



Assessment of the indoor environment: evaluation of mold growth indoors

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There has been a dramatic increase in attention over the past decade, and especially in the last few years, to the presence of mold in indoor environments. Some investigators find this surprising, because mold always has been present in buildings. References to indoor mold date at least to the book of Leviticus (14:34–48) as a leprosy of a house. So, humans are adapted to some mold exposure. The recent history of buildings and their use has introduced many changes. Fifty years ago, houses were built over several months or even a year so that rain-wetted materials, or unseasoned lumber, had time to dry. Solid wood, plaster, and masonry, which are relatively resistant to mold colonization, were a larger proportion of the construction materials used. Although buildings were not intended to be drafty 50 years ago, they not as tightly sealed as current buildings. Newer buildings conserve energy, but also better retain chemical emissions from interior materials or any dusts produced in the building, such as spores from mold colonies. Bathtubs, clotheslines, and drain boards, which produce less vapor or are typically outdoors, were more common 50 years ago than were showers, clothes dryers, and dishwashers, which produce more vapor, typically are indoors, and produce hot moist air or cause unconditioned air to be pulled into a building. Residential air conditioning has become common in the past 50 years, and although air conditioners may reduce the penetration of pollen and spores into a building [1] and can reduce relative humidity; they also produce cold surfaces that can promote condensation [2] and, if oversized, can increase indoor humidity. Unless care is taken in dealing with these issues, mold-friendly environments can develop. Mechanical ventilation or exhaust systems (eg, kitchen range hoods, bathroom exhausts, clothes dryers) can generate pressure differences and unplanned air flows.

The salient event that occurs in a mold-friendly environment is colonization of biodegradable materials that are damp, moist, or wet. Molds that thrive on

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saturated materials are well known, but some types of molds thrive on materials that are moist (ie, the moisture level of fresh bread) or barely damp (ie, the moisture level of salt fish) [3]. Many molds are promiscuous about their diet and see little differences between a fish, a ceiling tile, or dust laden with skin scales. In any of these cases, mold colonizes material when spores germinate and the mold body (hyphae, mycelium) develops on or in the material. This growth often culminates in the production of spores, frequently in massive amounts. Mold-colonized materials accumulate secreted-mold metabolites and fragments of the mold body. Some of these materials are biologically active, as are the spores of molds [4,5]. The amounts of spore production from different molds can vary drastically; some molds are prolific, whereas others are parsimonious. Further differences occur in the way that spores are released; some molds launch spores into the air as they are produced, whereas spores from other molds are trapped in slime [6]. Where colonization occurs, there may be many spores, a few spores, or no spores released, and other biologically active materials are produced. Assessment methods that are based on detecting airborne spores, although frequently useful, do not always reliably detect colonization and may only approximate exposure.

There are numerous ways to detect and quantify aspects of mold [5,7]. Success with correlating measures of mold with patients' symptoms has been inconsistent. Rather, as discussed in an article by Rogers elsewhere in this issue, the consistently strong association between damp or moldy indoor environments and occupants' respiratory complaints has been on a population basis [8–10]. Many of these studies have considered only whether the building was moldy (colonized) or not (often self-reported), rather than how much mold was airborne. There are several ways to detect colonization, or evidence of colonization, and air sampling is sometimes useful as part of this strategy. Perhaps the most frequently overlooked point about indoor mold assessment is the value of simply detecting

Table 1

Groups of molds that are common in outdoor air or that frequently colonize damp or water-damaged building materials

Phylloplane molds ^a	Xerophilic molds ^b	Moderate xerophiles	Hydrophiles ^c
<i>Cladosporium</i>	<i>Wallemia</i>	Many <i>Penicillium</i> species	<i>Chaetomium</i>
<i>Alternaria</i>	<i>Eurotium</i>	Some species of <i>Aspergillus</i>	<i>Ulocladium</i>
<i>Epicoccum</i>	Some species of <i>Aspergillus</i>		<i>Stachybotrys</i>
<i>Curvularia</i>			<i>Acremonium</i>
<i>Drechslera</i>			

The categories are not exclusive. Some molds may occur in more than one category. The molds listed are examples, other molds also occur in each category.

