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## **Interpretation of Air Test Results**

One of the most widely accepted methods of assessing indoor air quality and its effects on a building's occupants is the analysis of indoor air samples. Most often, these air samples are acquired using portable vacuum pumps that are calibrated to pull air through a tube at a specific volume of air per minute. The air that is pulled into the pump is trapped in a specially made cassette that contains an adhesive slide. Fungal spores, insect and skin fragments, and other airborne particulate matter are deposited onto the adhesive slide, which is then analyzed under a microscope.

The analysis of these slides can provide results relatively quickly because the samples do not require culturing or growing the fungal spores. Some of the mold types, however, produce spores that are so similar as to not be distinguishable by visual analysis alone and are therefore grouped together; e.g., *Aspergillus/Penicillium*. Still other spore types lack identifiable characteristics and therefore are counted as part of a larger group, such as Ascospores and Basidiospores.

Typically, the assessment of indoor air quality takes into account not only the analysis of the indoor air samples but also the comparison of these results to levels of fungi and other airborne matter in an outdoor baseline air sample. Spore count levels in indoor air samples generally should be lower than levels in outdoor air samples. Indoor spore counts that are lower than outdoor spore counts, however, do not automatically indicate that the indoor air quality is acceptable. Higher counts of individual types of spores or a higher count of the total spores in indoor samples may indicate mold growth inside buildings. The conclusion that indoor mold growth is occurring is strengthened further if mold spores' flowering bodies – called hyphae – also are identified in the indoor air sample.

There are other considerations to keep in mind when comparing outdoor baseline spore counts to indoor spore counts. The outside aerobiology is not constrained because of the variable, changing outside weather. For example, in the winter season, the spore count is always low in the outside sample. Similarly, rainy weather causes spores to be washed away or tamped down onto outside surfaces, resulting in lower counts in air samples. Also, in warmer weather, the evaporation process causes mold spores to rise in the air as well. Outside air, furthermore, has less of an influence on indoor air quality than it has in the past due to tighter, more energy efficient buildings as well as people's tendency to leave windows closed and rely on indoor air conditioning. As a result, when spores of particular species of mold – *Stachybotrys* and *Chaetomium*, for example – are found in indoor samples, even in a low count, their presence indicates a serious indoor mold issue because these mold types are not found in outdoor samples.

## Definitions

**Raw Count** – the number of mold spores actually identified and counted on the adhesive air sample slide

**Spores per Cubic Meter (Count/m<sup>3</sup>)** – calculated by raw count x (1000/(rate of air sampling) x (sampling time))

**Total Background** – the amount of particulate matter and skin fragments present on the slide; graded from 1-5 with 1 being very little, while a debris rating of 5 is unreadable. The higher the rating the more likelihood spores may be underestimated and overlap with background particulates.

### Total Background Interpretation Chart

Non-mold Particulate Level	Description	Conclusion
1	Up to 25% of the sample obscured by fibrous particulates, skin fragments, or insect fragments.	Results are not affected by debris.
2	Up to 50% of the sample obscured by fibrous particulates, skin fragments, or insect fragments.	
3	Up to 75% of the sample obscured by fibrous particulates, skin fragments, or insect fragments.	Results may not be accurate because the background debris overlaps the spores in the field.
4	Over 75% of the sample obscured by fibrous particulates, skin fragments, or insect fragments.	
5	Entire sample obscured by fibrous particulates, skin fragments, or insect fragments.	Sample is unreadable.

**Fibrous Particulate** – Fibrous particulates can come from many sources, including clothing, floor textiles, building materials, and paper products. They are often introduced into the air due to turbulence forces and friction applied to these materials. Improperly cleaned or maintained ventilation may increase the distribution of fibrous particulates.

**Skin particulates** – dead skin cells either from human or pets. Dead skin is continually shed by all the inhabitants of a home. Thousands of cells per day slough off of each person and into the living environment. Of course, our furry pets also shed lots of dead skin cells. The new skin cells gradually push their way to the top layer. When they reach the top, they die and are "weathered" by the environment and people's daily activities.

Particulate matter (PM) and skin particulates can be inhaled into the lungs where they can be absorbed into the bloodstream. They are a respiratory irritant and can cause direct pulmonary effects such as coughing, bronchitis, lung disease, respiratory illnesses, increased airway reactivity, and exacerbation of asthma. Particulate matter is also thought to have direct effects on the heart (EPA 2008c). Relatively recent mortality studies have shown a statistically significant direct association between mortality and daily concentrations of particulate matter in the air. Numerous studies link PM to a variety of health effects, including aggravated asthma, increased respiratory symptoms (irritation of the airways, coughing, difficulty breathing), and decreased lung function in children.

**Hyphal fragments** – Hyphae are small fragments of the mycelium of a mold. Mycelium is a mass of hyphae; this is the vegetative body portion of the mold. It is common to find small number of hypha fragments in outdoor air and possibly in indoor dust. Their presence in indoor air samples in a high quantity or as large segments indicates active fungal growth in the building. If conditions are suitable, the hypha fragments begin to grow and eventually also lead to mold spore production.

**Indoor air mold standard** – There are no state or federal statutes or regulations regarding molds and indoor air quality. Acceptable levels for individual mold species vary since species toxicity varies widely as do spore size, weight, and other features that affect risk to building occupants. However, some public agencies do make various publications regarding mold and indoor air quality available to the public. *Aspergillus/Penicillium* in a "clean" residential building study was at a mean of 230/m<sup>3</sup>; *Aspergillus/Penicillium* in buildings known to have a moisture or flooding problem was at 2235/m<sup>3</sup>; *Aspergillus/Penicillium* in mold contaminated buildings was at 36,037/m<sup>3</sup>.

The publication, American Conference of Governmental Industrial Hygienists (Air Sampling Instruments for Evaluation of Atmospheric Contaminants 1995), recommended the following guidelines:

100 cfu or less per cubic meter of air indicates low risk.

100 cfu to 1000 cfu per cubic meter of air indicates intermediate risk.

1000 or more cfu per cubic meter of air indicates a high risk.

Many people believe that a count of 48 *Stachybotrys* or *Chaetomium* spores/m<sup>3</sup> of air would be unusually high as this mold is not normally airborne. Conversely, a count of 200 *Aspergillus* sp. spores/m<sup>3</sup> of air in the same circumstances might be considered very clean.



After reviewing the literature standards of indoor mold spores, Enzcycle Lab, LLC proposes the following categories and the following actions:

Categories	spores/m <sup>3</sup> of air	Classification	Action
I	> 500	Normal	No action needed
II	500 - 999	Intermediate	Remediation required
III	<1000	High	Remediation required

### **Interpretation of Direct Test Results**

Direct surface samples may be acquired by swabbing a surface suspected of contamination, applying tape and lifting a sample, or analyzing a small piece of the surface material itself. These samples are then examined under a microscope.

Some of mold types that may be found in direct samples produce spores that are so similar as to not be distinguishable by visual analysis alone and are therefore grouped together; e.g., *Aspergillus/Penicillium*. Still other spore types lack identifiable characteristics and therefore are counted as part of a larger group, such as Ascospores and Basidiospores.

#### **Direct Sample Interpretation Chart**

<b>Mold Spore Estimate</b>	<b>Description</b>	<b>Interpretation</b>
0	None detected	No Action Required
1 to 10	Few spores found	Normal level detected
11 to 99	Light contamination	Remediation may be recommended, depending on other factors, such as total spore estimate, the presence of hyphae, and the species of mold identified.
100 to 1000	Intermediate level of contamination	Mold remediation is required for health of building occupants.
Greater than 1000	High level of contamination	

**Background Debris** – Non-mold particulate matter, including insect and skin fragments, that is present in the sample is rated from 1-5 with 1 being very little, while a debris rating of 5 is unreadable. The higher the rating the more likelihood spores may be underestimated and overlap with background particulates.

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## What IS MOLD?

Achyut P. Sharma, Ph.D., [www.EnzcycleLab.com](http://www.EnzcycleLab.com)



Mold is a fungus that thrives on moisture and poor ventilation. Molds are present everywhere - indoors and outdoors. In fact, there are more than 100,000 species of mold. They serve an important role by helping to break down organic matter. Outside, that's a good thing, but it's not good in your home. Molds are most likely to grow where there is water or dampness, such as in bathrooms and basements. They grow seeds, called "spores," that will float in the air like dust. Mold spores are in the air naturally and attach to any place that is damp, where they can begin growing immediately. These tiny spores cannot be seen without a microscope, but they can be breathed in. The spores, if inhaled, can trigger allergy and asthma symptoms in some people, or cause coughing, sniffing, and other cold-like symptoms.

