

PATHOGENIC FUNGI

by Laurence B. Molloy

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All life on earth is divided into five kingdoms: Plants, Animals, Fungi, Protozoa, and Monera (bacteria). In short, fungi are not plants; fungi are a different and more primitive kingdom whose differences provide the wherewithal to poison the denizens of other kingdoms, including the species, Homo Sapiens.

Biologists first identified Fungi in 1700 when life classifications comprised only two species, plants and animals. They mistakenly classified Fungi as Plants. In the 17th Century, Antony van Leeuwenhoek recorded vast differences between Fungi and Plants.

Differences Between Fungi and Plants

1. Fungi have no chlorophyll and therefore cannot make their own food.
2. Fungi digest food outside their bodies by excreting enzymes that ooze out of the fungus body, and then absorb digested material through the cell walls.
3. Fungal cells are simple in structure and function and each a clearly visible central body with nucleus. Most are tubular in shape, connected end to end and thereafter deploy as circular growths of hair-like material*.
4. Fungi cells do not differentiate and therefore Fungi have no roots, stems, leaves, bark, etc.
5. Fungi cell walls are made of chitin and other polysaccharides, not cellulose (Plants) or protein (Animals).
6. Fungi reproduce by producing spores which are little more than a fragment of the parent fungus cell. Sexual reproduction is possible for some Fungi under certain conditions, but is infrequent. In most cases spores are produced without any cross-fertilization and, except for mutations, most spore are genetically identical to the parent cell.
7. Virtually all growth occurs by elongation of hyphal tips, i.e., the organism grows by elongating threads of itself, whereas it propagates by producing spores. As a result of these and other differences, biologists created a third kingdom of living organisms, named the *Fungi*, in 1784.

There are many different forms of Fungi, including, but not limited to:

- mushrooms¹,
- molds,
- yeast,
- lichen,
- rusts, and
- truffles.

Fungi may exist as either a yeast or a mold and may alternate between these forms, depending on environmental conditions. Yeast are simple cells, three to five microns in diameter. Molds consist of filamentous branching structures (called *hyphae*), two to 10 microns in diameter, that are formed of several cells lying end to end. Molds are the common name for a group of fungi often characterized by the presence of threadlike filaments, called hyphae, that mass together to form mycelia, interwoven visible bodies that resemble cotton.

Development of fungi cultures usually begins with a spore. In the presence of moisture, the spore swells with water much like a germinating Plant seed. Then the spore wall expands through a preformed weak spot [the germ pore] to create a thin, balloon-like protuberance. This first extension of growth is called a hypha (pl. hyphae) resembling long, worm-like structures. With continued growth, the hyphae will branch and grow into a visible colony called a "mycelium." Molds grow on many surfaces, such as wood, masonry, fabric or skin, and thrive best in warm and moist conditions. Many, however, survive at freezing temperatures, whereas others survive at temperatures approaching boiling.

There are over 200,000 fungal species and they make up a quarter of the biomass of the earth. There are 100,000 genera of the mold species, but only approximately 80 genera are known to cause illness. Molds, however, comprise most indoor air pollution sickness. Once mold growth has started, each mold colony (mycelium) produces millions of microscopic spores within a few days.

Fungi are divided into four main groups:

1. Phycomycetes or Rhizopors (black brad mold)
2. Ascomycetes including Penicillium and yeast
3. Basidiomycetes which are mushrooms, and
4. Fungi imperfecti, which include the Aspergillus and some Penicillium species.

