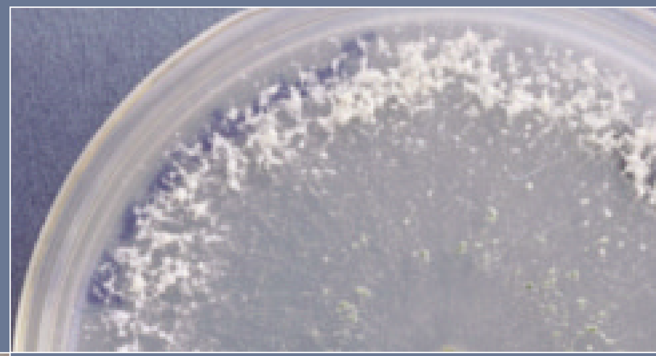

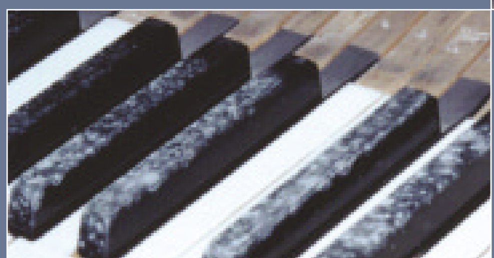

Microorganisms, Mold, and Indoor Air Quality

American Society for Microbiology

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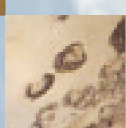

About the American Society for Microbiology

The American Society for Microbiology (ASM) is the largest single life science society, composed of over 42,000 scientists, teachers, physicians, and health professionals. The ASM's mission is to promote research and research training in the microbiological sciences and to assist communication between scientists, policymakers, and the public to improve health, economic well being, and the environment. The goal of this booklet is to provide background information on indoor air quality (IAQ) and to emphasize the critical role of research in responding to IAQ and public health issues which currently confront policymakers.

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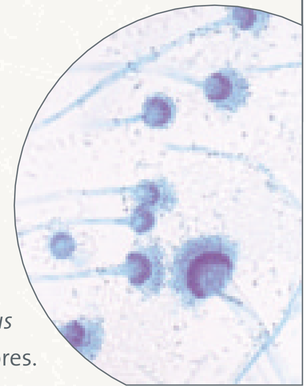
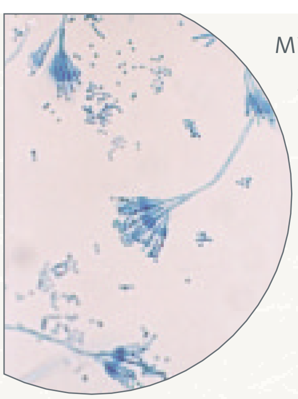
Introduction



Microscopic view of a cluster of *Aspergillus fumigatus* conidiophores and spores.

With every breath, we inhale not only life sustaining oxygen but also dust, smoke, chemicals, microorganisms, and other particles and pollutants that float in air. The average individual inhales about 10 cubic meters of air each day, roughly the volume of the inside of an elevator. Because people typically spend so much time indoors, poor indoor air quality (IAQ) can greatly affect individuals and, more broadly, the public health and national productivity. The US Environmental Protection Agency (EPA) Science Advisory Board rated indoor air pollutants, excepting radon, as the third highest of 30 environmental risks, well ahead, of sixth ranked occupational exposures to chemicals. However, a shortage of IAQ research leaves us with too many unknowns, even as more and more occupants of contaminated buildings are reporting a variety of health symptoms that they attribute to poor IAQ. This also leads to health treatment, expensive remediation activities, and litigation.

