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Indoor Mold A General Guide to Health Effects, Prevention, and Remediation

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*Report in Response to A.B. 284,
Chapter 550, Statutes of 2001*

JANUARY 2006

CRB 06-001

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ISBN: 1-58703-134-5

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Executive Summary

Background

During the 1990s, a series of widely publicized incidents brought attention to the potential health risks of indoor mold growth.

In response to the concerns raised by the reported incidents and by mold-related litigation, the California Legislature made a series of findings in Assembly Bill 284 (Chapter 550, Statutes of 2001) regarding indoor air pollution and the impact of indoor molds. The Legislature asked the California Research Bureau to prepare and publish a report in consultation with a review panel representing a wide range of professional and scientific expertise and experience.

We consulted with the review panel through telephone, mail, and email. The result of that process and of our review of books and articles is this report, designed to be a concise summary for a general audience. Included are a recommended reading list and an additional list of resources for those who wish to pursue topics in more depth.

Opinions and analyses on issues addressed in this report vary widely. This report is not definitive, as there are too many differing views in the literature and among the experts to permit a definitive review. The reader is advised to focus on the main points, to read the literature in the field for further information, and to seek advice of experts in connection with specific concerns about health effects, prevention, and remediation.

What are Molds?

Fungi (plural of the Latin word *fungus*), are a large class of living organisms, one of the “kingdoms” into which biologists categorize life. They are not plants, animals, or bacteria.

Molds, which comprise a large portion of the entire range of fungi, are found nearly everywhere on Earth. Molds are made of branching filaments called hyphae, plural of the Latin *hypha*. A mass of hyphae form a mycelium. Molds extend filaments into media on which they grow (substrates), whether a thin medium, like a layer of grime, or a thick one, like a wooden two-by-four. Molds produce reproductive structures called spores that can easily become airborne and spread the contamination throughout an environment, and that can result in occupant exposures.

Molds and other fungi can survive in a very wide range of conditions. They are hard to kill, especially where they have grown into substrates, such as wallboard, but they need moisture to grow.

Health Effects and Risks

Damp and unremediated water-damaged indoor environments can contribute to conditions that harm health.

Molds that result from indoor dampness and prior water intrusion or accumulation can contribute to allergies and may aggravate other health conditions, including asthma, but the *mere presence* of indoor mold has not in itself been proven to impair health.

The best documented and most common effects attributed to exposure to indoor mold, such as typical allergic responses, are relatively mild and reversible (if the exposure is stopped) in persons who are otherwise in good health.

Symptoms attributed to the presence of molds in indoor environments (especially nonspecific symptoms) may be the result of other causes, including other conditions that are associated with dampness, prior water damage, or other conditions entirely.

Exposure to indoor mold poses higher risks to children, to persons with preexisting conditions, such as asthma, and especially to persons with impaired immune systems, who are susceptible to direct and serious fungal infections.

Symptoms associated with exposure to damp indoor spaces and to related conditions, including mold, tend to subside when the individual is removed from that setting or when the conditions are corrected (remediated).

While there is some evidence for other adverse health effects *specifically* due to indoor molds, especially toxic effects, is currently inconclusive and requires additional research. However, such effects appear to be plausible under unusual environmental and individual circumstances.

All authorities, including those who question the evidence for health damage from exposure to mold and water-damaged environments, recommend prevention and control by avoidance of such environments and correction of the causes of indoor mold and other related microbial growth.

Assessing Mold Contamination

Fungal spores are everywhere, indoors and out. Indoor counts of mold spores typically reflect outdoor levels and species. Mold grows indoors on many kinds of surfaces if sufficient water is available. Significant indoor mold growth will lead to higher indoor counts of mold spores and particles and a different distribution of species than in the outside air. Biological contaminants of the air (bioaerosols) include much more than fungal products, so a full sampling and analysis of potential contributors to illness associated with indoor air contamination considers not only molds, but also bacteria, dust mite products, animal dander, and other contaminants.

Investigation protocols encompass visual inspection of walls, floors, ceilings, and plumbing and drainage systems, and, where necessary, inspection of interiors of cabinets, walls, ceilings, HVAC systems, and other building elements. Electronic methods (including infrared thermography and moisture meters) can help to locate areas of water

damage without opening walls or other cavities. Air, surface, and bulk sampling may also be performed.

Where mold or water damage are not apparent, epidemiological methods may reveal patterns of illness that suggest presence of and possible location of microbial (fungal and bacterial) contamination in a building. An epidemiological investigation analyzes a population and its symptoms in search of sources of illness.

Prevention

The essence of prevention is not to allow any part of a building that can support mold growth to become wet. If it does become wet, then it should be dried immediately, before mold growth can begin.

Key steps include routinely checking for and correcting potential problems before they become problems—sealing leaks, channeling water away from the building, preventing excess humidity indoors and preventing condensation on cold surfaces. Simple precautions such as always using bathroom and stove vents, covering pots while cooking, promptly wiping down damp surfaces (condensate on windows, for example), not overwatering indoor plants, and keeping rain gutters and drains in good order all make a difference.

Even before the building is occupied, it is essential that water intrusion issues receive proper attention through design and construction. Design must keep water out and must control humidity. Construction must see that details such as installation of flashing are properly performed and that materials are kept dry during the process, or promptly and fully dried if they have become wet.

Remediation

Remediation corrects the problems that caused mold growth, cleans the areas of mold growth, including removal of contaminated materials where necessary, and cleans areas contaminated by mold spores and other particles.

Several guides to mold remediation have been published by public and private agencies and organizations. The California Department of Health Services has concisely summarized the most essential points about indoor mold:

[I]ndoor mold growth is unsanitary and undesirable. Basically, if you can see or smell mold inside your home, take steps to identify and eliminate the excess moisture and to cleanup and remove the mold.*

* California Department of Health Services, “Indoor Air Quality Info Sheet, Mold in My Home: What Do I Do?” www.dhs.ca.gov/ps/deode/ehlb/iaq/Mold/MIMH_2004-06.htm, revised June 2004.

This is core advice, regardless of specific points of view about particular health risks. Indoor mold growth is a risk to human health and to valuable materials and should be corrected.

It is essential that those doing the remediation work use appropriate personal protective equipment, that barriers be erected to prevent contamination of the rest of the building, that occupants be protected from exposure to contamination, and that moldy porous materials be safely bagged and removed for disposal. Nonporous surfaces may be cleaned, but cleaning agents should be used according to label directions and with appropriate ventilation. The use of biocides alone to kill mold is inappropriate, as non-viable residue still presents a potential exposure risk.

Low-income homeowners may be eligible for assistance with repairs and cleanup, and should contact local agencies and organizations, such as community development departments and charitable groups, for information on available programs.

Communication of Hazards

There is no single means of communication about the potential hazards of mold that is suitable for the wide range of individuals and circumstances that might be affected by indoor mold or other risks resulting from a water-damaged indoor environment. Nor is there any one agency that is responsible for designing or conducting such communications.

Communications for workers can be handled in the normal course of business as required under state and federal laws relating to occupational health and safety. For people working in remediation, construction and remodeling, or facility maintenance, communications about hazards should be standard procedure. Risks posed by mold exposure are only part of the spectrum of potential risks relating to such workplaces, including chemical exposures, construction dust, and other safety hazards.

For workers in commercial or government buildings with known mold contamination, it is appropriate to post notices advising awareness of the potential health risks and warning workers away from seriously affected areas. During remediation, additional cautions are advisable with respect to areas that should be off limits to those not conducting the cleanup and repair, including the risk of additional airborne contamination stirred up by the activity.

Public health officials already provide information that is available to homeowners and others who face water-damaged environments. For example, the California Department of Health Services has published a document summarizing facts and cautions about indoor mold.* Public officials who may be contacted with inquiries should direct those inquiring to that and similar documents, or provide copies on request.

* "Mold in My Home: What Do I Do?"

It is important in all communications about potential hazards to present information factually and clearly without causing unnecessary alarm or overstating risks. In most cases, in the absence of widespread or chronic moisture problems, indoor mold poses relatively minor risks. However, persons (with asthma, for example) who may be at added risk from microbial contamination (fungal or bacterial) should be advised to inform their physicians of the possible exposure if symptoms occur.