^a Phylloplane molds normally occur on leaf surfaces (phylloplane) outdoors.

^b Xerophilic molds tolerate or thrive under dry conditions, such as in salt fish or salami, or in damp (but not wet) building materials.

^c Hydrophiles are moist-loving molds that require wet conditions or at least near-saturated conditions. The examples listed commonly present on water-damaged materials.

colonization. Where colonization (mold growth) has occurred, the single most important observation is the amount of surface area (ie, square footage) of visible mold. This information is important as a surrogate index of exposure and as a guide for remediation choices. Table 1 lists some common groups of mold.

Although this article focuses on assessment of mold in homes, it is important to note that moisture penetrates or accumulates in all buildings in the same way, regardless of the building's purpose. Moisture problems in homes are similar to those that affect schools, offices, and shopping centers [11]. Similarly, mold colonizes biodegradable building materials that have become water damaged or have been exposed to high humidity, whether the materials have been installed in a home or in another type of building [12]. The remainder of this article is organized as responses to several central questions: What information should be sought? What samplers and samples are useful? How should samples be analyzed? Who should conduct inspections? Who should analyze samples?

Questions

What should an allergist or investigator want to know about mold exposures in homes or other buildings?

Because there are only rather limited dose-response data for mold exposure and health effects, measures of mold levels have limited direct clinical use. Because mold allergens broadly cross react, the identification of molds in a building has limited use for the clinical management of allergic symptoms. Environmental inspections of buildings and results from well-planned sampling can provide useful information for clinicians. Objective environmental observations or data are essential if a clinician is to consider environmental factors. Environmental factors should be considered for disease management. The objectivity of patients about their homes or workplaces is not always reliable. The most useful and practical environmental information is whether there is mold growing in the building (ie, whether mold colonization has occurred on or in materials in the building), irrespective of airborne levels of mold at any given time.

An indication of colonization is usually easier to obtain than is a thorough assessment of mold exposure levels in a given building. Carefully collected inspection results and sampling data reliably can indicate whether there is mold colonization in a building. Any mold on exposed surfaces should be visible and noted. The amount of the area that is moldy is considered by some investigators to be a useful (although crude) proxy index for exposure. Determining the presence of mold growth in hidden parts of the building, such as wall cavities or ventilation systems, requires a destructive opening (eg, the wall [or duct] needs to be cut open). This step should be done only with good reason to suspect colonization and by qualified persons to prevent the potential massive release of mold in the event that there is significant colonization in the wall. Samples

frequently augment the inspection, providing additional information about mold colonization, but rarely substitute for an informed inspection of the building.

Respiratory complaints have an epidemiologic association with damp or moldy buildings, rather than with levels of mold. The diagnosis and management of a patient's respiratory disease is aided greatly by knowing if he or she is living or working in a building that has mold colonization, rather than knowing the colony-forming unit (CFU) concentration at a given point in time (sampling).

Perspective is important. Shower enclosures almost always have some small areas of mold growth on nonporous surfaces (eg, glass, tile). These growths are not usually of concern if they are limited in area and if the surfaces are cleaned regularly. Concern is warranted if colonization of molds occurs on or in porous construction or finishing materials, such as flooring, ceilings, wallboard, insulation in walls or ventilation systems, or fireproofing materials on structural steel.

What are the types, abilities, and limitations of samplers and analyses?

No single type of sample or make of sampler always can detect mold colonization in a building. Every type of sample and make of sampler has a constraint. The most important point is to have a specific question before sampling. Sampling is most useful when used to augment an inspection and to help address specific questions that derive from the inspection. A knowledgeable investigator knows what type of information that a sample can provide and when to collect samples. The choice of sampler is determined by what type of sample is useful. The widely used methods of sampling have been around for several decades [13].