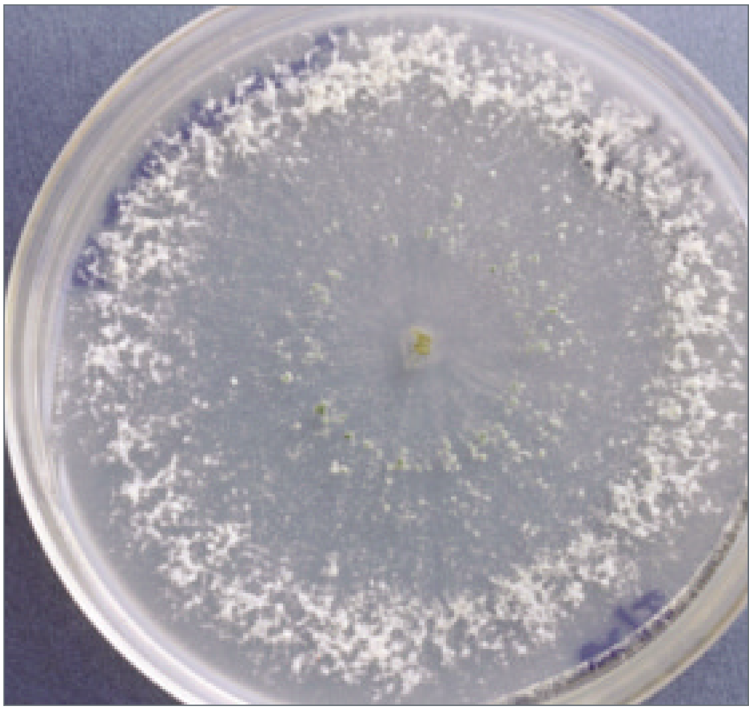


Microscopic view of *Penicillium chyrsogenum* conidiophores and spores.

Although poor IAQ is often viewed as a problem peculiar to modern buildings, linkages between air quality and disease have been known for centuries. Long before the germ theory of disease led to recognition of pathogenic microorganisms, foul vapors were being linked with infectious diseases. As our understanding of disease increased, public health workers made prevention of pathogen transmission a central concern. Today, we understand that airborne transmissions of pathogens, non-pathogenic organisms, fragments of microbial cells, and byproducts of microbial metabolism, collectively referred to as "bioaerosols," can all cause serious problems. Contaminated indoor air thus has the potential to harm public health and significantly affect the economy of the United States and other countries.

Wall cavity of a restroom with visible mold resulting from plumbing leaks.

Although the Centers for Disease Control and Prevention (CDC) does not track either the types or cases of illness attributable to bioaerosol exposure, bioaerosols are widely recognized to make asthma worse (*www.cdc.gov*). Asthma affects an estimated 20 million Americans and costs the US economy more than $13 billion annually. The American Lung Association cites asthma as the sixth ranking chronic condition in the United States as well as the leading serious chronic illness of children, with numbers of those affected rising each year. In a recent report, the Institute of Medicine (IOM; *www.nap.edu*) concluded that "there is sufficient evidence of an association between exposure to a damp indoor environment and asthma symptoms in sensitized asthmatic people" and that "there is a sufficient evidence of an association between the presence of 'mold' (otherwise unspecified) in a damp indoor environment and asthma symptoms in sensitized asthmatic people."



Culture of *Trichoderma* showing fluffy, spreading growth on the agar surface.

The US Government Accountability Office (GAO) reports that an estimated 20 percent of all schools in the United States have indoor air problems. Moreover, the general public is becoming increasingly aware of IAQ problems. Over 3,500 news reports related to mold toxicity have been published since 2000, and some 10,000 mold related lawsuits are pending nationwide. Many of these lawsuits have been filed in regions with hot, humid climates, but construction defects and inferior maintenance practices can lead to buildings with poor indoor air quality anywhere in this or other countries.

Water stained ceiling tile from an office building with chronic roof leakage.

Visible mold growing on a floor joist in the crawl space under a residence with chronic water seepage.

Bioaerosols in Indoor Air

Bioaerosols are collections of airborne biological materials. Ubiquitous indoors and out, bioaerosols in suspended, aerosolized liquid droplets typically contain microbes and cell fragments combined with byproducts of cellular metabolism. In addition, they may carry viruses, bacteria, and fungi that float on dust particles along with cells and parts of cells. Although there are no recognized standard levels for bioaerosols in schools, offices, and residential environments, several government agencies and professional organizations have published guidance documents that address bioaerosol concerns as an integral component of IAQ.

Agencies & organizations that have published guidance documents on bioaerosols:

- American Industrial Hygiene Association (AIHA)
  www.aiha.org
- California Department of Health Services
  www.cal-iaq.org
- Occupational Safety and Health Administration (OSHA)
  www.osha.gov
- US Environmental Protection Agency (US EPA)
  www.epa.gov/iaq/molds/index.html

Viruses

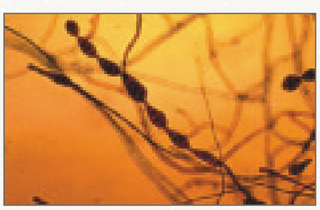
Viruses require a living host for replication, meaning they cannot by themselves multiply on or in building materials. However, they can contaminate interior spaces of manmade or natural structures such as occurred when Hantavirus infections resulted among building occupants because rodents had infested particular indoor environments. More commonly, many viruses that infect the respiratory tract spread from person to person, especially in crowded rooms with inadequate ventilation—thus making viruses common factors in poor IAQ. Coughing, laughing, and sneezing can discharge tens of thousands of virus filled droplets into the air and may readily spread illnesses in schools, offices, homes, or other settings.