There is no real standard that has been set that states what level of mold is 'safe' or can affect health. Every individual is different. Generally, however, there is consensus that, if you can see or smell mold, you should get rid of it.

Mold is alive; it will grow and reproduce if it has what it needs – moisture and food. What it lives on is organic matter, so anything that comes from an organic source can feed mold: dust, dirt, paper, food, furniture, fabrics, carpets, drywall, and wood.

Controlling the moisture and keeping your home dry is important in preventing mold growth. If you keep your

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home dry, mold is unlikely to grow. If you keep your house cold, or can somehow starve the mold, it won't grow, but that won't kill the mold you already have. Mold spores will remain dormant, and when the conditions are right again, they'll start to grow.

High moisture levels in your home can either come in from the outside such as through a foundation crack, flood or roof leak, or from inside from the people living in the home. In general, if you see condensation consistently on your windows, it is a sign of too much humidity in the home. The amount of moisture in the air can be measured. Humidity levels between 30 and 50 percent are ideal (relative humidity in the home should be under 45 percent in the winter or lower to avoid condensation on windows). Then, if necessary, you can use a dehumidifier to lower the relative humidity.

If you do have a water leak from inside or outside, don't put off the repairs. A roof leak or foundation crack won't get any better the longer you wait, and the more moisture that gets into your home, the worse the problem will get. Moisture can become a real problem in your home when there is not enough ventilation to expel that moisture.

### **Common molds and their impact on health**

Molds or fungi can be found in at least small amounts almost anywhere due to their release of tiny spores. Spores can be hazardous to human health and, if inhaled, potentially cause allergic reactions, asthma symptoms in some people, or coughing, sniffing, and other cold-like symptoms.

Health experts indicate that, depending on the type of mold present in a home, the amount and degree of exposure, and the health condition of the occupant, the health effects of mold can range from being insignificant to causing allergic reactions and illness. Molds also release a mixture of various volatile chemicals into air that people breathe and that impact health.

Pregnant women, infants, the elderly and those with health problems, such as respiratory disease or a weakened immune system, are more at risk when exposed to mold. Clinical manifestations range from harmless colonization to acute invasive disease. Predisposing factors include prolonged neutropenia, especially in leukemia or bone-marrow-transplant patients, corticosteroid therapy, cytotoxic chemotherapy, and AIDS.

Species of mold can be difficult to identify. Mold comes in many colors and thousands of types; it can be black, white, red, orange, yellow, blue, or violet. It can be fuzzy or have no texture. Sometimes it looks like dirt or a stain. Also, different kinds of molds grow on different materials – some need a lot of moisture while some are happy with the trace amounts of moisture that are found within materials like wood.

Following are descriptions and photos (taken with a microscope) of several common types of molds.

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## ABSIDIA



**Areas found:** soil and decaying organic matter, such as leaves, compost piles, and rotten wood

**Identification:** Small pyriform-shaped sporangia with a characteristic conical shaped columellae and pronounced apophysis; rapid growth at 40° C

**Mycotoxins produced:** none identified at this time

**Health effects:** Common human pathogen causing pulmonary, rhinocerebral, disseminated, CNS or cutaneous mucormycosis (skin fungal infections).

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## ACREMONIUM



**Areas found:** inside structures, frequently in insulation; widely distributed in the soil and in plant debris.

**Identification:** Colonies are usually slow growing, often compact and moist at first, becoming powdery, suede-like or floccose with age, and may be white, grey, pink, rose or orange in color. Hyphae are fine and hyaline and produce mostly simple awl-shaped erect phialides. Conidia are usually one-celled (ameroconidia), hyaline or pigmented, globose to cylindrical, and mostly aggregated in slimy heads at the apex of each phialide. RG-2 organism.

**Mycotoxins produced:** Crotoxin, Verrol4-acetate

**Health Effects:** Mycetoma (chronic inflammation of the tissues, usually of the feet or legs), which usually develops following trauma, is the most common infection caused by *Acremonium* spp. Other sites of infection include the eye (generally following abrogation of ocular defenses); colonizing disease of the lung and gastrointestinal tract; and locally invasive infections - osteomyelitis (inflammation of bone and bone marrow); sinusitis (inflammation of sinus membranes); arthritis; peritonitis (inflammation of abdominal membranes).

Pneumonia and disseminated infections including meningitis, endocarditis (inflammation of the membranes of the heart), and cerebritis (inflammation of the cerebrum area of the brain) rarely have been reported.



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## ALTERNARIA



**Areas found:** saprophytic contaminants (using nonliving organic material as a nutrient source for growth and reproduction); most are plant parasites, but a few species are ubiquitous and are also frequently soil borne

**Identification:** Dematiaceous hyphomycete producing chains of darkly pigmented, ovoid to obclavate dictyoconidia, often with short conical or cylindrical beaks

**Mycotoxins produced:** Altenuic acid, Alternariol, Alternariol monomethylether, L- tenuazonic acid, Alvertoxins I, II, III, Altenuene, Brefeldin A, Cytochalasins A&B, Destruxin B, Desmethyldestruxin B, Gliotoxin, Homodestruxin B, Zinniol

**Health effects:** Alternaria is one of the types of mold that commonly causes allergic reactions. If you're allergic to mold and you breathe in alternaria spores, chances are that your immune system will go haywire. Such symptoms are typically the same among all types of hay fever: sneezing, itchy and watery eyes, runny nose, congestion, coughing and dry skin. Alternaria also cause mycotic keratitis.

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## ARTHRINIUM



**Areas found:** in soil and decomposing plant material; common in outdoor and indoor environments

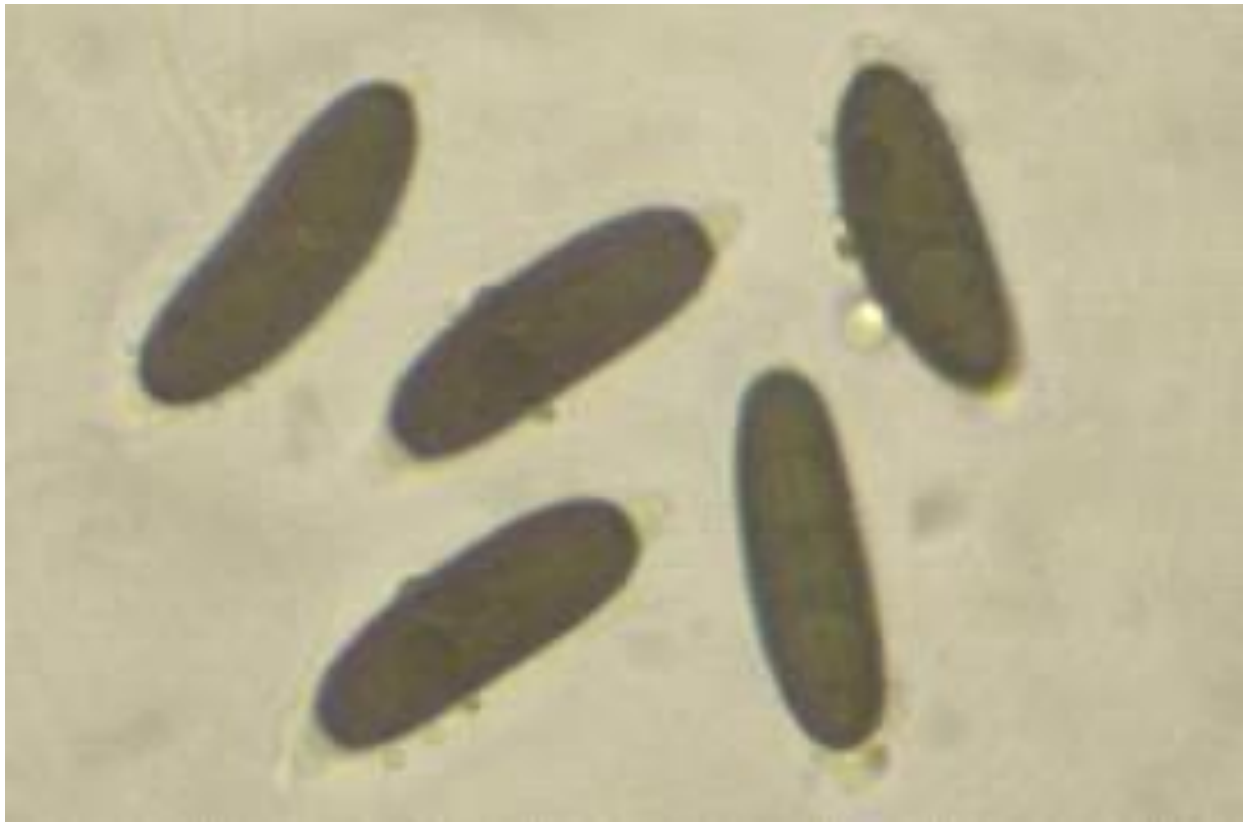
**Identification:** produces one celled dark conidia with a pronounced hyaline rim or germ slit

**Mycotoxins produced:** 3-nitropropionic acid

**Health effects:** This fungus has been documented in various subcutaneous infections; should be considered an allergen; no toxic related diseases are of record to date.

