BASIC MYCOLOGY

By David Spero, MS, and Alan Neumann, PhD

Over the past decade, the general public has become aware of health concerns related to mold and mildew growing in indoor environments of homes, schools, and offices. This awareness has prompted highly publicized litigation and has grabbed the attention of the banking and insurance industries. The construction industry has had to respond to these concerns. Only recently have governmental agencies – both federal and state – taken action to promulgate regulations concerning public health and business practices.

What are Fungi, Molds, and Mildew?

The fungi are a diverse group of organisms inhabiting nearly every habitat on earth. Mushrooms are perhaps the most recognizable members of the Kingdom Fungi, but there are many other non-mushroom fungi, such as yeasts and molds. Molds (the word mold is derived from Scandinavian languages and refers to something wooly or fuzzy) are commonly considered to be fungi that grow on wood, paper, cloth, and other materials. Unlike mushrooms, most molds cannot be observed in any detail, without the aid of a microscope. All molds are fungi, but not all fungi are classified as molds. Mildew is technically a group of fungi that are plant pathogens, such as powdery mildew of grapes, but the term is commonly applied to fungi found growing on clothing, fruit, and grout in bathrooms. Regardless of how we classify them, fungi are common and ubiquitous components of nature.

Fungi represent an assemblage of organisms that are distinct and separate from plants, animals, or bacteria. Fungi are characterized by cell walls similar to those of plants, but they cannot create their own food like plants; instead, they must digest organic materials like most animals do. Most fungi consist of filaments of cells called *hyphae* (hi-fee). The mass of hyphae is called the *mycelium* (my-seal-e-um). As the mycelium matures, it may begin to reproduce through the production of spores and spore-like cells. Some reproductive structures are large, such as mushrooms, puff balls, and the brackets seen on dead trees. Fungi obtain nutrients and water

Mold on dimensional lumber.

Mold and soft rot on floor joists in crawl space.

BUILDING MATERIALS COMPOSED OF ORGANICALLY-BASED MATERIALS, SUCH AS WOOD AND WOOD/TEXTILE PRODUCTS, ARE PRIME HABITATS FOR FUNGAL GROWTH AND PROPAGATION.

from their immediate surroundings. Fungal cells secrete enzymes and acids that digest organic materials, such as wood. The digested liquid is absorbed by the cell as its food. In digesting and metabolizing nutrient sources, some fungi provide us with economically important products such as bread, cheese, and beer. Fungal cells also produce chemicals to prevent other organisms from eating them or out-competing them for food. Many of our antibiotics are toxins produced by fungi.

Many fungi survive by decomposing dead/non-living organic materials, including materials we use for food stuffs and building materials; therefore, fungi can be a serious problem when they colonize and grow on building materials. Building materials composed of organically-based materials, such as wood and wood/textile products, are prime habitats for fungal growth and propagation. In the construction industry, several groups of fungi are of economic importance, including the mushroom group and the molds.

Growth requirements for fungi/molds

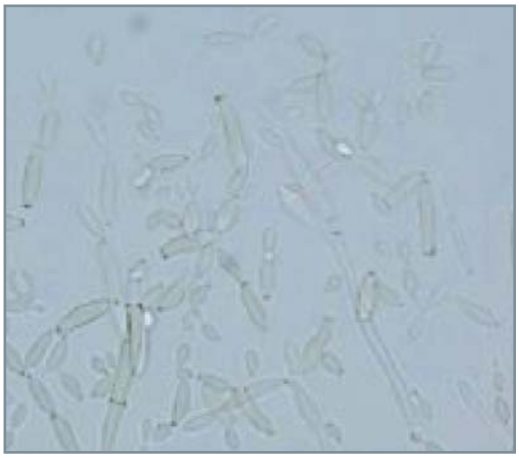
Considering the diversity of fungi, it is remarkable that only a very small fraction of the estimated 1.5 million species of fungi become problematic for us. In the construction industry, we are concerned with certain fungi that are able to use compounds in building materials, such as the complex, organic sugar molecules of wood and wood products (components of the plant cell walls) as food sources, thereby degrading the organic molecules and the building material itself.