Two basic types of analyses are used for analyzing samples for mold in buildings: (1) to culture dust, a piece of material or an air sample from the building, or (2) to examine microscopically a sample of material or an air sample from a building. The samplers that are used commonly in building investigations are discussed in an article by Muillenberg elsewhere in this issue. Specific samplers generally collect samples that are suitable for analysis by microscopic examination or by culture, but not by both. The choice of analysis and associated constraints must be made before sampling. A third general type of analysis detects metabolites, such as, allergens, toxins, microbial volatile organic compounds (MVOCs), or DNA. Detection of metabolites may be much more useful than measurement of spores or CFUs. Methods for this type of detection, however, have been developed only recently and are limited for allergens and toxins. Measures of metabolites likely will supplant measures of CFUs or airborne spores. Relating exposure to disease benefits from metabolite measures, because the specific metabolites, rather than the organism, are probably the proximal causes of the disease observed in residents of damp buildings.

The advantage of culture analyses of surface samples is that sporulating mold colonies can be obtained. A sporulating colony generally provides all of the features needed for identification of the species. Analysis by microscopy (direct examination, spore traps, tape lifts) may reveal spores, hyphae, or clumps of spores that cannot be identified if all features are not present. A disadvantage of

culture analyses (of swabs and bulk or air samples) is the time required for the cultures to mature and sometimes for the subcultures that are needed to permit identification of the mold to be made and to mature. Another disadvantage is that only living material can be detected and that only mold species that can grow on the culture medium can be used. This disadvantage is significant, because no culture medium works for all molds, although few if any of the common molds that colonize materials are exquisitely fastidious.

The strengths of analysis by microscopy are important and, in some ways, complement culture analysis. Any mold colony that has developed and then died can cause an allergen (or irritant or toxin) exposure, but is not detected by culture analysis. Microscopy can detect dead or otherwise nonculturable mold. It often reveals sporulating structures in situ, or mycelial penetration of materials, which are more definitive indications of colonization than culture analysis often provides. Respiratory complaints are associated with damp or moldy (colonized) buildings rather than a certain level of airborne mold. Microscopy is more useful than culture analysis, even if microscopy provides less information than culture analysis on mold identification. In practical terms, knowledgeable investigators often use a combination of these analyses.

New analytical methods that detect metabolites are becoming available. Major allergens of *Alternaria* and *Aspergillus fumigatus* can be detected and quantified by ELISA. *Alternaria* is seldom important indoors, although *Alta 1* likely cross reacts with allergens of *Ulocladium*, which is a useful water-damage-indicator mold. No data support this assumption, however. *Asp f 1* is not generally cross reactive with allergens of other *Aspergillus* species [14]. *Aspergillus fumigatus* is important as a cause of mycoses, but other species of *Aspergillus* are more useful indicators of mold colonization indoors.

Beta-glucans and MVOCs are other fungal products that can be measured in indoor samples. Beta-glucans are immunomodulatory, so such exposure may be of interest [4]. MVOCs can be irritants, but are probably more important as olfactory triggers and as indicators of colonization [15,16].

DNA-based detection and measurement have become available for some fungi [17]. Although reagent costs are minimal, associated costs of the technology have restricted the widespread use of this technique. Only limited reference data are available. Table 2 summarizes the investigation strategies discussed below.

Tape slides

Tape slides (eg, cellotape samples, tape lifts, tape teases) are samples of surface material that are lifted from the surface with clear cellophane tape. The tape is pressed against a surface, lifted off, and transferred to a microscope slide. Particles from the surface, including mold particles or fragments of mold colonies if they are present, are pulled free with the tape. Tape slides typically are analyzed by microscopy for the presence of mold. (Examination of the particles on the tape is aided greatly by adding a mounting medium and cover slip to maintain a consistent refractive index.)