Important Building-Related Illnesses and Exposure Sources

<u>DIAGNOSTIC CATEGORY</u>	<u>EXPOSURE</u>
Infectious Disease Legionnaire's; Disease Viral upper respiratory infection Tuberculosis	Legionella pneumophilia Respiratory viruses, influenza Mycobacterium tuberculosis
Allergy/Immunologic Reaction Dermatitis, urticaria Rhinitis, sinusitis Asthma Hypersensitivity Organic Dust Toxicity	Dust mite, fungi, copy machines Dust mite, fungi, copy machines Animal antigens, fungi, epoxy & resins Fungi & Bacteria, endotoxins & exotoxins Mixed organic dust (bacteria & fungi)
Toxic Reaction Central Nervous System Dysfunction (headaches, dizziness, cognitive abnormalities, chronic fatigue)	Pesticides, heavy metals (lead, mercury, chromium, arsenic, etc.), volatile organic compounds (formaldehyde and painting and cleaning solvents)

Irritant Syndrome	
Eye irritation/conjunctivitis	Glass fibers (man-made mineral fibers),
Mucous membrane irritation	Combustion products (CO, NO, NO ₂)
Epistaxis (nosebleed)	Low humidity

Sources: *Indoor Air Pollution. An Introduction for Health Professionals*, Environmental Protection Agency; Washington, D.C.; 1994. *New England Journal of Medicine*; 1997

Spores

There are many different kinds of spores. Those that come from mold mycelia asexually are called conidia, a round ball containing a genetically identical fragment of the parent fungus. Ascospores are different because they are formed when the nuclei of two different spores in the same species merge. Basidiospores come from parasite fungi such as "rusts" and are often multicellular. Spores either single or multicelled, vary greatly in shape and wall ornamentation by the species. All spores, however, are small they rarely exceed 100 microns and most are less than 20 microns. Spores also carry distinctive surface features that can cause allergic reactions, e.g., spikes, hooks, thorns, etc. adorn spore surfaces. Each species of mold produces a distinctive spore. Spore produced asexually are called conidia (conidium, singular) whereas spore produced sexually are called ascospores if produced by the main spore group, Ascomycetes. Conidia are genetically identical to the parent cell, whereas ascospores are genetically different.

For reproductive strategy, Fungi depend on wind and air for dispersing its "seed" and therefore each fungi produces a lot of spore. For example, the fungus responsible for corn smut produces about 25 billion spores per ear of corn. The wheat rust fungus produces about 10 billion spore per acre of moderately diseased plants and has been estimated to produce spore at the rate of 350,000 per second up to 5.4 trillion per year. In short, every active Fungi or mold colony produces millions of spore which contaminate the air within any enclosed space.

For dispersal strategy, Fungi produce very small "seed" (spore) that stay aloft for a very long time. Even in absolute still air, an average-sized spore of about 20 microns in diameter will fall at the rate of about seven feet per minute. In fact, fungi spores are lifted up and moved by the slightest draft and conceivably stay aloft indefinitely if, for example, windows in an apartment are left open. Professor C.M. Christensen at the University of Minnesota measured spore dispersal within an office building by using a marker fungus, a fungus with a distinctive color not normally found in the region. Five minutes after a culture dish was opened on the first floor, spore of the same fungus were detected on the fourth floor. Five minutes later, spore were falling on the fourth floor in amounts of thousands per square yard.⁴

For survival strategy, Fungi produce almost indestructible spore that survive a long time. Spore have very thick walls with dark pigmentation that defy ultraviolet light. In addition, many pathogenic spore have spiny cell walls that cause them to cling together as clumps when borne aloft. Fungi spore are capable of surviving both high and low temperatures. Many fungus colonies literally propel spore into the air by ejecting spore when water pressure builds up in the hypha stalk.⁵

Endotoxins, Exotoxins and Mycotoxins

Given the simple structure of a Fungi cell, its chemistry is nevertheless complex. Toxic products of Fungi growth are called mycotoxins. Each cell produces various exterior mycotoxins called exotoxins which can be either digestive enzymes or protective enzymes that ward away bacteria⁶. Chemicals produced inside the cell wall (and released later after ingestion, inhalation or death of the fungal cell) are called endotoxins.

Because a fungus has no chlorophyll, its physical structure is relatively simple: cells are nucleated and spore reproduce the parent. Since mold cells cannot produce their own food, they instead secrete digesting enzymes that surround the cell wall. Within a few minutes of germination, growing hyphae exude powerful enzymes that digest food for the fungus. Additional enzymes, protect the fungus from competing bacteria whereas other enzymes break down waxes and cellulose covering plant material. In short, the fungal cell is a factory of chemicals that contaminate its environment. This factory also produces effluent gasses which are also toxic in tight building environments.