Bacteria and Fungi

In contrast to viruses, bacteria and fungi will grow, often to an alarming extent, on building materials if moisture is available. Background levels of airborne bacteria and fungi change frequently inside buildings as a result of human activity, especially operation of mechanical air handling systems. Indeed, building conditions that allow excessive growth of bacteria or fungi can lead to occupants developing various specific medical symptoms or other complaints. Exposure indoors to unusual bacterial populations generally attracts notice when infectious disease results, such as the 1976 outbreak of a serious respiratory disease among attendees at a Legionnaire convention in Philadelphia, later associated with a bacterial contaminated ventilation system in the hotel where they had gathered. Endotoxin, a component of some bacteria, also can cause illnesses among building occupants who inhale this contaminant.

Fungi, especially filamentous fungi called mold, also lower air quality and cause public health problems though not typically as agents of infectious disease. Recently an IOM report stated that "there is sufficient evidence of an association between the presence of mold and bacteria in damp indoor environments and hypersensitivity pneumonitis" in sensitized persons. The IOM also referred to a possible association between exposure to damp environments, the presence of molds, and an increased risk of lower respiratory tract illnesses in otherwise healthy children. Of course, many fungi can play beneficial roles, for instance, when they help to recycle organic material such as fallen trees and leaves and when they are used in producing foods such as cheese, wine, and beer. However, when unwanted molds appear in ventilating systems or in other spaces within occupied buildings, exposures of occupants to those molds can lead to serious problems.

In general, the types and concentrations of mold that affect IAQ are similar to those found in outdoor air. However, background mold numbers may shift whenever water accumulates in buildings. Damage caused by floods, plumbing leaks,



Microscopic view of *Alternaria* spores in a chain.

Microscopic view of *Fusarium* macroconidia.

Microscopic view of *Cladosporium cladosporoides* conidiophores and spores.

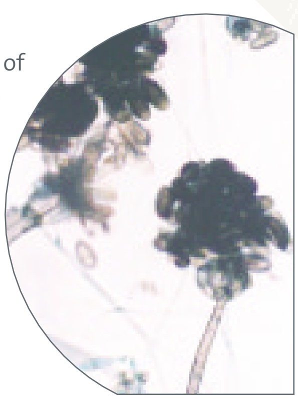
or roof and window leaks, and even climate and air conditioning related condensation can lead to long term water related damage indoors. Once water accumulates in building materials and furnishings, it takes less than 72 hours for mold to begin growing on those dampened surfaces. Hence, much of the information in this booklet addresses mold contamination, which is a readily recognized and frequent consequence of elevated indoor moisture levels.

Moisture

Building practices for commercial and public structures as well as residences have changed markedly in the past three decades, making many buildings more prone to moisture problems that lead to higher levels of microbial contaminants. For example, condensation often can occur in those buildings that are tightened to improve energy efficiency when appropriate care is not given to ventilation or how insulation is installed. Widely used building materials such as components made from wood chips or walls consisting of paper covered gypsum board are more sensitive to moisture than is plaster. Poor understanding of moisture dynamics and careless building design and construction lead to structures that are more susceptible to water intrusion. Also, lack of good maintenance practices in some buildings can lead to moisture buildups that, when left alone, can result in microbial contamination and higher levels of bioaerosols.

Visible mold on wall by a leaking hot water heater.

Moisture is the principal determinant of mold growth indoors. Different levels of moisture are needed for growth of different molds. For instance, *Aspergillus* and *Penicillium* require little available moisture and often are found along drier areas of water damaged materials. Other molds that require higher levels of moisture include *Stachybotrys* and *Chaetomium*. Not only are moldy surfaces aesthetically displeasing, they may require expensive repair and clean-up operations. Moreover, their presence can also lead to illnesses and loss of productivity among those who occupy such contaminated buildings. When water intrusion shifts indoor mold populations to those organisms associated with allergenic reactions or toxigenic byproducts, building occupants become more likely to report health problems and to incur increased costs for health care. Costs for building maintenance and repairs are also increased.



Microscopic view of *Stachybotrys chartarum* conidiophores and clusters of spores.