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## ASCOSPORES



**Areas found:** grow well under a variety of conditions; develop during the winter on dead, fallen leaves that were infected the previous season. From budburst onwards, rain triggers the release of ascospores into the air. Ascospores are frequently found indoors on damp substrates.

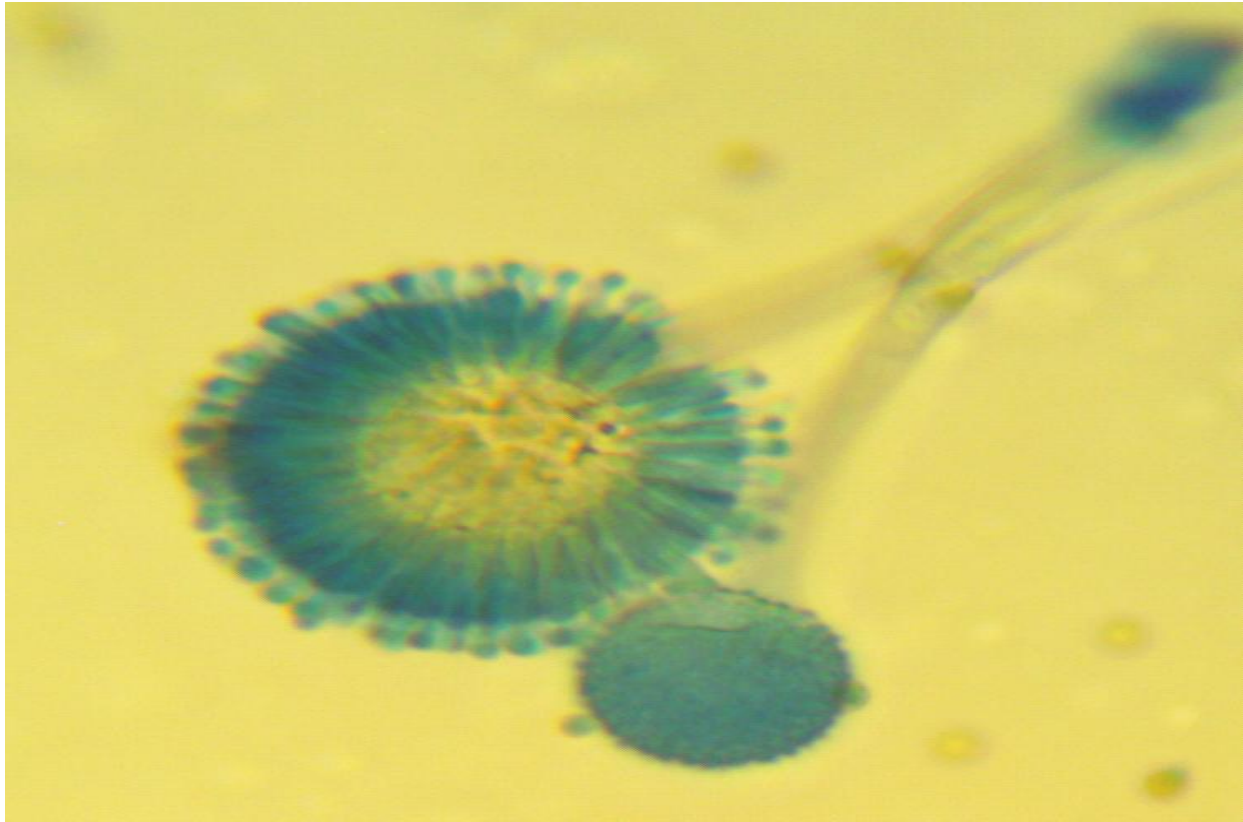
**Identification:** Ascospores are generally found in clusters of four or eight spores within a single mother cell, the ascus, and are characteristic of the ascomycete. The shape, size, and color are different depending upon the genus of ascomycetes fungi.

**Mycotoxins produced:** vary by individual type

**Health effects:** They are known allergens and these effects vary widely between genus and species of each Ascospore. Toxicogenic effects also vary widely within this group.

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## ASPERGILLUS



**Areas found:** dead leaves, stored grain, compost piles, or in other decaying vegetation and soil; very common in both indoor and outdoor environments; produce vast numbers of small, air-borne spores. They produce enzymes capable of degrading a great variety of organic substrates. A number of species are xerophilic and can thrive in relatively low moistures. In indoor environments, they are found growing on wood, paper, paint, glue, and even on metal doors that hold dust or dirt when the humidity is high.

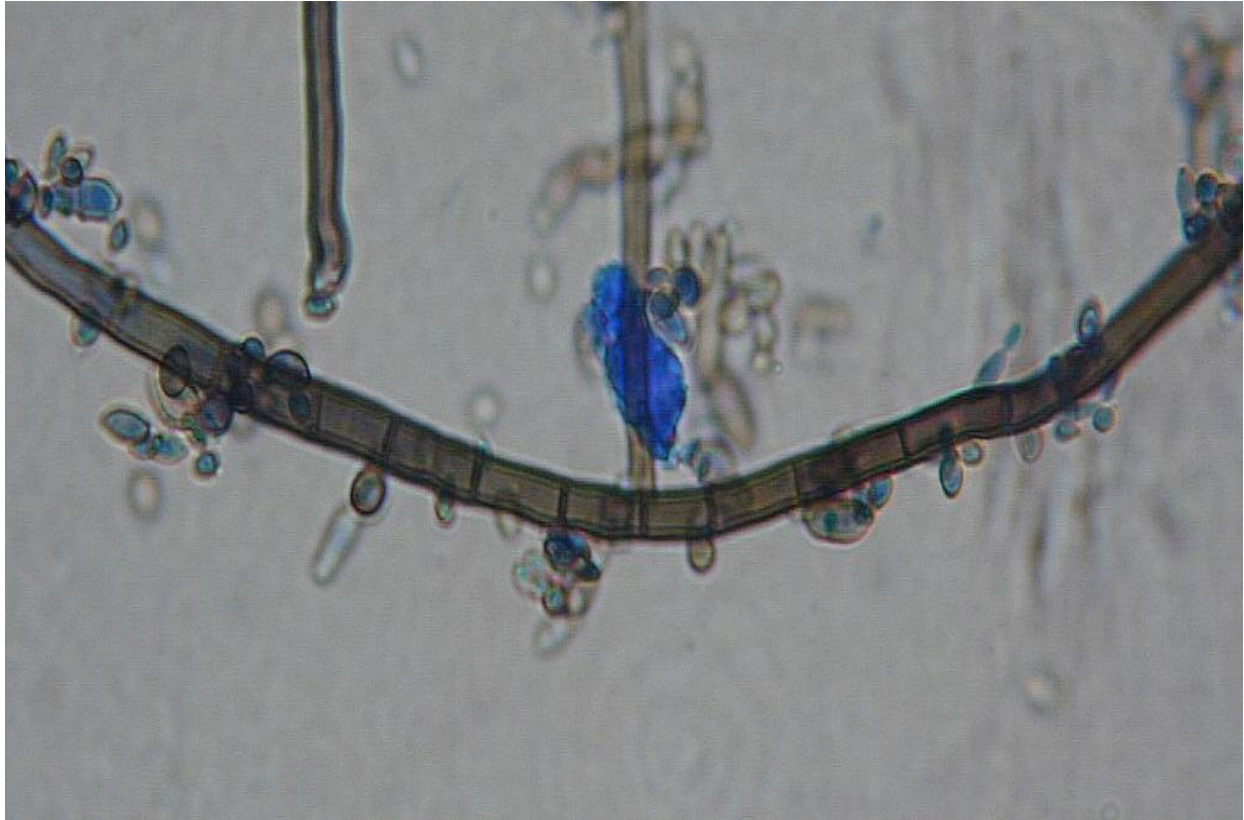
**Identification:** The identification of *Aspergillus* spp. was done with morphological taxonomy, in accordance with the colony diameter, conidial color, exudates, mycelium texture, soluble pigment, excretions, shape and size of conidiophores, vesicles, metulae, phialides, conidia, and their texture and color, following the identification system previously used for genus *Aspergillus* (Raper & Fennell 1973, Christensen 1981, Klich & Pitt 1988, Domsch et al. 1993, Klich 2002, Samson & Varga 2007).