Policy Options

Some policy options related to the subject of this report are presented at the conclusion of this report. Topics include:

- authorizing mold-related epidemiological analysis and health impact studies
- licensing or certification of providers of mold inspection, assessment, and remediation services
- authorizing a state agency to publish a list of California-based service providers in the areas of mold inspection, assessment, and remediation
- undertaking a review of building standards and practices with a view to finding ways to prevent water damage and resultant mold and other microbial growth
- requiring explicit mold hazard warning requirements as part of routine health and safety notification for workers and building occupants
- reviewing renters' rights with respect to cleanup of mold resulting from water damage

Recommended Reading and Sources of Further Information

Finally, this report presents a list of “recommended reading” for local government officials, including health officers. That list encompasses resources and references on fungi, health effects, prevention, remediation, and hazard communication. Included are books, articles, and reports, including professional association and government agency publications as well as commercial publications. Where available, links have been included to online versions of the resources. Supplementing the recommended reading is a further list of more specialized or technical resources, again with links to online versions where available.

Internet Access

This paper is available through the Internet at the California State Library's home page (www.library.ca.gov) under California Research Bureau Public Policy Reports.

1. Introduction

This report is designed to provide general information based on published studies, reports, and technical documents. It does not provide medical advice or diagnostic guidance.

Individuals, including occupants, building managers, and maintenance personnel, should consult qualified experts with regard to specific instances of, or concerns about, indoor mold contamination, effects of water intrusion, or symptoms that might be related to mold.

Where site remediation beyond ordinary cleaning and incidental repair is required, qualified professional advice and assistance should be sought.

BACKGROUND

During the 1990s, a series of widely publicized incidents and growing awareness of water-damaged indoor environments brought attention to the hazards of indoor mold growth.* “In Florida in the early 1990s,” one expert has pointed out, “several new courthouses with moisture and mold growth problems were vacated and rebuilt with the repair costs exceeding the initial capital costs of the buildings.”¹

One set of carefully studied and influential events took place in Cleveland, Ohio. During 1993 and 1994, eight infants were admitted to a children’s hospital with bleeding lungs (pulmonary hemorrhage, or hemosiderosis), a severe but relatively rare condition. Alarmed by the number of cases, physicians alerted the Centers for Disease Control (CDC). CDC investigators concluded that *Stachybotrys chartarum* contamination in the homes had led to the illnesses. (*Stachybotrys* is a slimy black mold.) However, later reexamination of the evidence questioned that conclusion.²

Although the role of the mold contamination in the Cleveland infants’ clinical conditions remains controversial, the cluster of cases brought the potential risks of indoor mold to the attention of medical investigators and the public. Additional cases in Cleveland and elsewhere brought the total to 45 cases, of which 16 ended in death, according to one report.³

Other mold-related incidents have led to lawsuits and large damage awards where water damage in homes and resulting mold growth were cited as the cause of serious illness and blamed for making homes uninhabitable. Some cases have involved celebrities. One

* Sometimes the word is spelled “mould.” This report uses the more common American spelling “mold” except where the other spelling occurs in quoted passages.

Source citations and additional information and references on technical issues mentioned in this report are in the endnotes.

involved Erin Brockovich, who testified before a California State Senate committee hearing about her experience with a mold-damaged home. Another involved Ed McMahon, whose settlements in mold-related cases exceeded \$7 million.⁴

In response to the concerns raised by the reported incidents and by mold-related litigation, the California Legislature made a series of findings in Assembly Bill 284 (Chapter 550, Statutes of 2001) regarding indoor air pollution and the impact of indoor molds. The Legislature asked the California Research Bureau to prepare and publish a report in consultation with a review panel representing a wide range of professional and scientific expertise and experience.

We consulted with the review panel through telephone, mail, and email. The result of that process and of an examination of books and articles* is this report, a concise summary for a general audience, focusing on key issues. Included are a list of recommended readings and an additional list of resources for those who wish to pursue topics in more depth.

Not addressed in this report are medical evaluation, diagnosis, and treatment of illnesses that might be associated with mold. Also not addressed, except incidentally, are laboratory techniques for assessing exposure to mold, mold toxins, or mold allergens.[†] Discussion of building construction and design issues related to moisture is limited. References listed in the bibliography and cited in the endnotes guide the reader to further information on those topics.

WHAT ARE MOLDS AND FUNGI?

Fungi (plural of the Latin word *fungus*), are a large class of living organisms, one of the “kingdoms” into which biologists categorize life. They are not plants, animals, or bacteria. Fungi encompass an estimated 100,000 species.⁵

Many species of fungus, such as certain varieties of mushroom, are cultivated as food. Some, such as certain yeasts, are used in making food products. For example, baker’s yeast helps bread to rise and brewer’s yeast helps in the brewing of beer. One type of mold (*Penicillium chrisogenum*) is used in the production of the antibiotic penicillin. A mold similar to one that grows on oranges was the basis of the first cholesterol-lowering statin drug.⁶

Fungi are essential to life on Earth. They break down organic matter, such as dead trees, shrubs, leaves, and grasses, providing food for living plants. Fungi are not plants. They do not convert sunlight into energy, as do trees, grasses, and flowers, nor do they contain

* The scientific, technical, and general literature on indoor mold and issues associated with it is very large. One typical journal article reviewed for this report is 15 pages long. Its reference list comprises one-third of that—five pages listing approximately 200 books, articles, and reports.

† “Exposure” as used in this report implies inhalation and other direct contact with mold spores, particles, and mycotoxins, not simply proximity to mold or mere presence in a building with mold growth.

chlorophyll, the substance that makes grass and leaves green and enables photosynthesis to occur.

By some estimates, fungi comprise about one-quarter of the entire weight of all living matter on earth. Fungi are at work wherever there is decaying organic matter.

Molds, which comprise a large portion of the entire range of fungi, are found nearly everywhere on Earth. Molds are made of branching filaments called hyphae, plural of the Latin *hypha*. Molds emit conidia (often called “spores”) as a means of reproduction.

A mass of hyphae form a *mycelium*. Molds extend filaments into media on which they grow (substrates), whether a thin medium, like a layer of grime, or a thick one, like a wooden two-by-four. Molds and other fungi can survive in a very wide range of conditions (they are hard to kill, especially where they have grown into substrates) but need moisture to grow. Molds produce reproductive structures called spores that can easily become airborne and spread the contamination throughout an environment, and that can result in occupant exposures.

In addition to their potential to colonize human tissue (that is, to cause direct fungal infections of susceptible individuals), fungi contain components that can be associated with human illness, such as allergens (particles that trigger allergic reactions) and mycotoxins (poisonous substances produced by fungi).

While many molds can produce toxic substances, toxicity risks associated with molds are controversial. Risks depend on specific circumstances of exposure and vary significantly among individuals. Section 2, “Health Effects and Risks,” summarizes findings and controversies over the human health effects of exposure to molds.

2. Health Effects and Risks

Published literature on the subject of molds and their effects on health is large and complex. Material reviewed for this report includes case studies, reports of animal experiments, studies of allergies, toxicology, and infectious disease, reports of epidemiological investigations, and “meta-reviews” summarizing many studies. Emphasis here is on areas of agreement and on essential concepts. This section also looks at why there is disagreement about evidence regarding health effects of exposure to indoor mold contamination.

Molds and their byproducts are only some of the microbial agents found indoors, the growth of which is increased by excess moisture. Thus, other allergens and agents may be responsible for health symptoms observed where mold is present. Final conclusions have not been reached on this topic. However, research continues. It may eventually provide evidence meeting strict scientific standards and allowing agreed-upon scientific findings about the causes of the kinds of symptoms that some researchers have attributed to mold or to environmental factors found in water-damaged indoor environments.

OVERVIEW

In its guide to mold remediation, the New York City Department of Health and Mental Hygiene provides a summary of the health risks of mold exposure:

Most types of mold that are routinely encountered are not hazardous to healthy individuals. However, too much exposure to mold may cause or worsen conditions such as asthma, hay fever, or other allergies. The most common symptoms of overexposure are cough, congestion, runny nose, eye irritation, and aggravation of asthma. Depending on the amount of exposure and a person's individual vulnerability, more serious health effects - such as fevers and breathing problems - can occur but are unusual.⁷

“Exposure” does not mean simply presence near mold. Exposure implies inhalation and other direct contact. It is extremely difficult to measure exposure (direct contact, inhalation) in normal settings, as mold particles are not like carbon monoxide or paint fumes, for example. However, “the majority of fungal spores are biologically designed to be easily aerosolized, as in pollen of flowering plants, and may stay afloat for an extended period of time.”⁸

Anything, even water or table salt, can be toxic in large enough quantities. Many toxic substances (mercury, ozone, and lead, for example) are encountered daily in food, air, and water in amounts small enough to be within what are generally considered safe limits. For that matter, everyone is exposed to mold spores and particles every day, outdoors and indoors, normally without harm. This report addresses unusual exposures in water-damaged, mold-contaminated indoor environments, not routine daily exposure to unavoidable natural environmental contaminants.