Table 2
Investigation strategies

Purpose	Appropriate samples	Types of results	Conclusion
Detect colonization	Tape slides	Mycelium/fruiting structures	Colonization
		Debris only	TTM
	Settled dust	Dominance by soil molds	Putative indication of colonization somewhere in the building
Establish an indoor mold source		Mixture of mold types	Accumulation of TTM and soil
	Air samples: HVAC off	Typical samples	Ventilation system (HVAC) may be colonized; cutting access panels to inspect is justified (proceed cautiously so as not to distribute spores)
	Air samples: HVAC on	Atypical samples	
Identify mold on building material	Bulk sample of material	Direct examination indicates fruiting structures	Material colonized by mold
		Culture analysis dominated by a high a_w molds	Likely water-damaged material

Abbreviation: HVAC, heating, ventilating, and air conditioning.

This method has been used widely in clinical and plant pathology laboratories for decades, although it is considered novel by some lawyers and building investigators [18,19]. Measures of metabolites likely will supplant measures of CFUs or airborne spores. Relating exposure to disease benefits from metabolite measures, because the specific metabolites, rather than the organism, is probably the proximal cause of disease.

Interpretation of results in which mold particles are seen is aided by noting the type of mold particles and their relative abundance. Spores also accumulate in dust in the absence of mold colonization by settling from air onto almost all surfaces. These molds have been referred to as table-top molds (TTMs) [3]. The presence of spores in this situation may indicate nothing relating to mold growth and is different from the presence of hyphae and spore-bearing structures from a mold colony.

Tape slides are useful to distinguish between discolorations and mold. They can detect microcolonies that are not visible on surfaces after water-damage events. Where mold growth is present on an accessible surface, tape slides objectively can confirm the presence of the colonization and often can provide information on the type of mold and sometimes identify the mold. Other significant advantages of analysis by microscopy are that dead organisms are detectable, and there is no requirement for long incubations for cultures and subcultures.

Swabs or wipes

Surfaces can be sampled by wiping with gauze or a swab, which picks up particles on the surfaces. If fungal colonies are present on the surface, spores or hyphae are collected. These spores can be suspended and diluted in a sterile fluid, plated on culture media, and incubated. Culturable spores or other propagules from the suspension fluid can develop into colonies that can be counted and identified. However, dormant TTMs will produce colonies as well as spores that are swabbed from an actively growing mold colony. Interpreting results of culture analyses of swab (or wipe) samples must be approached cautiously.

Bulk samples

Portions of moldy building or finishing material that are removed for analysis are referred to as bulk samples. Mold-stained areas of building materials (eg, ceiling tiles, duct insulation, carpet, wallboard) can be cut and submitted to a laboratory for analysis. This destructive technique may not be permitted. If materials can be divided, the samples may be examined by microscopy and by culture. If parallel analyses are desired, subsamples should be prepared in the field before they are submitted to maintain sample integrity. Dividing the sample in the field means that decision of how to divide the sample is made by the field investigator, who knows what is of interest or is suspicious about the sample, rather than by the laboratory staff, who have not seen the building.

Examination of bulk samples by microscopy may include direct stereoscopic examination of the sample, which can detect mold colonies. This method has the advantage of involving minimal manipulation of the sample. Portions of the sample may be removed and mounted, or tape lifts may be prepared from the sample and examined with a compound microscope for more detailed analysis.

Portions of a bulk sample may be used to prepare a suspension, and the suspension may be plated, as with a swab. Used jointly, these analyses can provide direct confirmation by microscopy of colonization of the sample and species level identification of the mold by culture analysis. The extra time and expense needed for such parallel analyses of a bulk sample should be justified in comparison to a simple tape lift. Such detailed information may be cost effective if it avoids a misinterpretation (eg, expensive remediation is recommended where it is not needed) or if it prevents the misdiagnosis of the underlying cause of the moisture problem that led to the mold growth.

Settled dust samples

Dust samples are collected widely for the analysis of indoor allergens such as mites, roaches, and pets. Settled dust almost always contains abundant mold spores. The types and mix of culturable molds can be determined from these samples. Although the concentration of molds in dust has not been shown to provide useful information about mold growth in buildings, the components of the mold population in dust reflect the ecology of the building. A variety of molds dominated by TTMs typically occurs in settled dust from buildings with no water damage or humidity problems.