Health Effects and Indoor Air Quality

Americans spend up to 90 percent of their time indoors, where contaminants in bioaerosols are generally at higher levels than those found in outdoor air. Frequently the duration of exposure to such contaminants also is greater indoors than out. It is estimated that more than 30 percent of buildings in the United States and Western Europe have moisture problems serious enough to promote microbial contamination of indoor air. Exposure to high levels of indoor moisture is associated with upper respiratory symptoms, including higher incidence of coughing, wheezing, and asthma in sensitized persons, according to several large epidemiological studies cited by the IOM. Additional case studies, cluster investigations, and clinical experience associate other health complaints with living and working in damp buildings where mold and bacteria grow. Occupants of such damp buildings report a variety of additional symptoms, including:

- Headaches
- Nasal congestion and runny nose
- Watery, burning eyes
- Sore throat and hoarseness
- Dry, irritant-type cough
- Tight chest, burning sensation, wheezing, shortness of breath
- Nosebleeds, coughing blood (rare)
- Skin and mucous membrane irritation, rashes
- Exhaustion, severe fatigue
- Memory and cognitive problems
- Gastrointestinal problems such as nausea, vomiting
- Joint and muscle pain
- Fever

Health care professionals face the challenge that these symptoms are common and are associated with many different disorders. Medical conditions associated with exposure to viruses, bacteria, or fungi include infectious diseases, respiratory disorders such as bronchitis and asthma, and other allergic, inflammatory, and toxic responses. In some cases, evidence links these disorders to exposure to bioaerosols. For others, evidence is insufficient, reflecting the small numbers of exposed individuals who have been carefully studied.

Research that could establish cause and effect relationships between exposure to specific biological agents and particular diseases awaits several critical developments. These include availability of methods to measure the spectrum of potential agents (mold spores and bacteria, their fragments, volatile and semi volatile emissions, and allergen- or toxin-bearing particles) with a high degree of accuracy or of having alternative methods to establish biomarkers that can link exposure and effect. Most health effects attributable to bioaerosol exposures last only briefly and typically are reversible, particularly once moisture and consequent microbial contamination problems have been appropriately corrected. However, in some instances, health consequences may be serious and possibly irreversible.

Visible mold growth on the cardboard frame of a heating/air conditioning filter.

Microscopic view of *Memnoniella* conidiophore and string of spores.

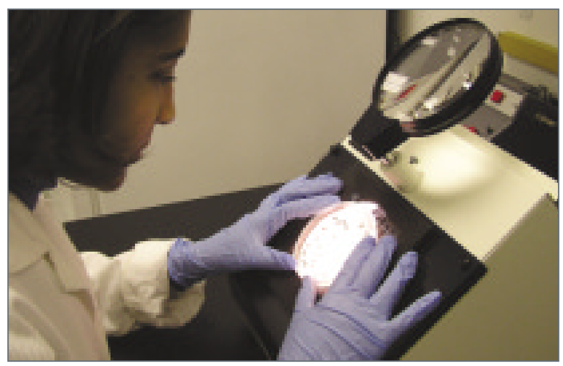
Assessment/Remediation Prevention Assessment

Assessment

The choice of which methods to use when assessing microbial contaminated environments depends upon the specific building type being investigated and also on who occupies those buildings. The classical approach to assessing such microbial contamination includes several basic steps:

- ***Gathering background information*** including, but not limited to, health of occupants (by questionnaire or medical examination), bioaerosol presence, excess moisture levels, microbial growth or unusual odors, location and status of microbial growth, and means by which contaminants may be disseminating through the building.
- ***Formulating and testing hypotheses*** to determine plausible reasons to explain how the building became contaminated, with an emphasis on:
  - — the building environment (i.e., sources of contamination and moisture, routes by which contaminants are transferred within the building);
  - — bioaerosol exposure data collected under a sampling plan that is specific to what is being studied because collecting samples from buildings demands a different approach than does assessing the health and well being of occupants.
- ***Making recommendations*** based on data collected, then implementing measures that remediate contaminants and will also prevent recurrences.

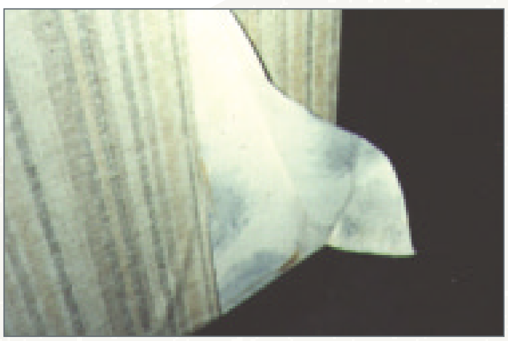
Microscopic examination to identify fungal spores on a sample from a building investigation.



Analyst identifying and counting mold colonies on a culture plate.