**Mycotoxins produced:** Aflatrem, Aflatrem, Austdiol, Austamide, Austocystin, Brevianamide, Citrinin, Citreoviridin, Cytochalasin E, Cyclopiazonic acid, Destruxin B, Fumagilin, Gliotoxin, Malformin, Maltoryzine, Ochratoxin, Oxalic acid, Patulin, Penicillic acid, Sterigmatocystin, Tryptoquivalene, Verruculogen, Viomellein, Viriditoxin

**Health effects:** The most important clinical species are *A. fumigatus*, *A. flavus*, *A. terreus*, and *A. niger*. Unlike mycotoxicoses, the primary infection route for aspergilloses is through inhalation. *Aspergillus* represent a continuum of symptoms from mild sneezing to fatal systemic infections. *Aspergillus* is recognized as causative agents of mycotic keratitis. More severe infections can occur in people with a weakened immune system, AIDS, leukemia, an organ transplant, or chemotherapy.

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## AUROBASIDIUM PULLULANS



**Areas found:** worldwide, usually isolated as a saprophyte (using nonliving organic material as a nutrient source for growth and reproduction); isolated from skin and nails

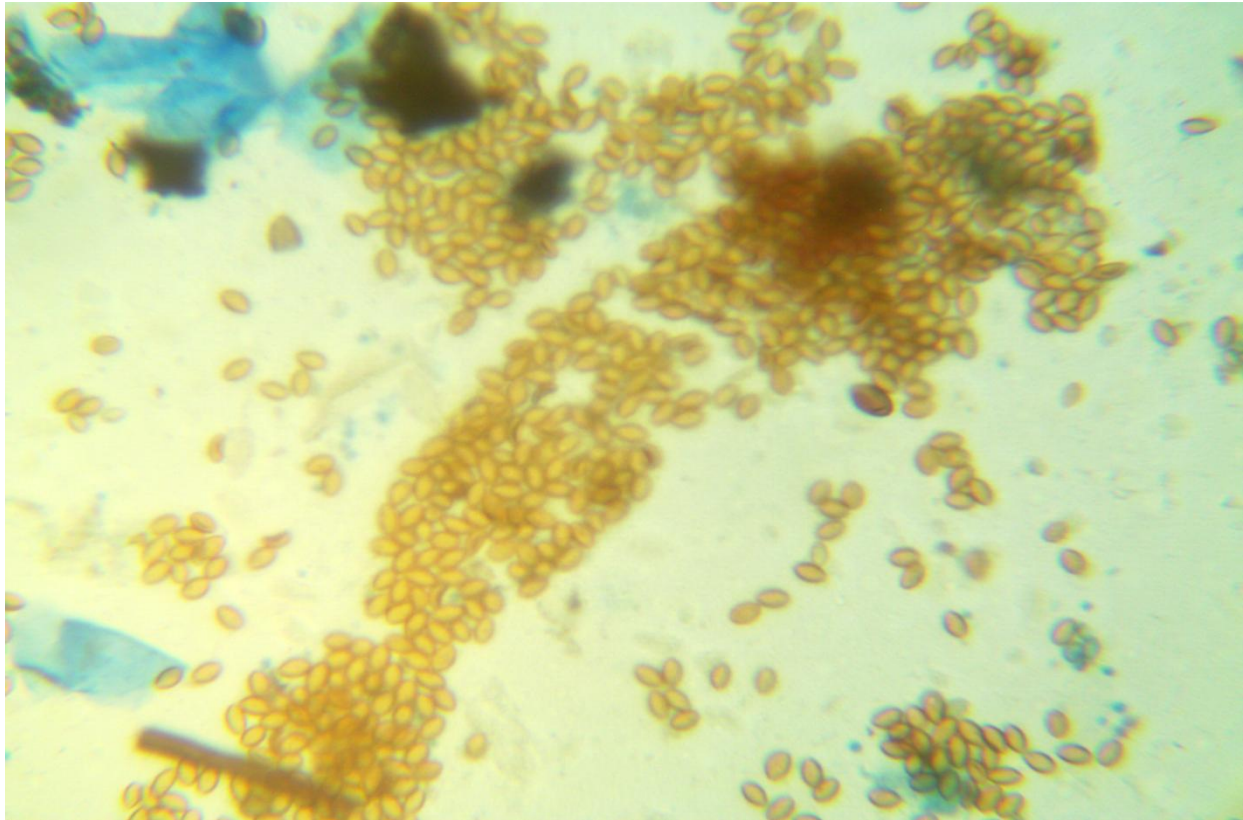
**Identification:** Produces hyaline blastoconidia simultaneously from the vegetative hyphae, which may also form chains of darkly pigmented, thick-walled arthroconidia.

**Mycotoxins produced:** none identified at this time

**Health effects:** rare causative agent of phaeohyphomycosis (fungal infection caused by a number of brown-pigmented fungi), mycotic keratitis (corneal infection), and peritonitis (inflammation of the peritoneum, the thin tissue that lines the inner wall of the abdomen and covers most of the abdominal organs) in patients on continuous ambulatory peritoneal dialysis (CAPD)

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## BASIDIOSPORE



**Areas found:** ubiquitous in nature; mainly found in gardens, forests, and woodlands. Basidiospores are moisture driven as their spores disseminate during rain or in times of high humidity. The presence of these spores at levels greater than those of the outdoor environment may be an indicator of fungal contamination and water damage inside a building. Inside buildings they can indicate the dry and brown rot of wood.

**Identification:** Basidiospores are the sexual spores produced by basidiomycetes including mushrooms, bracket fungi, and puffballs. Basidiospores show a wide range in size, shape, structure, and color; however, they are always single-celled and are frequently small, in the range of 5-12  $\mu$ m. The overall shape of basidiospores can be globose, elliptical, fusiform, nodulose, angular, or irregular. In addition, the basidiospores of many mushrooms and bracket fungi are asymmetrical due to the presence of a hilar appendage, which attaches the spore to the basidium. This attachment structure can be distinct or indistinct. Spore walls may be smooth or ornamented with spines, warts, or ridges. An apical pore is a common feature on many basidiospores and, when present, is generally visible in the light microscope. Basidiospore colors vary from completely colorless to various shades of yellow, golden brown, light brown, and dark brown to nearly black. Some basidiospores, such as those in the genus *Ganoderma*, have a transparent outer wall layer, while the inner wall layer is golden brown with spines.

**Mycotoxins produced:** none identified at this time

**Health effects:** These spores have been documented in cases of hay **fever**, asthma, eczema, allergic alveolitis, fatigue, runny nose, sneezing, stuffy nose, and plugged ears.

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## BIPOLARIS/EXSEROHILUM



**Areas found:** The fungi are either plant pathogens or saprobes in the natural environment

**Identification:** Colonies are moderately fast growing, effuse, grey to blackish brown, suede-like to floccose with a black reverse. Microscopic morphology shows sympodial development of pale brown pigmented, pseudoseptate conidia on a geniculate or zig-zag rachis. Conidia are produced through pores in the conidiophore wall (poroconidia) and are straight, fusiform to ellipsoidal, rounded at both ends, smooth to finely roughened and germinating only from the ends (bipolar).

**Mycotoxins produced:** Bipolaroxin, Dihydrobipolaroxin, BMT-toxin, Cytochalasins A&B, Pathotoxin, Siccanol, Sterigmatocystin

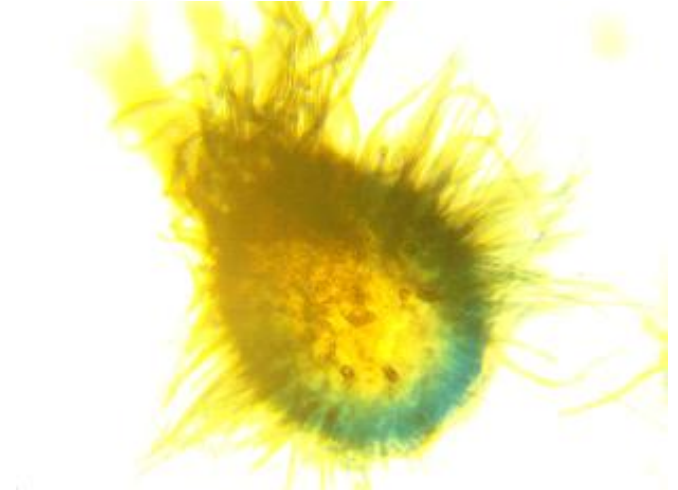
**Health effects:** Cause of mycotic keratitis, subcutaneous, sinusitis, peritonitis in patients on CAPD

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## CHAETOMIUM



*Chaetomium spores*



*Chaetomium fruiting body*

**Areas found:** Chaetomium has been found on paper in sheetrock. When this mold is found indoors, the site should be considered a wet condition, which means that other molds may be present. It may be found on wet drywall, wall-paper, carpets, window frames, baseboards and plywood. This mold causes many problems of bio-deterioration of paper and other cellulose-containing material, including paper and plant compost.