"Stuck to the wall in a room , fungal hyphae come out of the micro egg cell in great numbers because it uses hyphae to feed. For some species it's sulfur grains in concrete, in others, it's paint, or the glue in wallpaper, or... it is the actual antibiotic poisons in wood that the fungus uses as food.

"Not everything the arms absorb can be handled by the main body of the creature further back. Many compounds are too poisonous and any fungi that accepted them would lose its suction grip, unplug from the feeding spot and fall poisoned to the floor. The way they get out of this problem is by spraying out the excess they don't need, releasing it in gaseous aerosols. At any moment during the day there will be freshly landed fungi on the room walls in the home, aerosolizing out carbon dioxide, hydrogen cyanide, ethanol fumes, various alcohols, and much else. When fungi levels are high enough to produce (musty or rubbery smells), you're likely to be able to see the enormous colonies which appear as unpleasant fur. In older houses, underlayers of paint surviving from the 1920's are likely to contain arsenic - it was used as an oil binder - and fungi plugging in from newer layers above will spray out an arsenic derivative like everything else."

The Secret House, David Bodanis, Simon & Schuster, 1986

Fungal cells exude digestive enzymes (exotoxins) that attack the cellular structure of food and reduce the food to a fluid that is absorbed through the cell wall. In addition, fungal cells also produce poisonous by-products that attack animals or bacteria and inhibit the growth of microbes in its environment, another exotoxin. Fungal metabolism also produces gaseous by-products (exotoxins) that contribute to indoor air pollution. Altogether, these metabolites are called mycotoxins because they are toxic to their environment, also called exotoxins because they are excreted outside the cell wall.

"The affected individual develops symptoms approximately 55 days after exposure to a working environment containing significant fungal contamination. Initial symptoms included bronchitis, swelling, spastic colon, severe headaches and fatigue. Later abdominal pain, nausea, diarrhea, severe headaches and fatigue. Later, abdominal pain, nausea, diarrhea along with loose teeth were reported."

Larry D. Robertson, "Airborne Concentrations of Trichoderma and Stachybotrys linked to Mycotoxicosis," Third International Conference on Bioaerosols, Fungi and Mycotoxins, Eastern NY Occupational and Environmental health Center, 1998

The chemistry inside the fungal cell is also toxic. The enzyme manufacturing process is metabolic and therefore produces many chemicals that are poisonous to humans if eaten or inhaled. Consequently, both mold cells and spores contain mycotoxins inside the cell wall which can infect and immunize humans in contact with the cell. Because these toxins differ from the chemicals exuded outside the fungal cell and because they are contained only within cell walls, such mycotoxins are called endotoxins. Endotoxins mainly affect hosts who ingest or inhale whole fungal cells or spores or water in which endotoxins are soluble. Endotoxins often occur in water wherein Fungi thrive. Endotoxins mainly affect human health because they are inhaled. Gram negative bacteria also produce endotoxins in water and are hazardous when inhaled in showers or in cool water humidifiers^{6A}.

In 1960, 100,000 turkeys died on a farm in England. It was discovered later that the turkeys were fed on peanut meal that was infested with a mold called *Aspergillus flavus*. This mold and most other opportunistic *Aspergillus* species produce at least 16 different toxic chemicals which collectively are called "aflatoxins." *Aflatoxins are today the most potent carcinogenic substance known to man*⁷. They are suspected to be responsible for most liver and kidney cancer and suspected also to cause pancreatic cancer. The high incidence of liver cancer in humans, especially Africa, appears to coincide with ingestion of foods highly contaminated with aflatoxin.

Health Effects

Biological agents in indoor air are known to cause three types of human disease: infections, where pathogens invade human tissues; hypersensitivity diseases, where specific activation of the immune system causes immune disease; and toxicosis, where biologically produced chemical toxins cause direct toxic effects⁸. Fungal infections in humans are called mycoses; they include such disorders as histoplasmosis, coccidioidomycosis, and blastomycosis. These diseases can be mild, characterized by an upper respiratory infection, or severe, involving the bloodstream and every organ system. Eyes and nails are often fungal infection sites. The mold *Aspergillus* is known to produce infected fungal balls in the lungs.