Often a combination of building related factors is responsible for poor IAQ. Teams involved in IAQ investigations typically include a mix of professionals, each with different skills to draw on when analyzing and resolving building related problems. For instance, a medical professional or epidemiologist usually investigates health aspects, while environmental microbiologists are called upon to investigate issues such as microbial ecology within buildings. Additionally, engineers, industrial hygienists, and indoor environmental experts are trained to investigate other building related factors that contribute to water damage and result in microbial contamination, whereas toxicologists bring expert knowledge needed for analyzing potentially toxic exposures. Ideally, investigators with varied backgrounds work as an integrated team to study different aspects of building related problems, consulting extensively with one another and sharing information. Therefore, it is important that practitioners in different fields be familiar with and appreciate the information, qualifications, and insights that other disciplines contribute.

While indoor "dampness" is associated with adverse health effects, in many cases the specific agents responsible for poor health outcomes have not been definitively identified. Published reports often fail to demonstrate direct links between exposures of building occupants to microorganisms with the specific respiratory health effects that those occupants describe. This failure to provide definitive proof that poor IAQ causes particular illnesses may be related to several factors, including inadequate methods for assessing exposures of occupants to relevant microorganisms and their products, and a lack of understanding whether particular microorganisms are responsible for causing specific adverse health effects. Given the current state of knowledge, investigations of environments suspected of being contaminated with microbes should focus on conditions that contribute to the growth of those organisms (i.e., moisture accumulation and moisture infiltration) and also the means to prevent these conditions from occurring.



Visible mold behind wallpaper in a room that was flooded during a rain storm.

Investigations of mold related problems often rely upon sampling techniques to determine mold growth in the indoor environment as an indirect estimate of the occupants' exposure to those molds. There are disadvantages for each sampling method, meaning no one method is capable of fully characterizing building ecology or occupant exposure. Fungal growth entails a dynamic succession of events that vary over time and with environmental conditions. Although different sampling methods may yield abundant data, each such method can yield only a "snapshot" of this dynamic process, particularly when circumstances force investigators to collect limited numbers of samples. A strategy to more accurately characterize indoor fungal contamination may require collecting large numbers of samples over extended periods, but such approaches inevitably prove more costly and might not even prove more valuable when it comes to defining occupant expo-

Swab sampling of visible mold on a carpet tack strip.

Tape sampling of a visibly moldy carpet tack strip.

sure. In short, environmental sampling does not always provide clear explanations for poor IAQ or for the illnesses that it is suspected of causing.

Interpreting sample data presents a challenge to investigators. Currently no numeric standards establish acceptable concentrations for airborne fungi in non-manufacturing work environments. In 1999, the American Conference of Governmental Industrial Hygienists (ACGIH) stated that "no consensus health-based guidelines exist, nor are any likely to be developed, until more data are available on dose-response relationships for specific agents and health outcomes, and more baseline data have been collected from randomly selected environments." In the absence of numerical guidelines, those interpreting bioaerosol data rely upon: a) indoor/outdoor ratios of fungal concentrations, b) comparison of species collected indoors and out, and c) the presence of indicator species (i.e. presence of fungal types that arise because of excess moisture).

Perhaps the most useful overall tool available to building owners and operators and, more generally, the public is to conduct thorough inspections of buildings for the presence of visible mold and excess water. However, additional factors need to be considered, such as the presence of hidden mold and its potential impact on a specific indoor environment. Overall, decisions derived from an investigation should be based upon the best data possible, along with experience, expert opinion, specialized methods, and also common sense to interpret information and to design control and remediation strategies.

Visible growth of *Penicillium* on the keys of a piano in a water damaged house.