Scopulariopsis brevicaulis spores, conidiophores and hyphae viewed by Nomarski optics. Common source of soft rot.

We have already noted that fungi and molds require a nutrient source. These organisms are prolific in an ambient temperature range of 50 to 100 degrees Fahrenheit. Fungi also require oxygen, but this is not typically a limiting growth factor under ambient conditions. Fungi do not shun light but do not need it to grow. The fourth key requirement of fungi for growth is adequate moisture (i.e., available water). Some fungi require an abundance of available water to colonize and proliferate on a substrate (e.g., species of *Stachybotrys* and *Ulocladium*), while other fungi (e.g., species of *Penicillium* and *Aspergillus*) can survive readily in moisture regimes equivalent to 60 percent relative humidity. Of the basic habitat requirements of fungi and molds, moisture or water is a key feature and one that we can control. The key to keeping fungal growth in check is to keep materials dry.

Fungal Dispersal

Since most fungi cannot walk, swim, or crawl from one place to another, they need a mechanism to permit survival of the species. Mature mycelia may give rise to structures that produce spores. Spores can be produced through sexual activities as well as by non-sexual means. Spores are specialized cells that separate from the main body of the fungal colony and disperse through a variety of mechanisms to other suitable habitats. Some spores are simply carried away by air currents, while others are transported by water splash or other vectors, such as animals. When a spore lands in an appropriate environment (habitat) where food, oxygen, temperature, and moisture requirements are tolerable, the spore germinates and produces a new fungal colony (mycelium) that may eventually grow, mature, and produce more spores. Under optimum habitat conditions, this process can happen in a matter of days (as few as two).



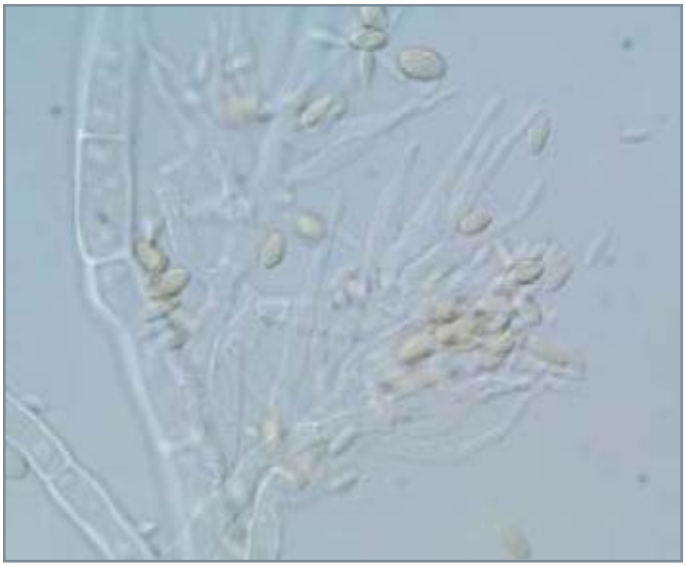
Cladosporium cladosporioides spores and conidiophores viewed by Nomarski optics. A common mold.