**Identification:** Perithecia showed densely haired surfaces and the shape of perithecia varied from globose to subglobose. The ascospores released inside the perithecium were seen oozing out from ostiole like cirrus. Under SEM, the shape of perithecia could not be ascertained, as they were densely covered with stiff hairs having depositions. Ascospores under SEM were lemon shaped, smooth surfaced with apical papillae. Chaetomium colonies are rapidly growing, cottony and white in color initially. Mature colonies become grey to olive in color. From the reverse, the color is tan to red or brown to black.

**Mycotoxins produced:** Chaetoatrosin, Chaetochromins (A To D), Chaetocin, Chaetoglobosin A & C, Chaetomanone, Chaetomin, Cochliodinol, Mollicellin, O Methylsterigmatocystin, Sterigmatocystin

**Health effects:** allergenic; a vast amount of medical news has been reported regarding Chaetomium. Chaetomium spp. are among the fungi causing infections wholly referred to as Phaeohyphomycosis, a fungal infection caused by a number of brown-pigmented fungi. Fatal deep mycoses (fungal infections) due to Chaetomium have been documented. Brain abscess, peritonitis (infection of the peritoneum, the tissue lining the inner wall of the abdomen), cutaneous lesions, and onychomycosis (fungal nail infections) may develop due to exposure. People who are exposed to Chaetomium may be predisposed to permanent neurological damage of the myelin sheath. Therefore, a noticeably high incidence of autoimmune diseases have been linked to exposure of this mold.



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## CLADOSPORIUM



**Areas found:** includes about 40 species naturally found in soil, on decaying plant material and as plant pathogens; several studies conducted in Europe and North America have shown that *Cladosporium* spores are present in the outdoor environment throughout the year. However, concentrations are very low in winter. In summer, daily peaks may range from 2,000 to 50,000 spores per cubic meter of air. Concentrations of *Cladosporium* species in indoor air is influenced by outdoor concentrations and indoor growth sources.

**Identification:** Colonies are rather slow growing, mostly olivaceous-brown to blackish brown but also sometimes grey, buff or brown, suede-like to floccose, often becoming powdery due to the production of abundant conidia. Vegetative hyphae, conidiophores, and conidia are equally pigmented. Conidiophores are more or less distinct from the vegetative hyphae, are erect, straight or flexuous, unbranched or branched only in the apical region, with geniculate sympodial elongation in some species. Conidia are 1- to 4-celled, smooth, verrucose or echinulate, with a distinct dark hilum and are produced in branched acropetal chains. The term blastocatenate is often used to describe chains of conidia where the youngest conidium is at the apical or distal end of the chain. Note that the conidia closest to the conidiophore and where the chains branch are usually "shield-shaped."

**Mycotoxins produced:** none identified at this time

**Health effects:** considered to be allergenic and can lead to sinusitis and pulmonary infections; *C. cladosporioides* reported from a cutaneous infection in an immunosuppressed patient. According to the MayoClinic, its various strains are some of the most common allergenic molds.

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## CURVULARIA



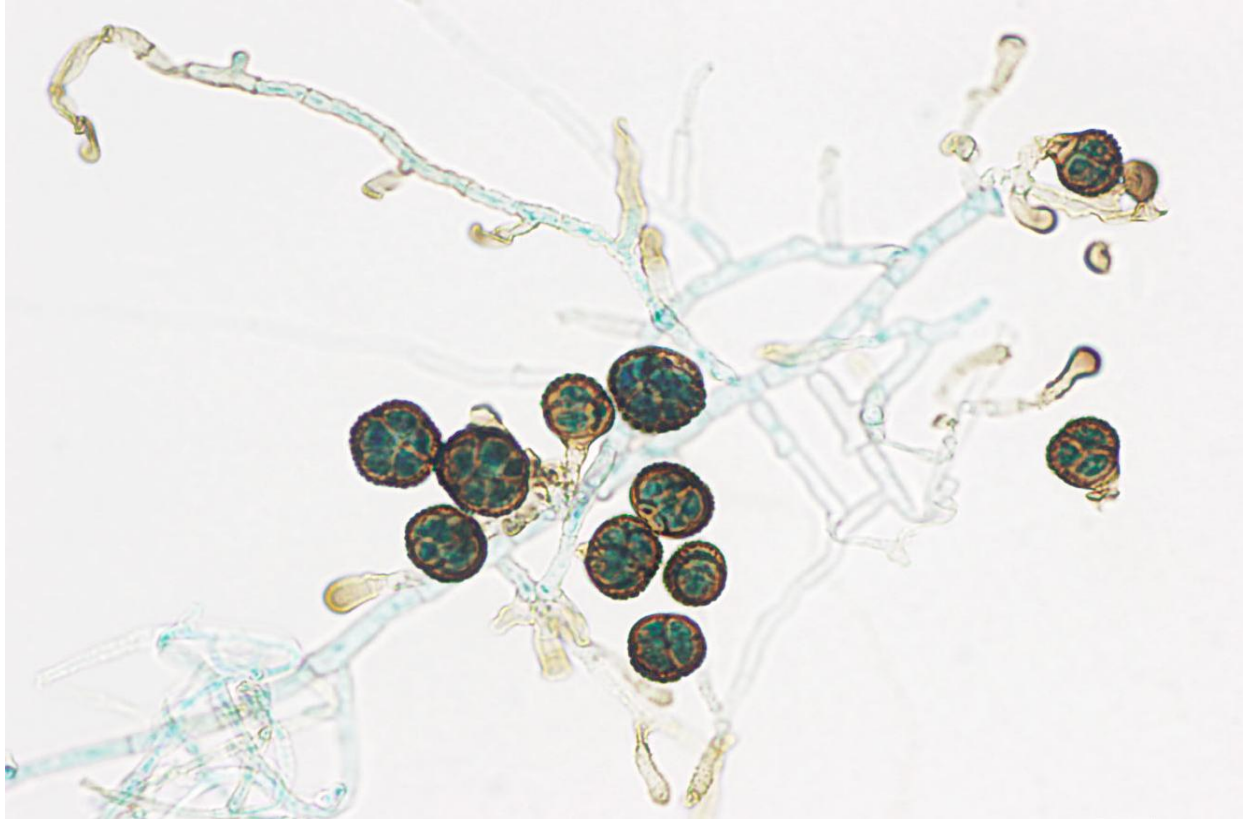
**Areas found:** particularly enjoys cellulose as a substrate, and can be found growing on wood, decaying plant matter, and living plants. Some colonize grasses and cereal grains, and others can live in the soil.

**Identification:** gray to black in color, typically darkening with age, and the underside of the colony will be a more pale white to gray

**Mycotoxins produced:** Belfedrin A, Curvularin, Curvularol

**Health effects:** onychomycosis (fungal nail infections), ocular keratitis (corneal infection), sinusitis, mycetoma (chronic fungal infection, usually affecting the foot), pneumonia, endocarditis (inflammation of the endocardium, the inner lining of the heart), cerebral abscess, and disseminated infection (infection that enters the body at a specific point then spreads throughout, often affecting numerous organs); most cases are from immune compromised patients

## EPICOCCUM



**Areas found:** Epicoccum is a widespread cosmopolitan saprophytic mold, most often associated with senescent and dead plant material. It is a common agent of leaf spot disease in various plants; it is also isolated from wood, paper, textiles and a variety of food, as well as on insects and human skin. It is also commonly found in the soil and easily isolated from air samples and occasionally found in indoor samples. The dry spores of Epicoccum are easily dispersed by wind and hygroscopic movement. In outdoor air, Epicoccum spores are more prevalent on dry, windy days, with higher counts late in the day.