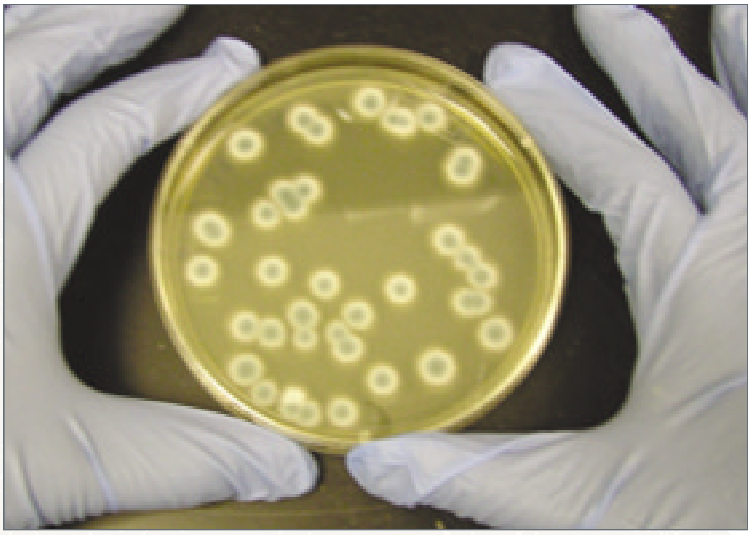
Remediation

The primary goal of remediation is to restore indoor spaces to their pre-contamination conditions. Defining "clean" and determining at what point a remediation project can be judged successful are subjects of considerable debate. The recently published *Standard and Reference Guide for Professional Mold Remediation* (Institute of Inspection, Cleaning, and Restoration Certification, 2003) defines a clean environment as "an indoor environment that may have settled spores, fungal fragments or traces of actual growth, whose identity, location, and quantity are reflective of a normal fungal ecology for a similar environment." Under any circumstances, parties should agree to the measure of "clean" that will be used to gauge the success of a remediation effort prior to beginning the corrective process.

The underlying principles of remediation are simple and straightforward, and they include:

- Identify and correct the moisture problem;
- Protect the health and safety of workers and occupants;
- Control mold contamination as close to its source as possible (prevent dispersion);
- Remove mold contaminated porous materials (e.g., upholstered furnishings, carpets, and drapery) that cannot be salvaged;
- Clean nonporous materials and surfaces;
- Remove remaining dust;
- Prevent reentry of moisture into the environment; and
- Rebuild using moisture safe structures, materials, and systems that can serve under prevailing environmental conditions without chemical or biological deterioration.

In practice, professionals have several options for removing molds or other contaminants, as determined by specific building type, climate, degree of contamination, and risks that those methods may pose to building occupants, including concerns about their health and sense of wellbeing.



Macroscopic view of *Penicillium* colonies on a culture plate.

Prevention

The best defense against excessive mold in indoor environments is to prevent microbial growth in or on building materials and furnishings. Within the home and office, some simple steps taken early can effectively reduce health problems related to indoor microbial contamination. They include:

- Maintain relative humidity below 60 percent within buildings;
- Use an air conditioner or a dehumidifier during humid months and maintain it properly;

- Provide adequate ventilation in buildings, including exhaust fans in kitchens and bathrooms;
- Keep bathroom and kitchen surfaces clean and regularly treat them with disinfecting products;
- Do not place carpeting in bathrooms, basements, or other areas where humidity is high; and
- Remove or replace carpets and upholstery if they cannot be dried out immediately after becoming wet.

In developing an indoor sampling protocol, consider:

- the number of samples to be collected;
- how bioaerosols and microbial growth vary over time and in different locations;
- an appropriate approach to documenting conditions under which sampling occurred (e.g., operation of the ventilation system, occupant activity, environmental conditions, status of doors, windows, and other openings);
- collecting extra samples for quality assurance and quality control purposes;
- collecting reference samples from additional locations, such as adjacent outdoor sites and noncompliant areas within the building being evaluated; and
- using equipment to protect on-site personnel.

Fungal colonies growing on an agar-filled Petri plate.

Research Needs and Issues

Studies of both the relationship between IAQ and microbial contamination and of the impact of poor IAQ on occupants are far from being definitive, making research needs in this field broad ranging and multidisciplinary; they include needs for:

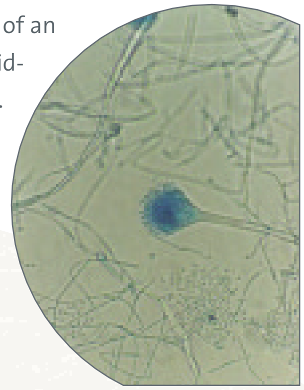
- **More objective, accurate methods, including standardized inspection protocols to assess the risk of exposure to various conditions and microbial agents.** Investigators assessing IAQ and its impact on health commonly refer to exposure indicators such as "damp housing," "water damage," and "visible mold." However, those investigators need to draw on objective methods for measuring these indicators instead of methods based on simple, visual observations of building conditions that are neither well substantiated nor standardized.

- **Better means for characterizing moisture related pollutants, including microbial and chemical emissions, and for estimating their importance as exposure agents.** Available direct methods for measuring and further characterizing pollutants associated with excess moisture in buildings do not provide reliable readings. One major problem is that current methods typically provide only short-term measurements, whereas longer sampling times would be expected to yield more reliable findings. More accurate analysis techniques are also needed.

- **Better understanding of how materials behave under environmental conditions such as high humidity, how different materials interact, and how different microbes interact among themselves and with different materials.** Building materials available for contractors and consumers are seldom sufficiently tested for their moisture related physical properties or their biological and chemical activities. Depending on what materials are being used, high moisture levels may lead to increased emissions due to microbial and chemical deterioration. The materials on which microorganisms are growing can affect the byproducts that they produce and may, for example, lead fungi to release particular toxins (called mycotoxins).