A committee of the Institute of Medicine, following a study of scientific literature on the subject, found “sufficient evidence of an association between exposure to damp indoor environments and some respiratory health outcomes: upper respiratory tract (nasal and throat) symptoms, cough, wheeze, and asthma symptoms in sensitized asthmatic persons.”

Further, the report stated, “studies indicate that there is sufficient evidence to conclude that the presence of mold . . . indoors is associated with upper respiratory symptoms, cough, wheeze, asthma symptoms in sensitized asthmatic persons, and hypersensitivity pneumonitis (a relatively rare immune-mediated condition) in susceptible persons.”

The committee distinguished between “an association” and “a causal relationship.” The committee deemed the available evidence insufficient to prove a causal relationship. That is not to say that there is no causal relationship or that a causal relationship could not be demonstrated through appropriately designed and conducted research. Rather, the finding is only that the scientific evidence reviewed did not meet the required evidentiary threshold for that finding. Because insufficient evidence of a relationship is not evidence that there *is* no relationship, the question remains unsettled.

Some evidence was “found for an association between exposure to damp indoor environments and dyspnea (the medical term for shortness of breath), lower respiratory illness in otherwise healthy children, and the development of asthma in susceptible persons.” The committee found some “evidence of an association [of the presence indoors of mold] with lower respiratory illness in otherwise-healthy children.”

Because damp indoor environments support other biological agents harmful to health, such as dust mites, cockroaches, and bacteria, it is not necessarily mold that is associated with (or that might cause) symptoms experienced by persons in mold-affected indoor environments. Mold might be present but not itself be the cause of observed health problems.⁹

The American College of Occupational and Environmental Medicine (ACOEM) issued a consensus statement on the impacts of indoor molds in 2002. ACOEM found:

Molds and other fungi may adversely affect human health through three processes: 1) allergy; 2) infection; and 3) toxicity. One can estimate that about 10% of the population has allergic antibodies to fungal antigens. Only half of these, or 5%, would be expected to show clinical illness. Furthermore, outdoor molds are generally more abundant and important in airway allergic disease than indoor molds — leaving the latter with an important, but minor overall role in allergic airway disease.¹⁰

ACOEM found little risk of toxicity from indoor mold exposure or of direct fungal infection from such exposure except for people with weakened immune systems. AIDS patients, persons undergoing chemotherapy for cancer, and others who are immune compromised are at much greater risk than persons with unimpaired immune systems. ACOEM concluded:

The present alarm over human exposure to molds in the indoor environment derives from a belief that inhalation exposures to mycotoxins cause numerous and varied, but generally nonspecific, symptoms. Current scientific evidence does not support the proposition that human health has been adversely affected by inhaled mycotoxins in the home, school, or office environment.¹¹

It is important to note the limitation of that paragraph to *mycotoxins*—fungal toxins. (See the “Toxicity” subsection below for other views of possible toxic effects on humans.) Health risks related to allergy or asthma resulting from inhalation of mold spores and other mold components are recognized by ACOEM:

Allergic responses are most commonly experienced as allergic asthma or allergic rhinitis ("hay fever"). A rare, but much more serious immune-related condition, hypersensitivity pneumonitis (HP), may follow exposure (usually occupational) to very high concentrations of fungal (and other microbial) proteins.¹²

Factors that complicate analysis of potential toxic effects include that molds may or may not produce toxins at a given time and place (this depends on the specific environment) and that the same species of mold may have different strains, sometimes rare, that are unusually toxic. Culturing and measurement of molds can also be difficult and determinations of species and strains can be subject to problems in identification. A rare strain, relatively toxic and damaging to blood cells (hemolytic) might have contributed to the Cleveland infant lung hemorrhages, but that is not known with certainty.¹³

This comment by the Institute of Medicine’s Committee on the Health Effects of Indoor Allergens outlines other complicating factors:

Dose-response data for fungal allergens are unavailable. Standardized protocols for the collection of fungal aerosols are not in wide use, and some of the current methods for quantitation may be unreliable Some studies have reported concentrations of measured viable fungal units (i.e., colony-forming units) in the air of homes that vary over several orders of magnitude both within individual homes, between homes in one community, and between communities¹⁴

Although that was written in 1993, the issues and impediments to reliable analysis have not yet been resolved. A more recent (2004) comment by another Institute of Medicine Committee observed, “Microbial exposure assessment in the indoor environment is . . . associated with large uncertainties, which potentially result in large measurement error and biased exposure-response relationships.”¹⁵ Measurement is made difficult by the very uneven distribution of contaminants in air and on surfaces and by the need for different methods to identify and measure different contaminants. Measurement is also complicated by the very uncertain relationship between presence of a contaminant and actual individual exposure, such as through inhalation. The inability to measure exposures with precision in typical indoor environments thus severely limits analysis of effects and specification of risks.

Despite those difficulties, there is broad (but not unanimous) recognition of risks of exposure to indoor molds, summarized as follows:

- for *many people*: allergic reactions, varying from mild to serious
- for *persons with asthma*: aggravation of symptoms
- for *immune-compromised individuals*: fungal infections that may become life-threatening
- for *some people* (and a matter of considerable controversy): other possible symptoms, varying from mild to serious, which usually improve after a person's removal from the site or after remediation of the site

The following sections expand upon those summary statements.

ALLERGIES

A 1993 report on *Indoor Allergens*, written by a committee of the Institute of Medicine, summarizes the connection between fungi and allergies:

Of the many different kinds of microorganisms, the fungi are most often associated with allergic disease. Airborne fungal allergens have been implicated in allergic rhinitis/conjunctivitis, allergic asthma, and hypersensitivity pneumonitis. . . . All fungi probably produce allergens that will cause disease with appropriate [that is, sufficient and direct] exposure, although skin tests [for allergy] vary with allergen sources and the populations chosen for study¹⁶

A more recent report from the Institute of Medicine notes:

Fungi produce an enormous array of potentially allergenic compounds; each fungus produces many allergens of different potencies. . . . Fungal allergen production varies with the isolate (strain), species, and genus Different allergen amounts and profiles are contained in spores, mycelium, and culture medium In addition, the substrate [what the fungi grow on] strongly influences the amount and patterns of allergen production.¹⁷

In brief, allergic responses to mold components (spores, fragments) may range from mild symptoms typically seen in hay fever or in reaction to breathing dust or other air contaminants (runny nose, coughing, wheezing, and so on) to the serious condition of hypersensitivity pneumonitis, associated with “farmer’s lung” resulting from exposure to moldy hay, for example.¹⁸ Hypersensitivity pneumonitis can mimic pneumonia and include severe cough (with phlegm production), difficulty in breathing (shortness of breath—dyspnea), and related symptoms.

All of those symptoms and conditions can also result from allergen exposures that have no connection to mold or to non-mold allergens that are also found in environments that are contaminated by mold. That is one of the sources of difficulty in assigning mold exposure as a cause without other specific evidence. It is very difficult to prove where the

blame (the cause) really lies, as there are always other biocontaminants besides mold in water-damaged indoor environments.

In its 2004 report *Damp Indoor Spaces and Health*, the Institute of Medicine committee found “sufficient evidence of an association” between “the presence of mold or other agents in damp indoor environments”^{*} and the following:

- nasal and throat symptoms
- asthma symptoms in sensitized asthmatic persons
- hypersensitivity pneumonitis in susceptible persons
- wheeze
- cough

The committee also found “limited or suggestive evidence of an association” for lower respiratory illness in otherwise healthy children. The committee did not find sufficient evidence to determine a relationship to a list of other health conditions, including, for example, asthma development and shortness of breath.¹⁹ (However, the committee did not state that evidence *disproved* such relationships. Those questions remain open pending additional research.)