**Identification:** Hyphae, conidiophores, sporodochia, and conidia are visualized. The hyphae are septate and yellow to brown in color. Short conidiophores that originate on hyphae form clusters. These conidiophores branch repeatedly and are visible as dense masses. Conidiophores give rise to conidia. Young conidia are round, nonseptate, and pale in color. Mature conidia (15-25  $\mu\text{m}$  in diameter), on the other hand, are rough, verrucose to warty, and brown to black in color. Besides, mature conidia contain multiple transverse and vertical septa and have a funnel-shaped base and attachment scar that is formed from aggregated conidiophores on the sporodochium.

**Mycotoxins produced:** none identified at this time

**Health Effects:** It is a common allergen, causing type I allergies such as hay fever and asthma. There are no cases of documented infection.

## FUSARIUM



**Areas found:** colonizes continuously wet materials such as soaked wallboard and water reservoirs for humidifiers and drip pans. A common soil fungus and inhabitant on a wide array of plants, this fungus has been isolated from water-damaged carpets and a variety of other building materials.

**Identification:** On potato dextrose agar medium, *F. solani* produces sparse to abundant, white cream mycelium. Macroconidia have three to four septa on average, are slightly curved, are rather wide and thick walled, and may have a slightly blunted apical end. Microconidia are abundant, oval to kidney shaped, and formed in false heads on very long monophialides. Chlamydoconidia are abundant.

**Mycotoxins produced:** Acetoxyscirpenediol, Acetyldeoxynivalenol, Acetylneosolaniol, Acetyl T-2 toxin, Avenacein +1, Beauvericin +2, Butenolide, Calonectrin, Deacetylcalonectrin, Deoxynivalenol diacetate, Deoxynivalenol monoacetate, Diacetoxyscirpenol, Enniatins, Fructigenin +1, Fumonisin B1, Fusaric acid, Fusarin, HT-2 toxin, Ipomeanine, Lateritin +1, Lycomarasin +1, Moniliformin, Monoacetoxyscirpenol, Neosolaniol, Nivalenol, NT-1 toxin, NT-2 toxin, Sambucynin +1, Scirpentriol, T-1 toxin, T-2 toxin, Triacetoxyscirpendiol, Yavanicin+1, Zearalenone

**Health effects:** Human exposure may occur through ingestion of contaminated grains and possibly through the inhalation of spores. *Fusarium* spp. is frequently involved with eye, skin, and nail infections.

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## GRAPHIUM



**Areas found:** Filamentous fungus found in soil and plant material

**Identification:** characterized by the formation of synnemata which consist of a more or less compact group of erect conidiophores that are cemented together, usually splaying out and bearing conidia at the apex. Synnemata are darkly pigmented, erect and occur solitary or in clusters. Conidia are hyaline, 1-celled, smooth, subglobose to ovoid and are usually aggregated in slimy heads at the apex of the synnemata

**Mycotoxins produced:** none identified at this time

**Health effects:** Common sites of infection by Graphium are the lungs, sinuses, bones, joints, eyes, and brain.

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## MYXOMYCETES



**Areas found:** decaying logs, stumps and dead leaves (particularly in forested regions). These organisms have both dry and wet spores. Wind disperses the dry fruiting body spores. While most often found in moist climates, several of these grass-inhabiting slime molds. Slime molds often appear in the same area of the lawn year after year.

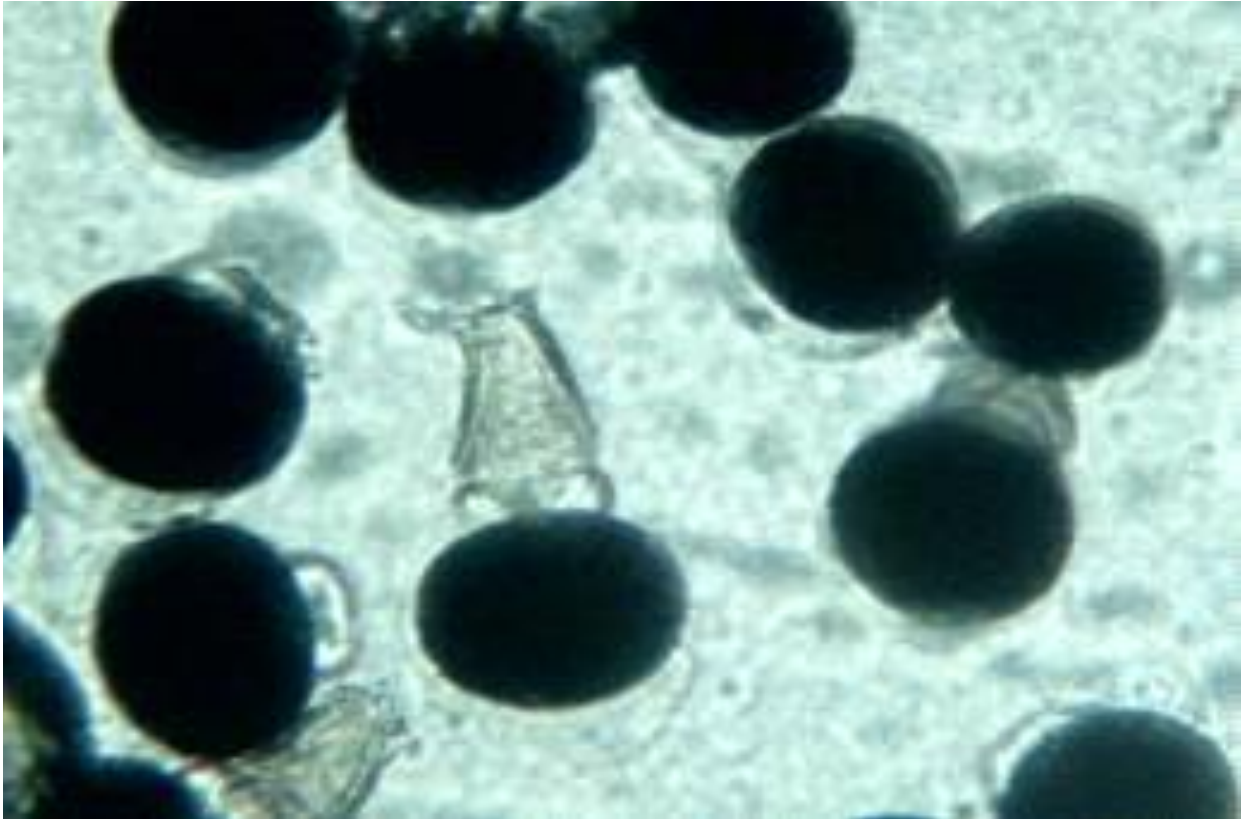
**Identification:** The colonies of slime mold living on logs and bark mulch can be strikingly colorful in yellow, orange or red. Some slime molds produce cream-colored masses of cells along grass blades.

**Mycotoxins produced:** none identified at this time

**Health effects:** Type 1 allergies (hay fever and asthma); fungal hypersensitivity reactions

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## NIGROSPORA



**Areas found:** widely distributed in soil, decaying plants, and seeds

**Identification:** filamentous dematiaceous fungus; unicellular, black, shiny, ovoid to ellipsoidal and horizontally flattened asexual spores (conidia), often with an equatorial colorless line