The extent of the fungi's role in human disease is only now becoming clear. Fungal spores are the chief vector for most human fungal diseases besides poisoning and cancer through ingestion. Recently the Centers for Disease Control in Atlanta pin-pointed the spore of *Stachybotrys atra* as a chief cause of Sudden Infant Crib Death, an overwhelming allergic response by infants to *Stachybotrys* spore that caused respiratory failure. Precisely because they are microscopic, inhaled fungi spore tend to produce violent allergic responses that persist in immunized individuals.

"Some biological contaminants trigger allergic reactions, including hypersensitivity, allergic rhinitis and some types of asthma. Infectious illnesses...are transmitted through the air. Molds and mildews release disease-causing toxins. Symptoms of health problems caused by biological pollutants include sneezing, watery eyes, coughing, shortness of breath, dizziness, lethargy, fever and digestive problems.

"Allergic reactions, occur only after repeated exposure to a specific biological allergen. However, that reaction may occur immediately upon re-exposure or after multiple exposures over time. As a result, people who have noticed only mild allergic reactions, or no reactions at all, may suddenly find themselves very

sensitive to particular allergens."¹¹

Hypersensitivity

Hypersensitivity is an immune disease. When exposed repeatedly or continually to a virulent antigen, such as mold spores and hyphae, endotoxins and exotoxins, blood cells called macrophages take up the protein (antigen) and produce a reaction of T lymphocytes and B lymphocytes. These lymphocytes remember the antigen and proliferate wildly when exposed again to this substance. The exposed person develops higher and higher levels of an antibody specific for molds which causes immune reaction symptoms.^{11B} The substances contained in pathogenic molds are sufficiently like the substances contained in other molds to the degree that hypersensitivity to one mold can cause reactions to other molds as well. This phenomenon is called cross reactivity.^{11C} It is not, therefore, unusual for someone who is hypersensitive to a pathogenic mold, such as *Aspergillus*, to react violently to ordinary molds released in a cheese shop, for example.

Immune responses that manifest as hypersensitivity disease fall into four classes:

Type I, or *immediate reaction hypersensitivity*, is caused when mast cells in mucous membranes produce histamines causing rhinitis, asthma, gastrointestinal distress, and sometimes hives.

Type II primarily involve immunoglobulin antibodies which circulate in the blood and destroy tissue; Type II hypersensitivity is most often caused by endotoxins and exotoxins rather than mold spores and hyphae.

Type III reactions are caused by blood-borne immune complexes which can cause tissue destruction and thickening; Hypersensitivity pneumonitis is a Type III reaction.

Type IV hypersensitivity is caused when T lymphocytes cause tissue inflammation primarily on the skin Ð contact dermatitis.

"The term, allergy, is now used primarily for Type I hypersensitivity reactions....People with hypersensitivity may react at low levels of exposure....Extrinsic allergic alveolitis (hypersensitivity pneumonitis) is an immunologic lung disorder representing a mixture of Types III and IV reactions....Hypersensitivity pneumonitis also may be seen in nonatopic (non-hereditary) people.¹³

Hypersensitivity Pneumonitis (HP) is caused by the inhalation of fungi spores. Repeated exposure cause the alveoli sacs of the lungs to become inflamed. Parts of the lung may then develop fibrous scar tissue which cease to function normally in breathing⁹. Hypersensitivity Pneumonitis is an immunologically mediated lung disease involving T-cells and lymphocytes¹⁰ The disease is also known as extrinsic allergic alveolitis. Symptoms are transient fever, hyperemia (deficient oxygenation of the blood), myalgia (pain in the muscles), arthralgia (pain in one or more joints), dyspnea (labored breathing) and cough.¹⁰ Other documented symptoms include mild gastro-intestinal disorder, chronic fatigue, unsteady gait when walking, and diminished memory^{11A}.