Wood Decay

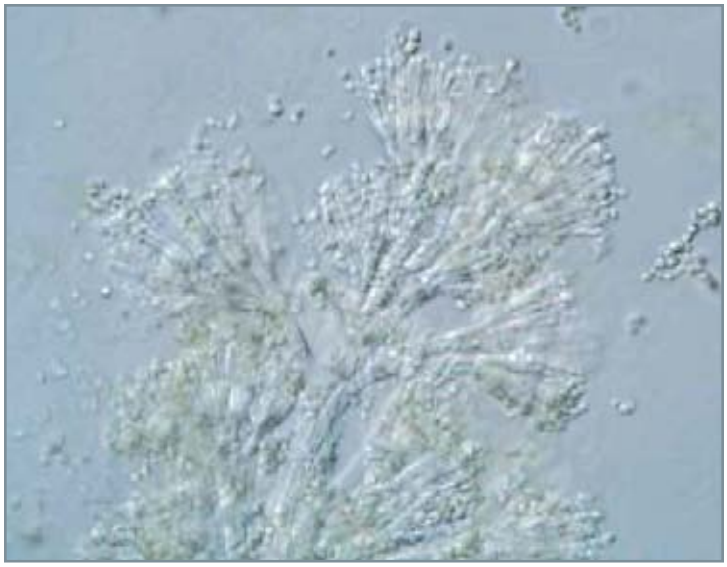
In building construction where wood (e.g., dimensional lumber, oriented strand board, and laminates) is utilized as a building material, excessive moisture content of the wood offers suitable habitats for several common fungi/molds. Colonization of wood by species of fungi, called the basidiomycetes, causes serious wood decay, also referred to as white and brown rots.

White rots are so named because, as the fungal decay proceeds, the wood takes on a whitish appearance. This type of decay requires very high moisture content in the wood (20% moisture content as measured with a reliable moisture meter). The degradation process is relatively slow, but is continuous, as long as the wood retains an elevated moisture content.

Brown rots, also known as dry rots, are a more serious type of wood decay because they do not require excessive moisture content to sustain active fungal growth. Brown rot fungi are able to transport water along filamentous structures, called rhizomorphs, from areas of high moisture to the actively growing cells of the fungal mycelium. This allows the fungus to invade wood with low moisture contents. Two of the main dry rot



Paecilomyces variotti spores, conidiophores and hyphae viewed by Nomarski optics. A common mold.



Penicillium species spores and conidiophoes viewed by Nomarski optics. A common mold.

fungi found degrading wooden structures are *Serpula lacrymans* and *Meruliporia (Poria) incrassate.* Brown rots are so named because as the fungi digest the wood, the wood takes on a brownish coloration. Wood in the advanced stages of brown rot also displays cubical checking (when the wood becomes permeated with voids, it becomes friable and breaks into cubical chunks).

Molds associated with wood and wood/plant products

Other fungi can attack wood but do so in a much less virulent manner. These fungi, typically molds, can cause decay of wood commonly referred to as soft rots. Molds decay only certain parts of the plant cell wall and do not produce the devastating effects of the basidiomycete rots. The effects of soft rot cause woody materials to feel soft and spongy. Some common molds commonly related to soft rots are species of *Chaetomium, Cladosporium, Alternaria, Ulocladium, Trichoderma, Aspergillus, Penicillium, Acremonium, Fusarium,* and the notorious "black toxic mold" *Stachybotrys.* Not surprisingly, these fungi grow well on other cellulose-based materials, such as textile upholstery and the paper facings of insulation and gypsum board.

The blue stain fungi are another group of fungi associated with wood. These fungi, in the *Ceratocystis/Ophiostoma* group, impart a bluish-black color to infected wood. The consensus is that these fungi do not damage wood in a way that would include a reduction in the structural integrity. Wood is often infected with blue stain fungi and other fungi in the lumber yard, and the infected lumber is brought into a building during construction.

Parting Thoughts

Fungi are ever-present in our environment and are too diverse and complicated to be completely summarized in a journal article. Fungi have attracted public attention over the past few years because of news media attention to litigation cases citing possible health effects of fungal elements on humans. When fungi grow in indoor spaces, there is a potential of exposure of building occupants to fungal elements, such as aerosolized spores, as well as physical deterioration of the substrate/building material. Fungi germinate and proliferate on indoor building materials when water and other parameters are tolerable. Keep in mind that moisture is the key to fungal growth. Should a consultant encounter an indoor fungal contamination situation, it is recommended that he or she seek advice/assistance of qualified consultants or remediation contractors.

MOISTURE IS THE KEY TO FUNGAL GROWTH.

Dr. Alan Neumann

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David Spero

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