**Mycotoxins produced:** Metabolite A

**Health effects:** Can cause skin lesions and keratitis (corneal infections).

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## NONSPORULATING FUNGI



**Areas found:** grow on a variety of substrates.

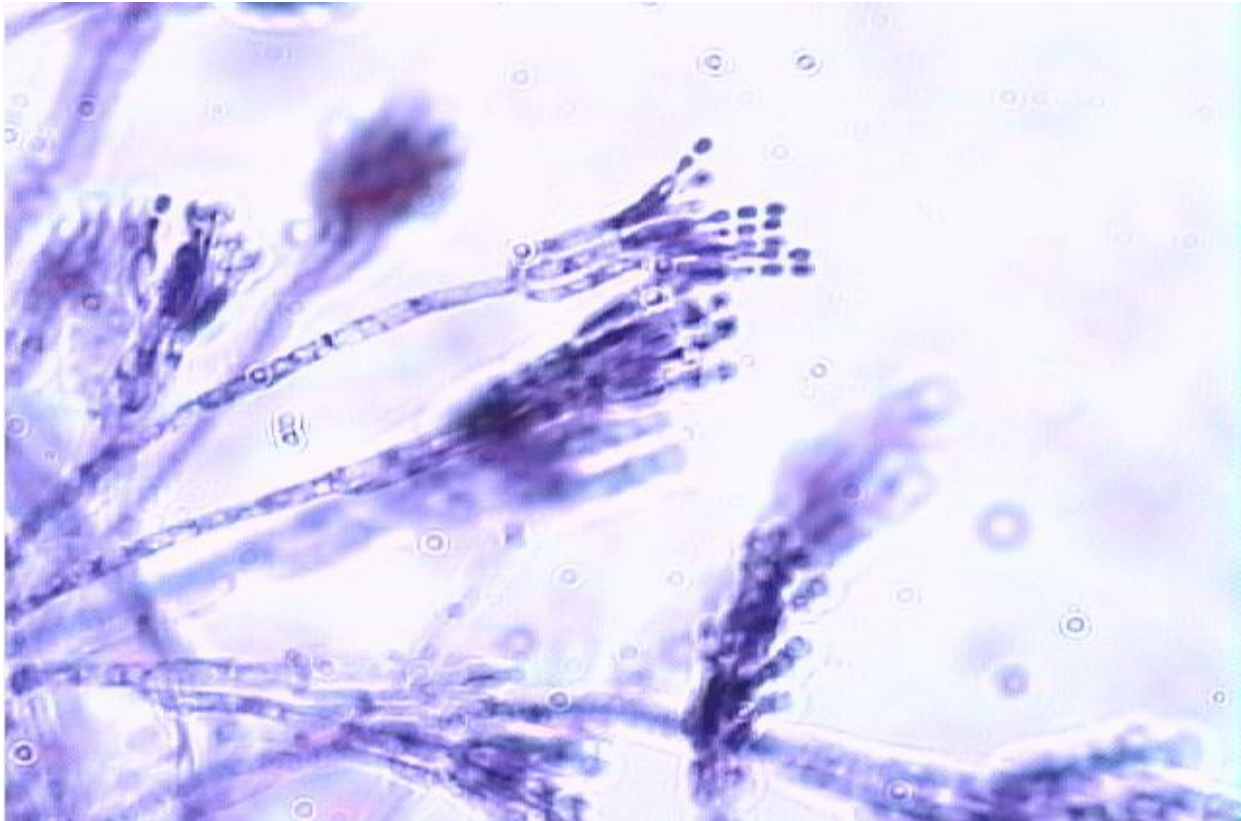
**Identification:** Identification is not possible without sporulation. These are organisms that have not sporulated under the culture conditions provided. Most never sporulate in culture (sterile mycelia). Potentially all fungi are capable of producing a non-sporulating state. Unless distinctive spore types are formed, identification may not be possible. Non-sporulating mycelia may appear as colorless or pigmented (brown), septate (with cross-walls) or non-septate.

**Mycotoxins produced:** none identified at this time

**Health effects:** They are known allergens and irritants; produce hypersensitivity pneumonitis, dermatitis.



## PENICILLIUM



**Areas found:** soil, food, cellulose, grains, paint, carpet, wallpaper, interior fiberglass duct insulation, and decaying vegetation

**Identification:** Microscopic characteristics of Penicillium: phialides may be produced singly, in groups or from branched metulae, giving a brush-like appearance known as a penicillus. The penicillus may contain both branches and metulae (penultimate branches which bear a whorl of phialides). All cells between the metulae and the stipes of the conidiophores are referred to as branches. The branching pattern may be either simple (non-branched or monoverticillate), one-stage branched (biverticillate-symmetrical), two-stage branched (biverticillate-asymmetrical) or three- to more-staged branched. Conidiophores are hyaline and may be smooth- or rough-walled. Phialides are usually flask-shaped, consisting of a cylindrical basal part and a distinct neck, or lanceolate (with a narrow basal part tapering to a somewhat pointed apex). Conidia are globose, ellipsoidal, cylindrical or fusiform, hyaline or greenish, smooth- or rough-walled. Sclerotia may be produced by some species.

**Mycotoxins produced:** Citrinin, Citreoviridin, Islanditoxin, Ochratoxin, Patulin, Penitrem, Rubratoxin, Rubroskyrin, Rubrosulphin, Rugulosin, Sterigmatocystin, Viopurpurin, Viomellein

**Health effects:** Scientific evidence has shown that asthma is more prevalent among adults living in damp homes and that asthma is three times more common in adults with mold allergy. Penicillium may cause hypersensitivity pneumonitis, asthma, and allergic alveolitis in susceptible individuals. Fungi have been isolated from patients with keratitis, ear infections, pneumonia, endocarditis, peritonitis, and urinary tract infections. Penicillium infections are most commonly exhibited in immunosuppressed individuals. Airborne Penicillium was shown to be significantly associated with lower respiratory infections in children.

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## PITHOMYCES



**Areas found:** grass and decaying plant material

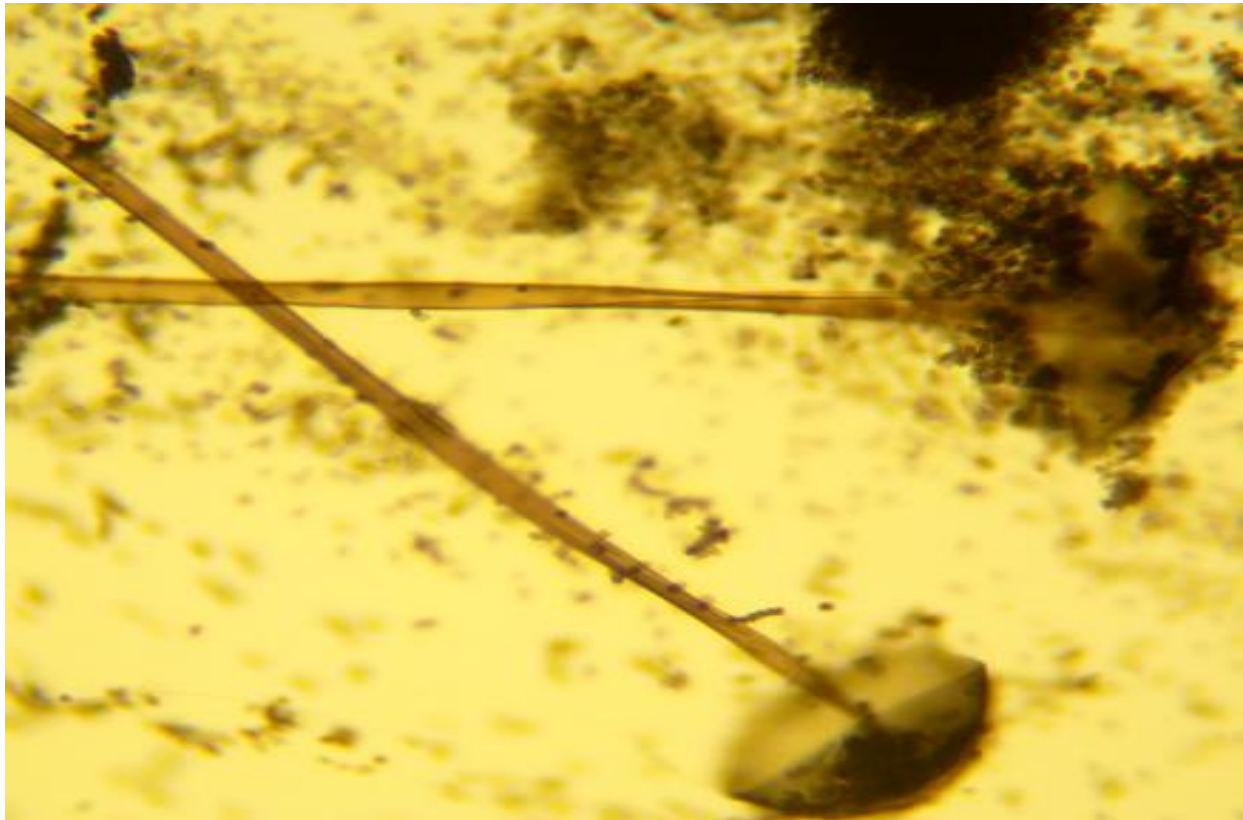
**Identification:** Usually grows very rapidly, woolly in texture. Pigment is pale/dark grey or brown on surface, dark brown on reverse. Hyphae septate, hyaline to brown. Conidiophores are very similar to the vegetative hyphae. Conidia muriform, brown, ellipsoidal/club-shaped, with smooth or rough walls.