Among the fungal products sometimes mentioned as potentially allergenic is one with the perplexing name “beta-1,3-D-glucans.” The name appears in other forms, often with the Greek letter β (beta), and sometimes with an arrow between the 1 and the 3. Often simply called “glucans,” “fungal glucans,” or “beta glucans” in discussions of mold-related health effects, these molecules are components of fungal cell walls and are found in mold-contaminated environments. The name refers to details of their molecular structure.²⁰ They are a marker for the presence of fungi, but, according to Dr. Chin Yang, not themselves considered allergenic.²¹

ASTHMA

The National Heart, Lung, and Blood Institute (U.S.) summarizes asthma this way:

Asthma (AZ-muh) is a chronic disease that affects your airways, which are the tubes that carry air in and out of your lungs. If you have asthma, the inside walls of your airways are inflamed (swollen). The inflammation (IN-fla-MAY-shun) makes the airways very sensitive, and they tend to react strongly to things to which you are allergic or find irritating. When the airways react, they get narrower and less air flows through to your lung tissues. This causes symptoms like wheezing (a whistling sound when you breathe), coughing, chest tightness, and trouble breathing.²²

* A more appropriate term might be “water-damaged environments.”

Although the potential for allergic response to fungal exposures (including exposures to indoor molds) seems to be settled, much research remains to be done with respect to specific allergens and their role (if any) in asthma:

Few fungal allergens have been identified, and patterns of cross-reactivity among fungal allergens have not been documented. Standardized methods for assessing exposure to fungal allergens are essential, preferably based on measurement of allergens rather than culturable or countable fungi. Acquisition of these data is a necessary step before adequate estimates of the role of fungal allergen in asthma can be documented.²³

An Institute of Medicine study published in 2000 presented a detailed discussion of the relationships between asthma and indoor air problems. Although the report found that more research is needed in order to determine the relationship between fungal exposures (and other indoor air exposures) and asthma, it observed, “One of the environmental factors most commonly associated with respiratory disease [not limited to asthma] is building dampness.”²⁴

Although an Institute of Medicine committee found evidence of a relationship between “the presence of mold or other agents in damp indoor environments” and “asthma symptoms in sensitized asthmatic persons,” it did not find evidence of a relationship with the *onset* of asthma. The committee did not cite mold specifically as the culprit in the association with symptoms in sensitized asthmatic persons, but rather viewed mold in the context of damp environments that include mold or (more likely *and*) other agents.²⁵

In summary, evidence suggests that moldy environments can aggravate asthma but might not cause asthma.

FUNGAL INFECTIONS

Some familiar fungal infections have no connection to molds associated with indoor water intrusion. Those infections include athlete’s foot, ringworm, and other infections of skin and nails.

Some fungal infections are rare in persons with normal immune systems. However, for persons with impaired immune systems, such as AIDS patients, persons undergoing chemotherapy, transplant patients, and persons undergoing high-dose courses of corticosteroids, even very limited exposure to certain fungi, including molds that may be found indoors, can result in serious and sometimes fatal colonization of lungs and other tissues. Immune-compromised individuals cannot fight off infections to which normal immune systems routinely respond without difficulty.²⁶

Such infections include invasive aspergillosis in the lungs, resulting from exposure to the fungi in the genus *Aspergillus* (in particular *A. fumigatus*).²⁷ *Aspergillus* species are common outdoors and can accumulate indoors.²⁸ Susceptible patients are at risk almost anywhere.

Fungal infections that might result from fungal exposures (indoors or outdoors) are rare and primarily of concern in hospital or other health-care settings. They are not addressed further in this report. The reader should be aware that persons with impaired immune systems are at risk of such infections. In the event of possible infection, consult a physician.

TOXICITY

Molds can produce toxic metabolic products, called mycotoxins. The U.S. government regulates mycotoxins in agricultural products because of their public health risk. Included are mycotoxins such as the aflatoxins, which are recognized as carcinogens. The types and amounts of toxins, depend on the types of mold and their environment.²⁹ The environment includes substrates (what mold grows on, including paper, carpeting, and drywall, and other organic matter, even layers of grime), temperature, moisture, bacteria, and other species of fungus present.

Because molds *as such* are not toxic, it is more appropriate to use the term “toxigenic mold” for those that produce toxins than the term “toxic mold.” The term “toxic mold” is often used in press reports about mold contamination, but it is misleading. “Toxigenic,” capable of producing toxins, has become the preferred term in scientific reports.

The measurement of exposure to mold toxins is neither simple nor easy:

[R]elevant to attempts to characterize occupant exposure to mycotoxins are recent observations . . . that toxins are not only found in and on spores, but also on mycelian fragments, and very fine particles that are of microbial origin, or are substrate dust with adsorbed toxins. Miller (2004) found that only 30 percent of recovered mass from settled dust containing toxins was spores; the rest were mycelial fragments (~30 %) and very fine particles (~40%). The particulate carriers of toxins may be a much larger source of toxins exposure because of their larger aggregate surface area, and their ability to penetrate deeper into the lung and be transported systematically by various mechanisms.³⁰

Because mycotoxins are carried in the outer shell of the spores, any fragments of cell-wall material derived from mold colonies probably carry the same toxins as intact spores. Indeed, the fungus might be dead long before the toxin-bearing fragments are dispersed into the air by disturbance to the colonies. Fragments will not germinate on culture plates, so they could contaminate a room that appears to be free from mold when attempts are made to culture fungi from air samples. The small size of the fragments relative to whole spores, and their irregular shapes, would also hide these particles from investigators trained to count spores on microscopic slides.³¹

Measuring spores—itsself difficult to do with certainty—may not provide an accurate representation of exposure to mold toxins and may significantly underestimate such exposure.

Scientific views vary widely on the potential for toxic effects on humans from inhaling mold-produced toxins, while recognizing the hazards from mycotoxin ingestion. Some analyses of the published literature conclude that there is no (or insufficient) evidence that inhalation can lead to toxic results.³² Some case studies suggest that inhalation of (and other concurrent exposure to) mold toxins may have contributed to various non-specific symptoms observed among occupants of mold-contaminated buildings.³³

What seems inarguable is that at least some mold-produced toxins can be very dangerous, as this passage from the *Textbook of Military Medicine* suggests:

[T]richothecene mycotoxins are proven lethal agents in warfare. Symptoms include vomiting, pain, weakness, dizziness, ataxia, anorexia, diarrhea, bleeding, skin redness, blistering, and gangrene, as well as shock and rapid death.³⁴

It appears reasonable to conclude that there is a potential risk to humans from toxic effects of inhalation of mold spores and other mold by-products, including fragments and dust that may have adsorbed mycotoxins (taken them on the surface). The level of risk would depend on the amount of the exposure and on individuals' susceptibility. Highly contaminated environments and long exposures increase risk. Lesser exposures might have minor or transient effects or effects too small to draw notice. Individual genetic factors, prior or concurrent illnesses, age, weight, and other risk factors affect risks presented by an environment containing mycotoxins.

WEIGHING COMPETING VIEWS

Views on the health impacts of exposure to indoor molds vary widely, especially with regard to the loosely defined classification of "building-related illness" or "sick building syndrome," and specifically with regard to potential toxic effects of mold exposure at levels that might be experienced in homes or commercial buildings. (Agricultural and industrial exposures are always considered separately from normal indoor exposures.)

Any indoor environment in which water intrusion has caused mold growth also may have elevated levels of other contaminants, including:

- bacteria and bacterial products
- dust mites and dust mite feces
- cockroaches and their feces and body parts
- volatile organic compounds (VOCs) and microbial volatile organic compounds (MVOCs)
- other organic and inorganic contaminants that may be found in the air and on surfaces

Therefore, symptoms observed in such environments might be associated with one or more of the contaminants or with a combination of contaminants that have an effect larger than the sum of the parts (synergistic effects).

No consistent, reliable measures of exposure to—or even levels of—contaminants exist for microbial contaminants found in indoor environments, whether or not the environments are affected by water damage or mold growth. As a result, reliable determinations of cause-and-effect relationships between contaminants and health symptoms may not be possible. Investigators must resort to uncertain methods of evaluating potential associations.