Because Hypersensitivity Pneumonitis is an allergic disease, there is a cause and an effect directly in response to contact with an allergen. The period of sensitization before a reaction occurs may be as long as six months or even years⁸. Once sensitized, however, the patient will exhibit symptoms on contact with any amount of the allergen. A classic characteristic of

HP is that a symptomatic patient will recover to full health and have no symptoms once removed from the allergen. If, however, the patient is exposed to any amount of the allergen again, acute symptoms recur within hours of exposure.

Indoor air exposure to mycotoxin and allergen producing fungi results in high frequency of health complaints, variant multi-organ and laboratory abnormalities requiring a detailed exposure assessment and clinical evaluation. Removal from fungal exposure and symptomatic treatment generally results in noticeable improvement of most patients. I propose to name these clinical findings - if certain criteria are met: "fungal syndrome."

Eckardt Johanning, "Clinical Experience of Diagnosis and Treating Patients with Indoor Fungal Exposure" Third International Conference on Bioaerosols, Fungi and Mycotoxins, Eastern NY Occupational and Environmental health Center, 1998

According to Dr. Johanning, symptoms of the "fungal syndrome" include, but are not limited to decreased resistance to disease, headaches, dizziness, unsteady gait, mood changes, lack of concentration, diarrhea, and extreme fatigue. Allergic reactions may also include rhinitis, sinusitis, conjunctivitis, asthma and hives.

Epidemiology

Because Hypersensitivity Pneumonitis is an allergic disease, its occurrence varies widely. Among farmers in Iceland (who stable horses in their homes in Winter) there is a 30% occurrence within the population. Presumably there is no occurrence among people who have no contact with fungi. However, anyone can develop the disease if exposed long enough to high exposures. The prevalence of HP in the general population is not known. Nevertheless, the general prevalence is rising. "Opportunistic fungal infections caused by molds such as *Aspergillus*, *Penicillium*, *Fusarium*, *Alternaria*, and *Rhizopus* have increased dramatically in the past five years due to HIV/AIDS, neoplasms, chemotherapy, transplantation, prolonged corticosteroid therapy, neutropenia and underlying lung disease."¹²

"The prevalence of Hypersensitivity Pneumonitis is quite variable in different populations presumably because of differing intensity, frequency and duration of inhalation exposure. Among pigeon breeders, 8% to 30% of members of pigeon breeding clubs who participated in surveys exhibited Pigeons Breeder Disease (PBD). Among farmers 0.5% to 5% have symptoms compatible with Farmers Lung Disease (FLD) The population at risk and the season of exposure vary: FLD in cold damp climates in late Winter and early Spring, PBD among women in Mexico, BFD (Bird Fanciers Disease) in Europe and the US among hobbyists. In short, there is a great variability of susceptibility."

Mark Schuyler, *Pulmonary Diseases and Disorders*, 3rd edition, 1997

In addition to those occupational diseases described above, the Merck Manual lists additional causes of Hypersensitivity Pneumonitis caused by molds: Bagassosis (moldy sugar cane waste), Mushroom workers lung, Suberosis (cork workers lung), Maple bark disease (syrup collectors), Malt workers disease, Sequoiosis (rangers in redwood forests), Cheesewasher's disease, Wheat weevil disease (bakers and processors), Snuff taker's lung, Fishmeal workers lung, Coffee worker's lung, Furrier's lung, and Thatched roof worker's lung.

The salient characteristic of HP is that the symptoms of the disease are directly related to exposure, i.e., those not exposed to the antigen have no symptoms. Once an individual develops HP, however, even small exposure to the antigen will provoke severe symptoms.

For this reason, some persons in an affected environment will get sick whereas others seem immune. However, given time and continued exposure, most people will develop the disease.

Buildings and Hypersensitivity Disease

"Most mold allergy is caused by the spores of *Alternaria* and *Hormodendrum* which flourish in the Midwest and grow least in dry regions. The usual indoor offenders are *Aspergillus*, *Penicillium*, *Mucor*, and *Rhizopus*."