- **Better understanding of what leads to adverse health effects and whether they will be readily reversible or chronic.** Most published studies rely on data collected by means of questionnaires distributed to building occupants for estimating risk to them of adverse health effects from exposures to poor IAQ. More objective methods to estimate health outcomes should be developed, including direct clinical diagnostic methods and indirect biomarker based methods. In addition, studies in which animals are exposed to comparable IAQs could lead to a better understanding of how different periods of exposure to dampness may affect the likelihood of developing adverse health effects.

- **Improved efforts to integrate scientific information with practical efforts to prevent and resolve problems arising from exposures to excess moisture.** Those who are conducting private and public assessments of IAQ should be encouraged to make better use of scientific findings. Remedial actions at specific building sites should include reviews of building codes and agreements to modify them where appropriate, as well as efforts to educate building professionals, owners, and occupants.



Microscopic view of an *Aspergillus terreus* conidiophore and spores.

Several US government agencies sponsor research addressing IAQ issues, although the focus of these efforts is often not directed specifically at problems with bioaerosols. The CDC sponsors grants and cooperative agreements for research in the areas of environmental health, epidemiology, and occupational safety and health. Meanwhile, the National Institute for Occupational Safety and Health (NIOSH) within CDC sponsors research on health issues affecting workers, with prevention of disease being the over arching goal of those research programs. NIOSH also sponsors studies to identify occupational populations at risk, to develop methods for measuring exposures to hazards and detecting adverse health effects, to determine the prevalence and incidence of occupational hazards, to understand the etiology of occupational diseases and injuries, and to reduce or eliminate such exposures. Grants managed by the US Department of Housing and Urban Development (HUD) include "healthy homes" projects for which mold and moisture could be a focus. The National Institutes of Health (NIH) funds a wide variety of health related studies, some of which gauge environmental effects on health, particularly through the National Institute of Environmental Health Sciences (NIEHS). Moreover, the US Environmental Protection Agency (EPA) sponsors research on children's health that includes investigations of adverse environmental effects.

During the past decade, excess moisture and mold related IAQ issues have attracted intensive attention from the public and the news media in Finland and other Nordic countries. In 1995, a random sample of 450 Finnish houses showed that over half of them needed repair due to problems from excess moisture. Subsequent in-depth analysis showed that many occupants of those moisture damaged homes reported various health symptoms, including respiratory infections as well as other respiratory or more general symptoms. These findings underscore the need for more scientific and practical information on excess moisture related phenomena in buildings,

Microscopic view of *Aspergillus niger* conidiophores and spores.

consequent exposures to microbiological and chemical pollutants, and adverse health effects among building occupants. An extensive study program in Finland demonstrated that the majority of mold related health consequences appear to be reversible following repair to moisture damaged buildings.

Educational Needs

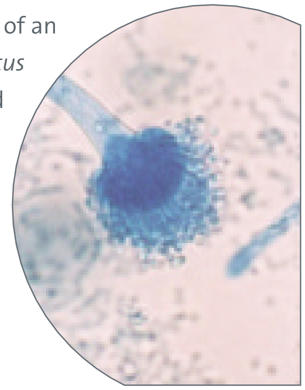
Determining the quality of indoor air, assessing microbial contributions to compromised air quality, and establishing protocols either to improve air quality or to prevent it from becoming compromised are complex challenges. Meeting these challenges will require multidisciplinary approaches involving a wide range of professionals working in academia, government, health care, and the building industry. New educational programs are essential for designing and implementing multidisciplinary approaches needed to address those challenges. Educational programs should be established to:

- increase, through continuing education, the capacity of microbiologists to conduct research, monitoring, remediation efforts, and prevention programs;
- support certification programs for industrial hygienists and other professionals who monitor and remediate indoor environments;
- educate undergraduate and graduate students in biological, environmental, and engineering programs by augmenting course curricula;

- inform medical and occupational health professionals about the diverse roles and impact of microorganisms on IAQ; and

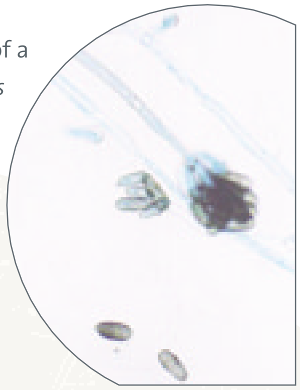
- inform professionals in building design, construction, and maintenance on causes of and solutions to compromised air quality.

Microscopic view of an *Aspergillus fumigatus* conidiophore and spores.