Studies of possible environmental illnesses can suffer from study design problems, including misclassification of subjects, lack of controls, unreliable questionnaires, self-selection of respondents, and subjectivity or lack of clear definition of some symptoms. Further, and significantly, ethical considerations prohibit any deliberate exposure of human subjects to potentially hazardous conditions, as would be required for a prospective comparison of occupants of normal-background versus mold-contaminated buildings. (All expert guidance suggests avoiding and remediating such environments.)

Reviews of published reports risk “publication bias.” That is, even the most diligent and objective reviewer can only review what has been published, not what has gone unpublished. This is a recognized problem in reviews of literature on pharmaceutical products, as the tendency is to publish reports of positive results but not to publish those with negative or inconclusive results.

The mechanism of bias may be less clear for environmental studies, but the possibility of bias cannot be ruled out. Of particular importance is reliance on strict standards for findings of causality—standards that are difficult to meet in case studies of mold-contaminated buildings—with the result that such studies avoid findings of causality. Evidence may be sufficient to support inferences or hypotheses of causality (even if the mechanism is not fully understood or documented), but not sufficient to prove causality through formal demonstration of dose-response relationships and comparisons to control groups.

Although cautious interpretation remains appropriate pending further research, the following points suggest that some health problems reported or clinically diagnosed following or concurrent with significant exposure to indoor mold and mold fragments reflect toxic effects, not just allergic effects:

- Some species of fungus, including some commonly encountered in water-damaged buildings, produce toxins under suitable conditions.
- Some mold toxins, including trichothecenes and aflatoxins, are especially potent, and were considered for use in chemical warfare.
- Toxins may be found not only in fungal fragments and spores, but also adsorbed onto dust particles.*
- Effects of toxins may be seen at levels far below those that cause death.

* Adsorption is surface attachment. It is not the same as absorption.

- Inhalation of spores may be more potent than inhalation only of fungal fragments.³⁵
- In agricultural and industrial settings where severe exposure has been documented, toxic effects have been seen from inhalation of mold spores and other mold-related air contaminants (organic toxic dust syndrome³⁶).

Given the evidence of actual and potential toxicity associated with fungi, including molds, it is reasonable to consider that even for concentrations that are low in comparison to highly contaminated agricultural and industrial settings, the potential exists for observable toxic effects on exposed humans in mold-contaminated indoor environments. Any such effects would reflect:

- extent and specific type of exposure (inhalation and other direct contact, not mere proximity)
- demonstration of toxicity of specific species and strains involved
- synergistic (mutually reinforcing) effects of multiple contaminants
- susceptibility of the exposed persons, given their individual age, sex, weight, activity level in the environment, genetic predisposition, and preexisting health conditions³⁷

In summary, depending on many specific factors and circumstances, toxic effects may be plausible but are by no means inevitable for any individual in typical situations of indoor mold contamination and other results of water damage.

SUMMARY

- Damp and unremediated water-damaged indoor environments can contribute to conditions that harm health. Those conditions should be avoided and the causes corrected.
- Molds that result from indoor dampness and prior water intrusion or accumulation contribute to allergies and may aggravate other health conditions, including asthma, but the *mere presence* of indoor mold has not in itself been proven to be impair health.
- The best documented and most common effects attributed to exposure to indoor mold, such as typical allergic responses, are relatively mild and reversible (if the exposure is stopped) in persons who are otherwise in good health.
- Symptoms attributed to the presence of molds in indoor environments (especially nonspecific symptoms) may be the result of other sources and conditions, such as bacteria, dust mites, animal allergens, or prior water damage and dampness.
- Exposure to indoor mold poses higher risks to children, to persons with preexisting conditions, such as asthma, and especially to persons with impaired immune systems, who are susceptible to serious fungal infections.

- Symptoms associated with exposure to damp indoor spaces and to related conditions, including mold, tend to subside when the individual is removed from that setting or when the conditions are corrected (remediated).³⁸
- Evidence for other adverse health effects *specifically* due to indoor molds, especially toxic effects, is inconclusive and has been questioned by some scientists on the grounds that the evidence does not meet strict scientific standards for proof of causation. However, such effects appear to be plausible under unusual environmental and individual circumstances.

All authorities, including those who question the evidence for health damage from exposure to mold and to water-damaged environments, recommend avoidance of such environments, correction of the causes, and remediation of indoor mold and other microbial growth.

3. Assessing Mold Contamination

This section summarizes recognized practices for assessing mold contamination in homes and commercial buildings.* Considered here are tools and techniques for identifying the type and extent of mold growth in walls, floors, ceilings, HVAC systems (heating, ventilating, air conditioning), framing materials, carpeting, and cabinetry, as well as means of measuring mold and mold byproducts in the air and on surfaces. It is critical to understand that various approaches to sampling for mold constitute an element of environmental assessment, but not of human exposure assessment. The latter would require a detailed, comprehensive, time-consuming, and costly research approach.

Some experts on indoor mold and its prevention and remediation state that there is no reason to test for mold where a mold problem is already recognized. “Don’t test for mold,” writes Joe Lstiburek, of Building Sciences, Inc., and his coauthors. “If you see it or smell it, you have it. There is no need to know what species it is to deal with it. You should deal with all mold exactly the same way. Fix the water problem that caused it. Replace the water damaged materials. Clean up the mold, dust and mold spores.”³⁹

The Canada Mortgage and Housing Corporation also takes a cautious view of the value of testing:

Should I have my house air tested for mold? This is the question most frequently asked by homeowners who think their home may have a mold problem. Testing is generally not recommended for homeowners. Testing of moldy materials or an air sample identifies the types of molds that may be present but does not identify the cause/source of moisture. . . . You have to clean up the mold and correct the problem irrespective of the type of mold. The cost of testing may be better spent hiring a professional investigator or fixing the problem.⁴⁰

Where a mold problem is suspected as a possible contributor to illness but growth has not been observed, taking samples from the air or from surfaces or both may be appropriate as a step toward identifying causes of symptoms. That is a step that should be taken in consultation with a physician and in a scientifically appropriate manner.⁴¹

Compiling a history of the home or building, including past conditions and response measures, is also an important component of a mold assessment.

* This discussion is designed with building owners and managers in mind. Occupants of commercial buildings (renters and lessees) who observe mold or other evidence of water damage in the building should of course report it promptly to the building’s maintenance personnel or management and take whatever immediate corrective steps may be appropriate, such as turning off water supply to a leaky fixture.

VISUAL AND OLFACTORY INSPECTION

The first step in assessing mold is to look for signs of water damage and for visible signs of mold. At the same time, awareness of mold-related odors (resulting from microbial volatile organic compounds, or MVOCs) is an essential component of inspection. Often, building occupants are alerted to the problem by seeing mold growing on a wall, carpet, window frame, or other surface, or by smelling odors produced by molds. Signs of water damage even in the absence of visible mold, such as water-stained ceiling tiles, suggest the need for a closer inspection for the source of water intrusion or accumulation and for indications of growth.

Some mold growth is obvious, limited, and easily addressed. An example is mold (“mildew”) on a shower curtain or on shower tiles. Even in simple cases it is prudent to examine adjacent areas as well, as the dampness that led to growth on curtain and tiles might have led to growth on other nearby surfaces. If the growth is limited and local, cleanup is simple⁴² and prevention of reoccurrence requires only basic preventive measures, such as using exhaust fans, wiping down shower enclosures after use, and spreading shower curtains open to allow them to dry after each use.

Other cases may require looking further—under carpet and carpet padding, for example.

Where walls, ceilings, or wooden floors are involved, it may be necessary to remove baseboards, wall panels, ceiling tiles, or floor boards for a proper inspection. Proper precautions are important in those cases, both to minimize exposure of individuals to spores and particles and to prevent spreading of spores and particles to other areas of the building. For example, access holes should be patched and surrounding areas cleaned.

For HVAC systems and hidden spaces in buildings, more complex and difficult procedures may be required, with details depending on building design, accessibility to spaces, and use and occupancy of any affected spaces. Discussion of specific procedures is beyond the scope of this report.

The essential point here is that water damage must be traced to its source—a leak from outside, leaking internal pipes, capillary action, condensation, or other source.

Any affected areas and components must be appropriately inspected. The inspection might result from an initial observation of water damage or mold growth (or both) or from other testing and analysis that has indicated that there is a mold amplifier (source of growth) somewhere in the building, possibly with the location narrowed to a particular area or system. For example, a pattern of allergy symptoms among workers nearest to air conditioning vents might point to contamination in the HVAC system. (See “Epidemiological Investigations,” page 29.) If so, prompt inspection of that system is appropriate.