Complete Medical Guide, The Columbia University College of Physicians and Surgeons, Columbia University, New York, NY.

Moisture caused by plumbing leaks and seepage is the primary cause of mold growth in buildings, followed by water from floods and fires. As discussed previously, however, not all molds are dangerous; and fungi are ubiquitous on Earth. *Cladosporium* is the most common mold found in the Northeast. Nevertheless, there are a few "rules of thumb" about molds to guide investigators in sick buildings:

Moisture in the air and in building materials is the key indicator of potential fungi contamination. Some fungi grow only when immersed in water. The most common and widely distributed fungi, however, grow vigorously on paper, wood, plaster, paint, leather and fabric that contain 12% to 15% water. To remediate a building, it is essential to remove the reservoirs of fungal growth. The lower limit of growth of such drought-resistant fungi is a water content in equilibrium with relative humidity in the surrounding air from 70% to 75%. In other words, it is important that the air and building materials are dry. Molds grow best on damp materials at a temperature of 90 degrees with a 75% relative humidity. In order to remediate an infested building, damp and moldy building materials and personalty must be discarded, the temperature must be reduced below 70 degrees and the air must be conditioned to below 50% relative humidity. Mold remediation should avoid saturating the air and building materials with moisture which may cause a latent contamination that surfaces later after the effects of the fungicide have dissipated.

Moldy, musty or rubbery smells indicate extreme fungi contamination. Often, the contamination is invisible between walls or in ceilings and the smell is produced by molds as volatile organic compounds which escape into the air. Visible signs of molds (circular mycelia) on building surfaces indicate an extreme and entrenched contamination. People who report feeling bad inside a building and getting better when outside are another possible indication of mold contamination. And sickness among certain kinds of occupants (children, immunocompromized, and elderly) whereas healthy adults are not affected is often typical in mold contaminated environments.

Fungi are unable to control temperature and are thus susceptible to temperature variations. Yet, they can adjust to temperature changes more readily than higher life forms. In general, drought-resistant fungi (*Aspergillus* and *Penicillin*, grow best at 70 to 90 degrees Fahrenheit. At 50 degrees, these fungi grow somewhat slower than at higher temperatures, and will stop growing at 30 to 40 degrees. They do not die, but simply become dormant until conditions become more favorable to growth.) Most ordinary fungi easily survive freezing for months, even years. In fact, fungi at absolute zero are not killed. Low temperature, therefore, is not effective for elimination most fungi. In fact, many fungi actually grow and produce spore and mycelia at temperatures below freezing. Meat and other food products must be stored at 20 degrees Fahrenheit to prevent mold contamination. This explains why ordinary kitchen freezers often contain moldy food. At high temperatures, a fungus that grows well at 80 degrees, begins to slow down at 100 to 110 degrees Fahrenheit. It stops altogether at 130 to 150 degrees. At boiling, 212 degrees F, the heat kills most fungi instantly. However, some strains are thermophilic, i.e., they grow best between 120 and 130 degrees.

Given any of the above conditions, tests for fungi contamination is essential. Some researchers recommend indoor and outdoor air tests for comparisons suggesting that fungi contamination comes from outside the building. However, research indicates that the number of airborne fungi outside buildings is greater than airborne fungi indoors. Most studies indicate that average indoor airborne fungi levels are 25% of the levels outside. (Solomon, 1975) Although there are no standards or rules regarding airborne fungi, it is generally agreed that healthy air contains no more than 150 colony-forming units (CFU's) per cubic meter of air.¹⁵

Nevertheless, certain fungi are considered unsafe at any level, Aspergillus, Penicillin, and Stachybotrys, for example. At 41 Arnold Court, East Rockaway, New York, the spore levels exceeded one million spores per cubic meter. On July 29, 1999, the Penicillium/Aspergillus spore level at 41 Arnold Court was approximately a half million spores per cubic meter of air. An adult at rest breaths 10 liters (10,000 cubic centimeters) of air each minute. There are 1 million cubic centimeters per cubic meter of air. If the air contains 520,000 fungi spore per cubic meter then an adult breathes more than 50 *million* fungi spores *each minute*. Consequently, an adult breathes nearly 75 *billion* mold spores in an 24-hour day, as clear and present a health hazard as ever existed.

