*Ganoderma tsugae*)

The Arboretum's Hemlock Hill offers visitors a chance to see the interaction between a fungus and a specific type of tree. The hemlock varnish shelf (*Ganoderma tsugae*) has a preference for conifers and specifically for hemlocks (*Tsuga* spp.). It is found on living and fallen trees on Hemlock Hill and was also reported growing in a mulch bed along Meadow Road. If seen growing on a living hemlock it is safe to say that the tree is not in perfect health.


ROBERT MAYER

The hemlock varnish shelf is a beautiful polypore. Its hard, shiny cap is dark red to reddish brown, sometimes with prominent concentric zones. Young specimens may show white and yellow segments also. This annual mushroom grows individually or, less commonly, in limited clusters. This species is closely related to the more common taxa *Ganoderma lucidum,* (sometimes known as reishi or lingzhi); extracts of both have been used in herbal medicine.

SUSAN HARDY BROWN

Dog Vomit Slime Mold (*Fuligo septica*)

I have had Arboretum visitors ask me about "the lumpy yellow (or tan) stuff in the mulch bed that looks like vomit." Well, that's the descriptively named dog vomit slime mold, commonly seen in planting beds mulched with wood chips. *Fuligo septica* is a type of Myxomycetes, so not a true fungus. It is a plasmodial slime mold; this means that the "vomit" is actually a huge single cell containing millions of nuclei.

Dog vomit slime mold is motile, but moves quite slowly. It is not harmful to animals or plants and usually vanishes in a short period of time. This species and similar slime molds feed on bacteria, fungal spores, and smaller protozoa found on wood chips. Slime molds feed much like an amoeba feeds; they ingest their food and then digest it (unlike fungi, which digest and then ingest). If conditions are favorable, these slime molds will produce reproductive structures (sporangia) that produce spores. When conditions are unfavorable (loss of food, dry conditions), the plasmodium will form hard, dormant, protective structures called sclerotia. Inside the sclerotia the plasmodium will divide into "cells" containing up to four nuclei. When conditions become favorable each "cell" will form a new plasmodium.

Dog vomit slime mold is primarily an aesthetic problem in mulched garden beds. It can be physically removed, but more is likely to return. So, before panicking and taking your dog to the veterinarian, take a closer look and consider that that stuff is likely just *Fuligo septica* working away at cleaning the mulch.

Acknowledgments

Thanks to Susan Hardy Brown, Nima Samimi, Eric Youngerman, Bob Ervin, Marc Devokaitis, Nancy Sableski, and all staff for their help in surveying and photographing fungi at the Arboretum, and to Don Pfister for reviewing this article.

Kathryn Richardson is a Curatorial Assistant at the Arnold Arboretum.