AIR SAMPLING

Spores and other products of molds are among a large set of air contaminants called *bioaerosols*.^{*} Techniques and limitations affecting bioaerosols in general apply to molds. This overview by the American Conference of Governmental Industrial Hygienists (ACGIH) introduces the topic:

Bioaerosols are those airborne particles that are living or originate from living organisms. Bioaerosols include microorganisms (i.e., culturable, nonculturable, and dead microorganisms) and fragments, toxins, and particulate waste products from all varieties of living things. Bioaerosols are ubiquitous in nature and may be modified by human activities. All persons are repeatedly exposed, day after day, to a wide variety of such materials. Individual bioaerosols range in size from submicroscopic particles (<0.01 μm) to particles greater than 100 μm in diameter.^[†]

. . . ACGIH has defined *biological contamination* in buildings as the presence of (a) biologically derived aerosols, gases, and vapors of a kind and concentration likely to cause disease or predispose persons to adverse health effects, (b) inappropriate concentrations of outdoor bioaerosols, especially in buildings designed to prevent their entry, (c) indoor biological growth and remnants of growth that may become airborne and to which people may be exposed The term *biological agent* is used here to refer to a substance of biological origin that is capable of producing an effect, for example an infection or a hypersensitivity, irritant, inflammatory, or other response.⁴³

In summary, indoor air may contain many kinds of biological contaminants in addition to such nonbiological contaminants as asbestos fibers, upholstery or carpet fibers, and chemical emissions from paints, carpeting, furniture, and so on. For purposes of this report our interest is specifically molds and their products, especially spores, cell wall fragments, toxins, and volatile organic compounds (VOCs or microbial VOCs) produced by sources within a home or other building.

Fungal spores and particles are found everywhere, both indoors and outdoors. Except in the most rigorously controlled environment fungal particles will be found in the air and on surfaces. They enter with the outside air, are tracked in on shoes and clothing, and enter on the fur of dogs and cats. Depending on time of year and weather, outdoor concentrations of fungi may be high or low and the resulting indoor level likewise high or low in any building that does not have carefully controlled air entry, circulation, and cleaning.

Newspaper weather pages and television weather reports often cite total mold spore counts along with measures of temperature, precipitation, pollen, and other atmospheric

* Some prefer to refer to bioaerosols as “components” of the air rather than as “contaminants.”

† Note: μm = micron = one millionth of a meter (also expressed as m⁻⁶) = one thousandth of a millimeter.

conditions and contaminants. Mold spore counts may be found on the Internet, too.⁴⁴ Figure 1 shows an example from the Sacramento area.

Sampling indoor air for mold contamination is not a simple task:

Determining [mold] exposure to individuals living or working in damp indoor environments is highly imperfect. In the recent past, attention has primarily focused on measurement of airborne [mold] spores, which is constrained by the complexity of measurement itself. Additionally such attempts are complicated and confounded by the biological activity of the fungi as they sporulate episodically, but also by human activity of various sorts, which can disturb and resuspend spores into the air and result in temporal and spatial variations in measurement.⁴⁵

In other words, growing fungi emit particulates and MVOCs into the air when they choose to, and spores (conidia) and other fungal particles are stirred up into the air by what people do, so airborne concentrations are highly variable in time and in space, making measurement uncertain.

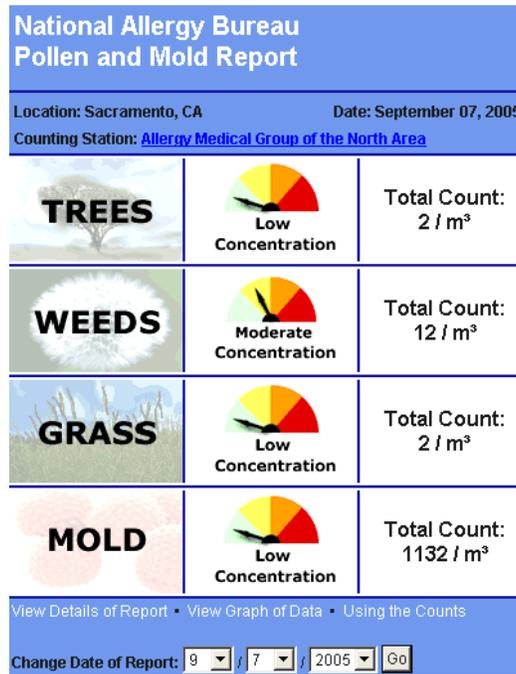


Figure 1: An Outdoor Pollen and Mold Report

Reproduced with permission of the National Allergy Bureau and its Sacramento, California station, Allergy Medical Group of the North Area.

Air sampling methods are complex, require expertise to use, may require expensive follow-up analysis, and vary widely with respect to what they can identify and measure. Sampling methods range from “settling plates” that collect falling spores (settling plates are considered an unreliable method) to several types of air-volume samples (impactors of various types, impingers, membrane filters). All of those techniques require expertise as well as a strategy for their effective use⁴⁶ in any given setting, and none is suitable for all purposes.⁴⁷

An Institute of Medicine committee found that “molds that can produce mycotoxins . . . can and do grow indoors” and that indoor dampness can contribute to growth of hazardous bacteria. The committee found no scientific agreement or standard protocols on exactly how to measure airborne mold or mold byproducts in the home. The committee concluded that the sparseness of available data prevented a recommendation on “how many samples should be taken to produce an accurate assessment of risk-relevant exposure.”⁴⁸ (However, see table 5.9 in the 1999 ACGIH report, *Bioaerosols*.⁴⁹)

There are, according to one expert, no accepted standards or other criteria for distinguishing such samples from normal background.⁵⁰ However, “Air sampling for culturable fungi has been shown to be predictive of the presence of concealed mould growth”⁵¹ This remains an area of dispute.

SURFACE SAMPLING

Air sampling may be supplemented by surface or source sampling, and vice versa, to enable a better picture of the kinds and amounts of mold byproducts (spores and particles) that are or have been in a building’s indoor air. Larger, heavier particles settle out of the air quickly, and therefore might not be found suspended in the air when samples are taken, but they will be found on surfaces.⁵²

As with air sampling, surface sampling may be appropriate to verify that remediation has been successful or to help in an investigation when it is not yet known that mold is growing in the building. It is an unnecessary expense if the fact and location of mold growth have already been determined unless a medical investigation is required in connection with the situation.

Techniques include tape sampling (placing a piece of clear cellophane tape on a surface, lifting it, and sending it to a lab for analysis) and swab sampling (gathering the sample by rubbing a sterile swab across the surface, and sending that to the lab for analysis).⁵³ Another technique uses a vacuum with a special filter to collect spores and dust from the surface for referral to a lab for examination.

Each technique has its advantages and disadvantages, including whether it allows for culturing of spores in the lab, whether it damages spores and particles, and whether it is effective on rough surfaces.

BULK SAMPLING

Where mold has been found and it is appropriate to determine the kinds or species involved (which, as noted above, is generally not the case for mold remediation), samples may be taken of the substrate—what the mold is growing on. For example, a piece might be cut from moldy wallboard or carpet or ceiling tile. A laboratory can examine the sample to determine species.

Although this step is typically unnecessary, as the procedures for mold remediation do not depend on the kinds of fungi present, it may be appropriate where clinical

investigation is indicated (to help with medical diagnosis or treatment) or for research purposes.

ASSESSING EXTENT OF HIDDEN MOLD GROWTH

Sometimes the task of assessment is simple, as in the case of carpet that had become and remained damp long enough for mold to grow in and under it. In that case, removal of the carpet will reveal growth underneath and allow a determination of whether growth has extended into adjacent surfaces. Another simple and common case is a moldy shower curtain that may be removed and machine-washed or discarded.

At the other extreme, a longstanding plumbing leak inside of a wall, or leakage into a wall via a hole or crack, might have caused widespread mold growth that is hidden from view.

Although a visual inspection of surfaces, supplemented by air and surface samples, will provide information on the types of molds present and on numbers of spores and other particles (those that have emerged from cavities), it may be necessary to conduct a more thorough—and possibly intrusive or destructive—investigation before the extent of mold growth in a structure may be determined.⁵⁴

Where readily observable evidence is limited, some nonintrusive electronic means can help in finding and evaluating the extent of hidden moisture that can be accompanied by mold.