The molds in dust from a building with water damage include types that are not common in air but that commonly occur on water-damaged building materials. Such mold species include *Acremonium*, *Chaetomium*, *Stachybotrys*, and *Ulocladium*. The molds in dust from a building with poor humidity control (in cold climates in winter or in hot, humid climates) may contain abundant propagules of xerotolerant molds that thrive in damp environments rather than on wet materials. Examples of xerotolerant molds are *Eurotium* species (also known as *Aspergillus glaucus*), *Aspergillus restrictus*, *Wallemia sebi*, and various terverticillate species of *Penicillium*.

Air sampling

Airborne mold samples are often the samples that are requested first, because mold exposure is principally through airborne spores or other particles. Air sampling for mold has inherent problems that are similar to the problems related to other types of sampling for mold indoors. The main disadvantage is the variability of airborne spore levels. Mold concentrations can fluctuate dramatically over relatively short distances and times [20]. This degree of variation often requires that large numbers of samples be collected and analyzed to permit reliable interpretation of the results.

Spore traps

The term *spore trap* is applied to various air samplers that collect airborne particles by impaction for analysis by microscopy. These samplers are reviewed in an article by Muilenberg elsewhere in this issue. The advantage of spore trap samples is that they require no culture and can be analyzed immediately. Analysis of spore trap data, however, cannot resolve many of the specific types of molds. This analysis is conducted by viewing the collection surface and categorizing the spores by morphologic category. Some species have distinctive spores and can be tallied separately. Other tally groups that are used to categorize the spore catch are broad and include many species that have similar spores, such as the group basidiospores [21].

Spore trap data are used widely, and if they judiciously are interpreted, they can be useful. As with the analysis of dust, the types and rankings of mold spore types (or categories) provide more useful information than the absolute concentration. If a sufficient number of samples are collected to assure that true differences are seen rather than just short-term or spatial variation, the presence of mold growth often can be detected. In buildings with no moisture problem (or mold growth), the typical outdoor airspora dominate the indoor air. In the presence of water damage or damaging humidity levels, a high proportion of the mold types are types that are not typically dominant in outdoor air. These types may be the xerotolerant molds, which were discussed in the section on bulk samples. In spore trap analyses, the *Aspergillus* and *Penicillium* spores usually are lumped together though in a Pen/Asp category, because the spores of many of these species are insufficiently distinctive to permit identification. Species-level

identification of members of this group often provides useful information, but is only routinely available by culture analysis.

Air culture plates

Air samples can be collected directly onto culture media with various impactor-type samplers. After incubation, the mold colonies that develop can be identified and counted. This method can provide detailed analyses of the specific types of mold in a culture plate; however, not all airborne molds spores produce colonies: Some airborne spores are dead, some are obligate parasites, and others may be fastidious and not germinate on the culture medium. This constraint of only detecting culturable spores (rather than all spores) should be recognized when interpreting culture analyses of air samples. Because most of the molds that readily colonize building materials are generalist saprobes, the risk for missing fastidious molds is not great. There is a risk for missing dead spores, because spore longevity differs among molds. If several molds develop on a material as a result of a leak or water damage, the molds become dormant and ultimately die when the material dries. Some molds die quickly, within weeks to months, whereas the spores of other molds persist for decades or longer. Sampling at some point in this process may indicate only the presence of persistent spore types rather than the presence of a mold that may be more allergenic or more of an irritant.

Culture analysis of air samples remains a powerful tool for detecting the presence of colonized building materials. If there is a significant amount of mold growth on materials in a building, there is usually a change in the types of airborne molds in the building. A frequently occurring example is the elevated airborne prevalence of compost-type molds in buildings with mold caused by humid-air infiltration. This condition occurs in hot humid climates if the building is not designed and operated to breath out during the cooling season. When materials in the exterior walls become damp and moldy, the spores of these molds can infiltrate into the space [22] and shift the airborne-mold mix indoors. These effects can be detected by the presence of specific mold types that are scarce in outdoor air, if the sample is analyzed by culture with molds being identified to the species level.