Summary

Clearly, only a cautious remediation standard can be applied to the building and its contents. At the very least, the roof must be repaired, the building air conditioned, the air dehumidified, and its contents either discarded or decontaminated and removed from the premises. Moisture tests must be conducted on building materials in order to ascertain whether walls, ceilings, and wood members can remain or should be discarded. As a given, all carpets, paper and fabrics must be discarded. Tests should be conducted inside walls and between floors in order to discover hidden reservoirs of fungal growth. Work areas of remediation must be completely demised in order to prevent recontamination from one space to another.

Footnotes

* All Fungi colonies (mycelia) grow in circles. Ring worm, for example is a round fungi infection whereas "Fairy Rings" found around trees or in lawns are underground Fungi colony growths.

1 Investigators trying to resolve taxonomic questions about mushrooms collected from a 35 acre woodland in northern Michigan discovered that their genetic material was identical in every way. They concluded that the 35 acre mass was one mycelium approximately 1,500 years old and expanding annually. M.L. Smith, J.N. Bruhn and J.A. Anderson, "The fungus, *Armillaria bulbosa*, is among the largest and oldest living organisms." Nature Magazine 356, 1992.

2 A micron, aka micrometer, is one millionth of a meter. An object 20 microns long is not visible to the naked eye. An object 100 microns is barely visible, about the thickness of the smallest hair, or one tenth the thickness of a dime. Objects less than 5 microns are not visible even with a microscope. An asbestos fibril, for example, is one micron wide and ten microns long.

4 C.M. Christensen, The Molds and Man, Minneapolis University of Minnesota Press, 1965.

5 G.W. Hudler, Magical Mushrooms, Mischeivous Molds, Princeton University Press, 1998.

6 Fungi exotoxins include some of the most potent medical antibiotics. The exotoxin Pennicillin, discovered by Dr. Alexander Flemming in 1928, is produced by the mold, Penicillium notatum.

6A "Micromenaces," Chen Yang, P&K, Microbiology, August, 1998

7 *Magical Mushrooms Mischiveous Molds*, Dr. George W. Hudler, Professor of Plant Pathology, Cornell University, Princeton University Press, 1998.

8 *Indoor Air Pollution: An Introduction for Health Professionals*, Co-Sponsors: The Environmental Protection Agency (EPA), The American Lung Association (ALA), The Consumer Product Safety Commission (CPSC) and the American Medical Association (AMA), 1994.

11 *The Inside Story: A Guide to Indoor Air Quality*, US EPA and CPSC, 1988

11B "Bioaerosol-Induced Hypersensitivity Diseases," CE Cookingham et al, 1995, CRC Press, Florida

11C Eckardt Johanning, Mt. Sinai School of Medicine, Albany, New York

13 *Fungal and Related Exposures*, E. Johanning, ENYOEHHC, Albany, NY 1999

9 American Lung Association, Web Page

10 *Pulmonary Diseases and Disorders*, 3rd edition, 1997, Mark A. Schuyler et al.

11A Third International Conference on Bioaerosols, Fungi and Mycotoxins, Eastern NY Occupational and Environmental health Center, 1998

12 "Opportunistic Fungi in the Home Environment: An Exposure Reduction Guide for the Immunocompromised." P. Dulaney, C. Cook, E.Cole and K. Leese, Durham, North Carolina, Third International Conference on Bioaerosols, Fungi and Mycotoxins, Eastern NY Occupational and Environmental health Center, 1998

15 "Biocontaminants in Indoor Environments", DA Etkin, Arlington, MA 1994

An adult breaths 10 liters (10,000 cubic centimeters) of air each minute. There are 1 million cubic centimeters per cubic meter of air. If the air contains 150 fungi spore per cubic meter then an adult breathes 15,000 fungi spores *each minute*. In an 24-hour day, an adult consequently breathes three million, six hundred thousand mold spores when the air is theoretically "healthy" according to this standard.