Thermal imaging (infrared thermography) displays an image of temperature variations within walls, floors, and ceilings:

Infrared thermography is a technique that produces video-quality visible images from thermal patterns. Temperature differences as small as 1/20°F may be viewed by sensitive thermal detectors. Radiant heat is then converted to electrical energy, which is amplified and viewed as a visible image. Under the right conditions, infrared thermography is a quick and cost-effective approach for assessing hidden water damage. Because the heat capacity of water-damaged material is greater than that of dry material and air, areas of high moisture content appear either warmer or colder than the surrounding infrastructure.⁵⁵

Infrared thermometers provide similar information about temperature differences, but without the image display.⁵⁶

Moisture meters measure moisture content of substrates such as walls and carpets:

Moisture meters may be helpful for measuring the moisture content in a variety of building materials following water damage. They can also be used to monitor the process of drying damaged materials. These direct reading devices have a thin probe which can be inserted into the material to be tested or can be pressed directly against the surface of the material. Moisture meters can be used on materials such as carpet, wallboard, wood, brick, and concrete.⁵⁷

Those technologies are not suitable for use by homeowners or building managers who lack the appropriate expertise. They do not identify mold as such, but rather help to identify areas of abnormal moisture. Areas that became wet, developed mold, and are now dry might not be identified by moisture meters or thermal imaging.

Borescopes are also of value as a professional tool for investigating hidden spaces, but also are not suited to use by those without training:

These devices are used to assess the condition of wall cavities, HVAC systems, and inaccessible areas within work spaces. Some have video cameras attached so that the condition of surfaces may be documented. Most systems have limited distance or range, and may be subject to errors.⁵⁸

After remediation of identified mold (removal, repairs, and cleaning), air and surface sampling may be appropriate to verify that the problem has been fully corrected.⁵⁹ Post-remediation testing might also be required by an insurance company.

If sampling after remediation and cleaning finds evidence of a continuing indoor source of spores, further investigation is warranted. Evidence of an indoor amplifier (that is, an indoor area of mold growth) would include:

- spore counts that are significantly higher than currently found outdoors in the vicinity⁶⁰
- spores or other evidence of molds different from those commonly found outdoors on leaves (phylloplane species), especially if those found indoors are species commonly found in water-damaged indoor environments

EPIDEMIOLOGICAL INVESTIGATION

In some cases, mold intrusion into buildings has been discovered through investigations of reported illnesses among building occupants. For example, James Craner and Linda Stetzenbach reported on an investigation in a Las Vegas, Nevada, state office building.⁶¹ A survey of building occupants identified certain areas of the building where the ill occupants tended to be located. Investigation identified water damage, leaks, mold growth, and HVAC operational issues particularly affecting those areas. The investigation also identified other localized areas of mold growth in the building. Remediation was followed by recovery from the reported symptoms.

That example, and others like it, suggest that where a pattern appears of otherwise unexplained illnesses of types associated with dampness and mold infestation, a systematic investigation may discover significant mold growth.⁶² Although such an investigation may not meet strict criteria for proving a cause and effect relationship, it may support inference of an association and point to needed assessment and remediation.

SUMMARY

Fungal spores are everywhere, indoors and out. Indoor counts of mold spores typically reflect outdoor levels and species. Mold grows indoors on many kinds of surfaces if enough water is available. Significant indoor mold growth will lead to higher indoor counts of mold spores and other products and a different distribution of species than in the outside air.

Biological contaminants of the air (bioaerosols) include much more than fungi, so a full analysis of potential contributors to illness associated with indoor air contamination considers not only molds, but also bacteria, dust mite products, animal dander, and other contaminants.

Investigation protocols encompass visual inspection of walls, floors, and ceilings, air samples, surface samples, and, where necessary, inspection of interiors of cabinets, walls, ceilings, HVAC systems, and other building elements. Electronic methods (infrared thermography and moisture meters) can help to locate areas of water damage without opening walls or other cavities.

Where mold or water damage are not apparent, epidemiological methods may reveal patterns of illness that suggest presence of and possible location of microbial contamination in a building.

4. Preventing Mold Growth

Where there is sufficient **moisture** and an organic **medium** (anything that serves as mold food, from carpet to drywall to a layer of grime on tile), **mold will grow**. The types of mold that will grow depend on the amount of moisture and on the medium (surface, substrate), but some kind of mold will grow wherever the essential elements exist, even inside of pillows and other bedding materials.

In brief: **Moisture + Medium → Mold** or **Water + Food = Growth**

Prevention of water damage and remediation of mold contamination in buildings would be important even if mold presented no health issues, as mold damages (deteriorates) whatever it lives on and continues to grow and spread as long as conditions permit. One expert points out, “there is even a scientific journal, *International Biodeterioration & Biodegradation*, that focuses primarily on the material damage caused by molds and other microorganisms.”⁶³ The risk of adverse health effects from mold contamination makes prevention and remediation even more important than the physical damage to structure and contents alone.

Studies suggest that some unwanted indoor dampness (excessive, inappropriate) is found in at least 20 percent of buildings. That is a very rough figure reflecting various widely differing studies, and not taking into account how serious the condition was in each building.⁶⁴ As a rough guide, the figure suggests that the problem is common, but not inevitable.

The best solution to an indoor mold problem is to prevent it from developing in the first place through proper design, construction, operation, and maintenance, including use of exhaust fans and air circulation. When the problem has not been prevented, timely and effective remediation is required.

ROUTINE PREVENTION AND BUILDING MAINTENANCE

A habit of watching for potential trouble can prevent leaks or other water intrusion or minimize effects immediately. Preventing entry or accumulation of water where it does not belong is key to preventing growth of mold and other results of water damage.

Routine procedures include:

- Check plumbing fixtures to be sure connections are tight, seals properly functioning, and pipes free of cracks or other signs of deterioration.
- Fix leaks immediately. Turn off water flow to affected areas until repairs can be made or, where appropriate, use a container to catch dripping water until the leak is fixed.
- Check caulking for signs of deterioration and repair promptly.

- Use vents (in bathrooms and above stoves, for example) to remove moist air from the building.
- Cover pots when cooking to minimize release of steam.
- Use a dehumidifier if necessary to reduce excess moisture content of indoor air. If using a dehumidifier, regularly empty and clean the drain pan to keep it from becoming a source of contamination.
- Do not overwater indoor plants.
- Adjust sprinklers, hoses, and other irrigation equipment to keep water away from windows, walls, and doors and to prevent pooling of water next to foundation.
- Use drainpipes or spouts as well as proper drainage to channel water (from a rain gutter, for example) away from the building. Keep them clean and unobstructed.
- Trim shrubbery near walls to prevent blockage of vents and drains and to prevent diversion of rainwater toward windows, walls, or foundation.
- If eligible, contact the local energy supplier or the city or county community development department for assistance in sealing seams and repairing leaks. The same kinds of repairs that can help to conserve energy can sometimes also help to prevent water intrusion into a home. See the Remediating Mold section, below, for resources for low-income homeowners.

Regular attention to basic preventive measures is the most important step toward preventing mold and other results of water damage in an already-constructed building.*

DESIGN AND CONSTRUCTION

Every building should be designed to prevent water intrusion and leaks and to prevent buildup of moisture inside of walls, service areas, or occupied space. As Edward Allen points out in *How Buildings Work*, “Elaborate and expensive precautions are taken in buildings to prevent the entry of even a drop or two of water, because water is an agent of destruction.”⁶⁵

Design should to the extent feasible prevent entry of mold spores and other contaminants. Some entry is normal or commonplace, as some spores from outside sources will be carried in on shoes and clothing, for example, or be blown in through open doors. More

* For information on related renters’ rights, see California Department of Consumer Affairs, “Having Repairs Made,” www.dca.ca.gov/legal/landlordbook/repairs.htm. Quoting in part: “If a tenant believes that his or her rental unit needs repairs, and that the landlord is responsible for the repairs under the implied warranty of habitability, the tenant should notify the landlord. Since rental units typically are business investments for landlords, most landlords want to keep them safe, clean, attractive, and in good repair. It’s best for the tenant to notify the landlord of damage or defects by both a telephone call and a letter. The tenant should specifically describe the damage or defects and the required repairs in both the phone call and the letter. The tenant should date the letter and keep a copy to show that notice was given and what it said.”

important, water intrusion, for example via leaks or capillary action (wicking of soil water into a concrete foundation slab), must be prevented. Likewise, accumulation of water through condensation must be prevented through management of humidity and of temperature gradients.