What are the best uses of the available sampling and analysis techniques and the data generated?

In the simplest terms, the best use of environmental data is to establish whether there is mold colonization (growth) in a specific building. This step is usually not difficult for an informed and experienced investigator. Clinicians and environmental investigators should resist the temptation to interpret results in greater detail than the data warrant.

Where visible mold is present on exposed surfaces in a building, sampling for mold is usually superfluous; the presence of mold is confirmed, and it needs to be removed. If documentation is needed, surface sampling, such as a cellotape lift, usually suffices. Sampling of bulk materials (eg, portions of wall, flooring, ceiling

materials) may prove useful to confirm colonization. An advantage of bulk samples is that they may be divided for separate analyses. Divided samples are not exactly the same, so some variation in results must be tolerated. Culture analyses of bulk samples can reveal the types of (culturable) molds that are present. This finding can indicate colonization if the molds present are not the TTMs but are spoilage or compost molds that also colonize water-damaged materials. Detecting colonization is the most reliable way to use the data, however.

Settled dust frequently is sampled from buildings, because dust accumulates over a period of time. Slight airborne concentrations of atypical molds that may be indistinguishable by air sampling may be detectable in dust either from current or past events. Evidence of colonization is often evident on reviewing the types of molds and their relative dominance in settled dust. If the settled dust is collected from the floor, the accumulations of outdoor soil from foot traffic must be discerned and discounted.

Air is the most relevant indoor matrix for exposure assessment. Airborne material is presumably the chief source of an actual dose of bioaerosol. Sampling air is also more challenging than collecting dust, cellotapes or bulk samples because of air sampler constraints and the short-term variability of many bioaerosols. As with sampling dust or bulk materials, the types of molds and their relative dominance are key to detecting evidence of colonization. Air samples have the additional factor of routinely being compared with outdoor samples, because the outdoor bioaerosol affects the indoor bioaerosol. This component can be discerned and factored out by examining the outdoor types and levels of molds.

What are the qualifications of indoor mold investigators and laboratories?

The rapid expansion of the mold industry has brought many people to the field, many of whom are qualified and others who are opportunistic. No traditional professional training program focuses on indoor mold. Environmental microbiologists, biodeterioration researchers, aerobiologists, mechanical engineers, structural engineers, chemists, environmental engineers, architects, mycologists, remediation contractors, and industrial hygienists have some training that is useful for investigating mold in buildings. Home inspectors have begun offering a mold sample as part of a prepurchase evaluation. These diverse fields include people from a wide array of backgrounds and with varying levels of expertise.

The most important factor is the qualifications of the individual. No traditional discipline focuses on the principles and techniques of indoor mold investigations as part of a formal training program. Investigators should be selected carefully. Previous experience with mold investigations is an important component, as is familiarity with different types of samples and samplers. The ability to prepare a clearly written report of an investigation is important. Reports from mold investigations that contain medical conclusions might be cause for concern. Although there is ample literature (and common sense) to indicate that mold colonization is not acceptable in occupied spaces, these studies are not detailed

sufficiently to permit individual diagnoses. Physicians, rather than mold investigators should assess any health complaints or symptoms in relation to any exposures. (Allergists, pulmonologists, and other physicians to whom these patients present should become versed in the available information on exposure in mold-colonized buildings. Progress in this area lags.)

There is no specific credential that assures that an individual is qualified to investigate buildings for mold growth. The professionals that most directly have addressed the need for expert mold investigators are industrial hygienists. This movement primarily has been through professional development efforts of individuals after their formal education. Recently, bioaerosol issues have been incorporated into traditional curricula for industrial hygiene training. Although the industrial hygiene community is a leader in the area of indoor mold evaluations, this leadership is result of individual efforts; the qualification of investigators needs to be established individually rather than by any credentialing group.