Recommendations

Microscopic view of a young *Stachybotrys chartarum* conidiophore and spores.



- Create an interagency committee, which would include experts from agencies such as EPA, NIOSH, CDC, NIH, and NIEHS, plus nongovernmental advisors with appropriate expertise for assessing IAQ related issues;

- Determine and then provide the levels of research and education funding needed to significantly reduce and prevent IAQ health effects;

- Adopt standardized methods for collecting data and reporting findings;

- Define and compile appropriate databases needed to establish appropriate IAQ policies, particularly as related to microbial pathogens;

- Identify and develop appropriate science based curricula to educate the general public, healthcare personnel, and building professionals about the best available methods to assess, control, prevent, and remediate microbial contamination in indoor environments; and

- Develop interagency collaborations to address fundamental research gaps regarding indoor mold contamination, such as, but not limited to:

  — Improving the understanding of the ecology of mold and other microorganisms.

  — Developing an understanding of the etiology of mold and other microbial related illnesses.

  — Studying the potential synergistic effects of mold, other microorganisms, and other pollutants.

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For more detailed information on remediation strategies and techniques consult the current existing guidance documents including: New York City Department of Health *Guidelines on the Assessment and Remediation of Fungi in Indoor Environments* (2000), American Conference of Governmental Industrial Hygienists (ACGIH) *Bioaerosols: Assessment and Control* (1999), U.S. Environmental Protection Agency *Mold Remediation in Schools and Commercial Buildings* (2001), and the Institute of Inspection Cleaning and Restoration Certification (IICRC) *Standard and Reference Guide for Professional Mold Remediation* S-520 (2003).

Glossary of Terms

Bacteria—single celled microorganisms with varying nutritional and physical/chemical requirements that allows them to colonize and grow in the environment.

Bioaerosol—a collection of airborne biological material that may include bacterial cells, fungal spores, virus particles, microbial fragments, skin cells and other particulate.

Conidia—An asexually produced fungal spore, formed on a conidiophore.

Conidiophores—Specialized fungal threadlike filaments forming the mycelium of a fungus that produces conidia.

Ecology—the study of the relationships between organisms and their environment.

Endotoxin—a heat-stable complex of the outer membrane of some bacteria that can elicit adverse health effects in exposed people.

Epidemiologist—the branch of medicine that deals with the study of the causes, distribution, and control of disease in populations.

Etiology—the study of the causes of a disease.

Fungi—microorganisms that are non-photosynthetic and utilize organic materials as nutrients for growth including damaged building materials and furnishings, and may produce toxins or cause allergic reactions when growing in water damaged buildings.

Hyphae—Any of the threadlike filaments forming the mycelium of a fungus.

Indoor air quality (IAQ)—the condition of the air outdoors and inside buildings with respect to the level of biological, chemical, and particulate material. IAQ is also known as Indoor Environmental Quality (IEQ) when additional factors are considered such as lighting, temperature, humidity, and draft.

Industrial Hygienist—a specialist in the science of health promotion and preservation in the workplace and community.

Microbial pathogens—microorganisms which cause adverse health effects.

Mold—filamentous fungi classified by their growth structures and categorized by their nutritional, temperature, and moisture requirements.

Mycelium—The vegetative part of a fungus, consisting of a mass of branching, threadlike hyphae.

Mycotoxin—chemical produced as a natural product of fungal metabolism that is toxigenic to other organisms.

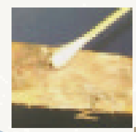
Remediation—the removal of biologically contaminated building materials following water damage and resultant growth of contaminant organisms.

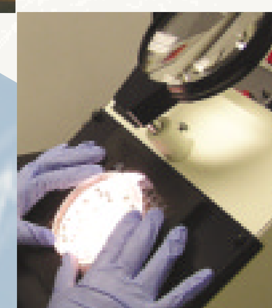
Spore—A small, usually single-celled reproductive body that is highly resistant to desiccation and heat and is capable of growing into a new organism, produced by certain bacteria, fungi, algae, and non-flowering plants.

Toxicologist—the study of the nature, effects, and detection of poisons and the treatment of poisoning.

Toxigenic—a chemical which will damage organisms.

Virus—a small acellular biological particle that has nucleic acid, but cannot replicate without an appropriate living host cell.





Front Cover Images:

Culture of *Trichoderma* showing fluffy, spreading growth on the agar surface.
Visible growth of *Penicillium* on the keys of a piano in a water damaged house.
Microscopic view of *Penicillium chyrsogenum* conidiophores and spores.
Microscopic view of a cluster of *Aspergillus fumigatus* conidiophores and spores.

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