**Mycotoxins produced:** Sporidesmin

**Health effects:** allergen, irritant; produces hypersensitivity pneumonitis, dermatitis

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## RIZOPUS



**Areas found:** soil, decaying vegetation, foodstuffs, and animal and bird dung

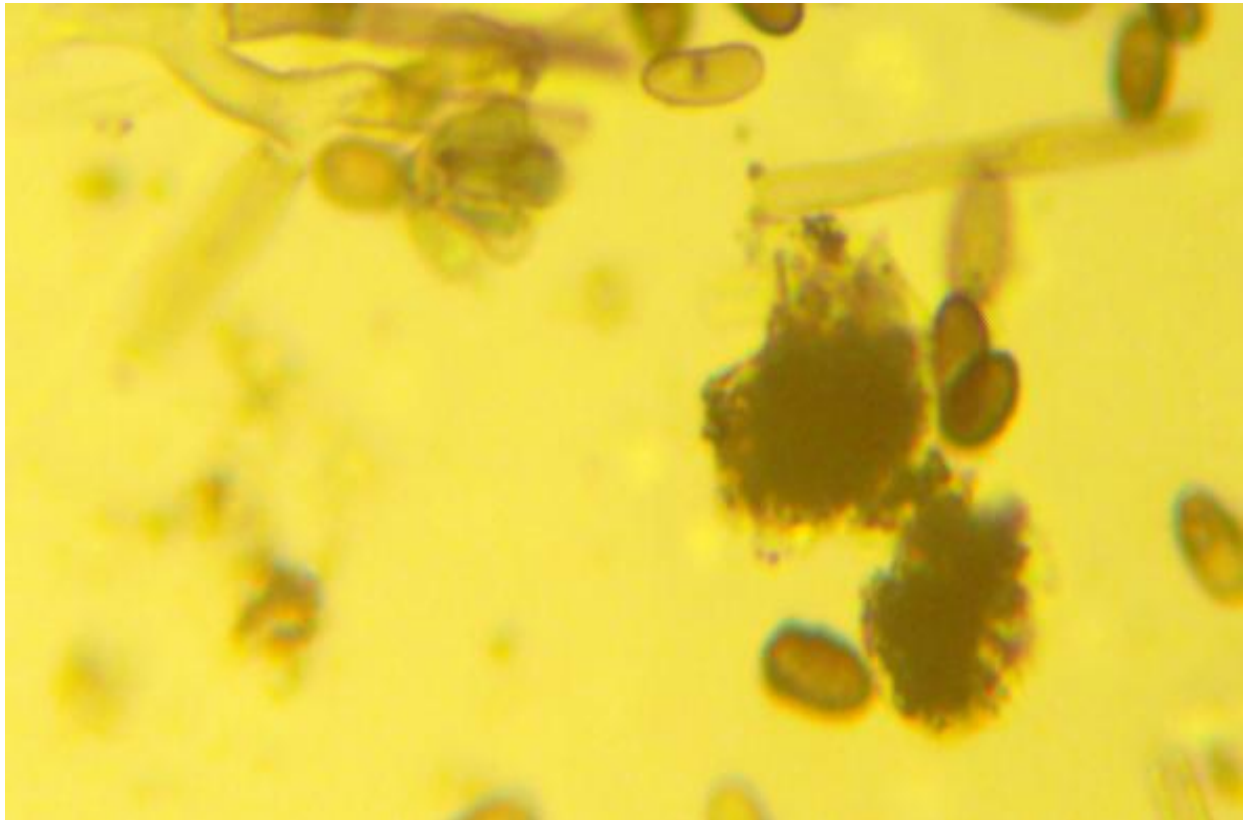
**Identification:** Rapid growth at 40°C; sporangiophores often >1 mm in height, formed opposite rhizoids, sporangia 100-200 µm in diameter with distinctive columellae and apophyses

**Mycotoxins produced:** Rhizonin A

**Health effects:** the most common causative agent of zygomycosis (fungal infections), accounting for 60% of reported culture positive cases and 90% of rhinocerebral cases; may cause mucorosis in immune-compromised individuals. The sites of infection are the lung, nasal sinus, brain, eye and skin. Infection may have multiple sites.

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## STACHYBOTRYS



**Areas found:** grows well on materials with high cellulose content (such as drywall, ceiling tiles, jute-backed carpets, etc.) that become chronically moist or water-damaged due to water leaks, flooding, excessive humidity, or condensation

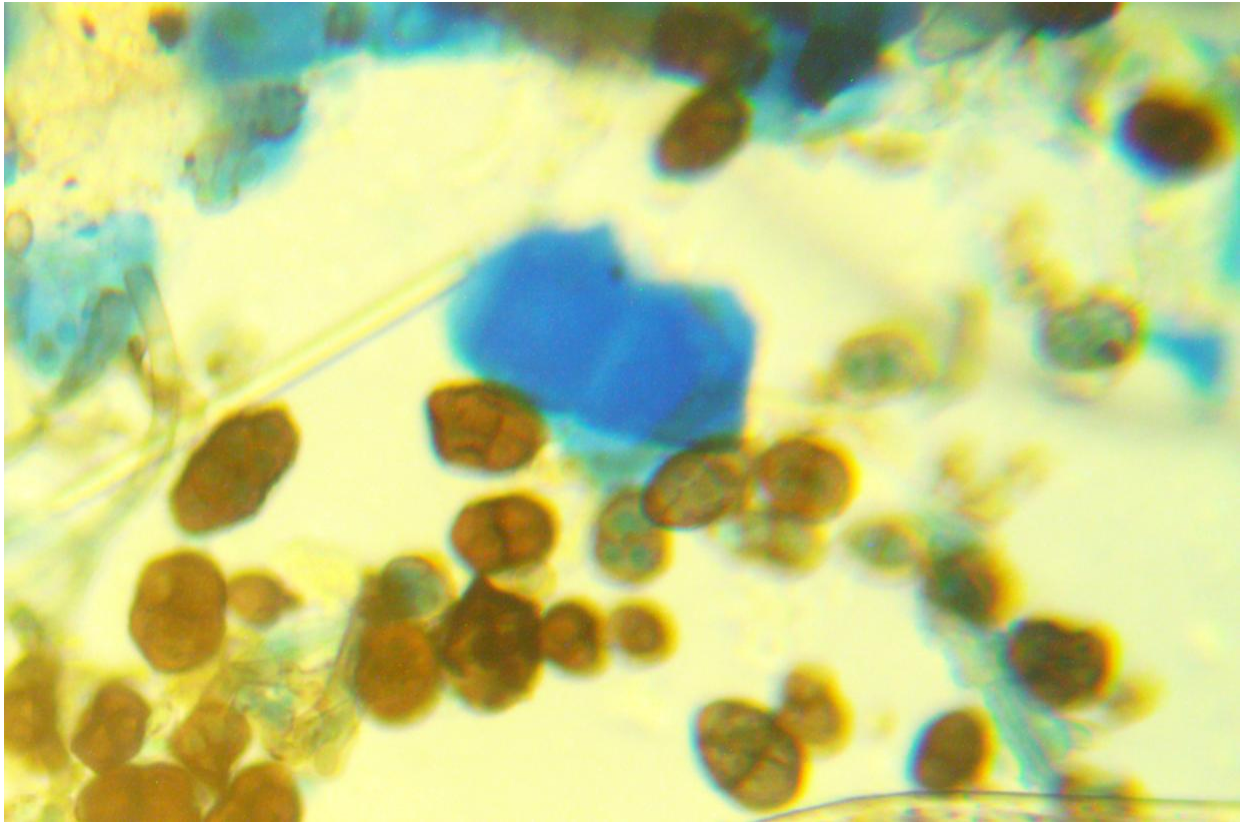
**Identification:** Grows moderately rapid; texture is powdery, pigment is white, pink, orange, black on surface and pale, orange, pink, black on reverse

**Mycotoxins produced:** Roridin E, Satratoxins, F,G,H; Trichoverrins, Trichoverrols, Verrucarins, Verrucologen

**Health effects:** *Infants under one year old are most at risk if they breathe high levels of Stachybotrys spores for long periods of time. Stachybotrys has been linked to a very rare condition called "pulmonary hemosiderosis" (bleeding of the lungs) in infants from extremely contaminated dwellings. This condition can only occur in the developing lungs of infants, and it does not occur in anyone else. However, other people may develop more general health effects, like eye irritations, asthma aggravation, cold-like symptoms, rashes, headaches, fatigue.*

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## ULOCLADIUM



**Areas found:** gypsum, paper, paint, and straw materials; requires a large source of water

**Identification:** Grows moderately rapid; texture is woolly/cottony. Pigment is olive brown/black on surface and reverse. Hyphae are septate, brown; conidiophores are brown with knee-like bends. Conidia (poroconidia) are brown, muriform, obvoid/ellipsoidal, smooth or rough walls, usually singly.

**Mycotoxins produced:** none identified at this time

**Health effects:** allergenic effects generally displayed in the form of Type I allergies; has been implicated in phaeohyphomycosis (fungal infection caused by a number of brown-pigmented fungi) and in rare subcutaneous tissue infections.

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## Acknowledgements and Helpful Links

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