Laboratory analysis of samples taken to support mold investigations is another area that should be approached with caution. The techniques used to analyze these samples were adapted from related disciplines, such as food microbiology, soil microbiology, and water testing. Although many of these procedures are directly applicable, no governing or regulatory body has approved standard methods. Laboratories that conduct these analyses rarely use directly comparable methods.

The American Industrial Hygiene Association operates a laboratory quality assurance program that accredits laboratories in several programs. There are programs for laboratories conducting analysis of industrial hygiene samples, environmental lead samples, and environmental microbiology samples, including samples from moldy-building investigations. Laboratories that are accredited through the environmental microbiology laboratory accreditation program (EMLAP) have demonstrated a proficiency in correct identification of environmental microorganisms, have a quality-assurance and quality-control plan in place, and successfully have completed a site assessment of their facility. In the absence of standard methods, using laboratories with an accreditation, such as from the EMLAP, may be advisable.

Are buildings guilty until proven innocent?

Recognition of the bounds of professional expertise is useful. It is not unusual for environmental investigators who discover mold colonization to provide conclusions on the medical effects of exposure to the mold. The presence of mold colonization in occupied buildings is unsanitary, and persistent exposure to moldy buildings should be avoided, especially by anyone with respiratory complaints or who is incompletely immunocompetent or immunocompromised (including the very young and the elderly). These general statements are useful information for anyone, regardless of the state of their homes, schools, or workplaces. A specific determination that an environmental exposure is the cause of an occupant's symptoms is a medical decision and should not be the responsibility and should not be made by the environmental investigator.

Environmental investigators seldom are trained to evaluate clinical signs and symptoms or diagnose disease regardless of how familiar they are with the literature on the health effects of molds. Physicians routinely see patients that have been told by a mold professional that the mold in their homes has made them sick. Physicians then bear the onus of educating the now skeptical patients about other possible causes.

The presence of mold colonization in a building cannot be determined reliably by taking a clinical history of a patient in a physician's office. Regardless of the certainty with which patients may assert (or deny) the presence of mold colonization in their homes, schools, or offices, a reliable (and defensible) determination of mold colonization usually requires an inspection on the building. Recommendations about the suitability of a building for occupancy, based on the presence of mold, should not be made without a competent inspection. Decisions to recommend removal of a patient from a particular building, to vacate a building, or to impugn a building as a cause of a patient's disease should refer to inspection or sampling results of the building. Acceptance of a patient's uncorroborated observation of mold in a building may miss the real exposure or lead other occupants to conclude that they are at risk. In extreme cases, occupants may leave and refuse to return, which can stigmatize and greatly devalue a building.

There are enough patients whose symptoms have real causes, and there are enough buildings with real problems. Environmental investigators should avoid providing medical opinions that, even if accurate, complicate the physician's job. Physicians should not accept uncorroborated environmental information about buildings, which can be inaccurate. Physicians should increase their use of reliable environmental observations and data when environmental factors are believed to be related to a patient's symptoms. This step requires the expansion of the trained workforce of investigators to include a sufficient number that can address residential issues economically. Physicians should become familiar with the usefulness of good environmental reports and to recognize reports that are not.

Summary

Much attention has been focused on indoor molds, resulting in modest amounts of new research. There is strong evidence of respiratory effects. Although mechanisms are disputed, some of the effect (but not all) is likely to be allergy related (8–10). There is some evidence that atopic individuals may be more affected, but many nonatopic individuals also are affected. This area needs more general research and specific research on exposure measures (such as what fungal components should be measured) and on health-effect mechanisms.

It is worthwhile to emphasize the practical knowledge that is readily available. Buildings should be designed, built, operated, and occupied so that the buildings stay dry. When this situation does not occur, the environmental and clinical

aspects that are observed by competent professionals should both be considered when determining causal relationships.

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