The core concept is summarized in a report prepared for the U.S. Department of Housing and Urban Development:

Build In Moisture Protection through Proper Design and Construction Detailing. The first line of defense against moisture problems is undoubtedly good design and the proper execution of design details that prevent moisture intrusion.⁶⁶

Construction issues can be subtle. For example, concrete shrinks as it cures, so over its early years a tall building can shorten enough to stress joints and cause leaks in pipes.⁶⁷ Some issues are much more obvious and may be associated with design or construction choices. Homeowners and building managers should be alert to design and construction problems that might put their buildings at risk of water damage despite careful maintenance.

Following are a few examples of design and construction issues that relate to moisture in buildings.⁶⁸

- **Roof design.** Slope of roof and presence or absence of overhangs influence how much rainwater reaches foundations and walls. Cornices change wind patterns and reduce rainfall against walls, as can even simple overhangs.⁶⁹ Placement of roof drains is critical. If not placed at the lowest spot on the roof, the drains (or rather, lack of drains where they are most needed) can lead to leakage. Likewise, roof-top air handler units lead to water intrusion if placed on the lowest part of the roof.
- **Path for water drainage.** Some water will enter walls through any opening, such as a crack or seam. It is essential that a path be provided for water to drain. Where there is no drainage, the water will accumulate and find its way toward the interior to cause damage and support mold growth.
- **Synthetic stucco without a drainage plane** illustrates the previous point. Synthetic stucco, also called Exterior Insulation and Finish Systems (EIFS), allows water buildup, followed by wood rot and mold growth on biodegradable materials such as sheathing if the EIFS has not been installed with a drainage plane (space for water to drain away from the wall).⁷⁰ EIFS has been the subject of numerous lawsuits, some with multimillion dollar damage awards.
- **Grading of lots.** It is essential that lots be designed and buildings placed so that water drains away from the walls. Water accumulating at the base of walls is a serious hazard for water intrusion directly or via wicking. Where the slope cannot entirely meet the need, then drains are necessary to allow water to flow away from the building.

- **Insulation of pipes.** Cold pipes invite water condensation. Over time, condensation, especially if repeated, will lead to water damage.
- **Condensation on windows.** Likewise, windows that are cold on the interior cause condensation and invite water damage and mold growth. Thermally insulated windows can prevent this problem.
- **Vented crawl spaces.** Especially in humid climates, vented crawl spaces bring hot, humid air into contact with cooler surfaces, resulting in condensation and facilitating mold growth and other damage. Vented attics pose similar risks.
- **Leaky ductwork and plenums.** A building with leaky ductwork and plenums, especially if the building has negative air pressure, draws in a large amount of air that can contribute a large moisture load to the interior.
- **Vinyl wallpaper on the inside of exterior walls.** Vinyl wallpaper is a moisture barrier. Moisture that might otherwise diffuse harmlessly through a wall becomes trapped behind the wallpaper and leads to mold growth on the wallpaper paste and the paper face of wall board, sometimes enough growth to raise bubbles in the wallpaper or to dislodge it.

Building design and construction are complex topics. Many requirements must compete for attention and be balanced and coordinated. At the same time, building standards are not always compatible with control of moisture. For example, some efforts to make buildings energy efficient have led to water condensation, inadequate air exchange, and microbial growth in energy-efficient buildings—bad results of good intentions.

Differences between design specifications and actual construction can cause problems that were not inherent in the design. Simple mistakes or omissions can allow water damage where none had been foreseen. It is essential for architects, engineers, and contractors to determine where moisture in any form will be encountered in and adjacent to a building, what surfaces and openings it will reach (whether as liquid, vapor, or ice), and where it can accumulate as a result.

Design and construction issues are being extensively examined by architects, engineers, contractors, builders, and regulators. A U.S. Department of Housing and Urban Development report on the effect of moisture on building durability, published in 2004, includes an extensive list of related ongoing public and private sector research.⁷¹

BUILDING MATERIALS

Building materials should not be allowed to become wet or remain wet. Lew Harriman, an expert on humidity control in buildings, cites expert opinion “that keeping materials dry during construction is at the heart of the contractor’s role in preventing mold.”⁷²

Damp wood, wallboard, concrete, or other components can lead to the growth of mold. Even non-organic components (such as concrete slab) that do not support mold growth can provide a source of water to be drawn into organic elements on which mold grows (wood frame, drywall, carpets).⁷³

It might be impractical to test construction materials for unseen mold (present, but not yet visible on the surface), as at most it would be possible to test a very small sample of what might be an enormous supply of lumber or other construction materials. Further, mold spores and hyphal fragments are found in small numbers on most material surfaces, so mere presence of spores or fragments on a surface does not itself demonstrate active growth on that surface or into the underlying material.

Even without visible mold, if building components have been exposed to rain, flooding, water leakage, or simply not allowed adequate time to dry, they should be examined by the contractor to determine whether they can be dried before being closed in. Wet building materials and those that have become wet, especially if repeatedly so, increase the risk of early mold growth in the completed building.⁷⁴ It must also be considered that many wood products include pre-existing mold growth and normal discoloration which is not mold.⁷⁵

SUMMARY AND COMMENT

The essence of prevention is not to allow any part of a building that can support mold growth to become wet. If it does become wet, then it should be dried immediately, before mold growth can begin.

Key steps include routinely checking for and correcting potential problems before they become problems—sealing leaks, channeling water away from the building, preventing excess humidity indoors and preventing condensation on cold surfaces. Simple precautions such as always using bathroom and stove vents, covering pots while cooking, promptly wiping down damp surfaces (shower stall tile, for example), not overwatering indoor plants, and keeping rain gutters and drains in good order all make a difference.

Even before the building is occupied, it is essential that water intrusion issues receive proper attention through design and construction. Design must keep water out and must control humidity. Construction must see that details such as installation of flashing are properly performed and that materials are kept dry during the process, or promptly and fully dried if they have become wet.

Comment: One valuable measure would be a plan to deal with water intrusion, so that when an event occurs steps may be taken promptly to minimize damage and expedite drying of the affected parts of the building. Such a plan could be an element of a broader operational recovery or business continuity plan for an agency or organization.⁷⁶

5. Remediating Mold

Mold remediation exposes the persons doing the work—whether they are homeowners, maintenance personnel, or professional remediators—to mold spores, fragments, and toxins via inhalation, skin and mucous membrane contact, and possible ingestion.

Where contamination is more than trivial (a small, confined, easily accessible area), it is essential to use appropriate protective measures. Where there is risk of spreading spores or particles to other areas within a building, it is also essential to use appropriate means of isolation, as remediation activities and air movements spread spores and particles.

This section only provides an overview of the elements of remediation. Readers with a mold contamination situation should consult the more detailed guidance provided by resources cited elsewhere in the report. Where the contamination is significant, homeowners, building managers, and maintenance personnel should seek qualified professional advice and assistance.

To remediate is to fix or correct a problem, or in other words, to apply a remedy. “Remediation” encompasses actions and techniques to correct growth of mold (fungi) in indoor areas.* According to Health Canada (the Canadian health department):

“Remediation” includes both the thorough cleaning of any mold growing in the building and the correction of the defect that led to mold growth—excessive humidity, water leaking, or water infiltration from the outside.⁷⁷

GUIDELINES

Because indoor mold growth has been a matter of public concern for more than a decade, various agencies and organizations have developed guidelines regarding remediation, some of which are frequently cited in the literature on indoor mold. Intended audiences and level of detail vary among the guidelines.

* This section is directed to homeowners and to building owners and managers. Residential and commercial renters and lessees may have particular concerns regarding liability and responsibility for correcting issues of use and occupancy, including those related to mold. Rental and lease situations and renter-landlord relations and responsibilities are outside the scope of this report and vary with specific contract provisions, including rental and lease agreements. Renters and lessees who have concerns about water damage or mold should discuss those concerns with their landlords, advise them in writing about water damage, mold, or other conditions, and, if necessary, seek appropriate legal consultation. For information on residential renters’ and landlords’ rights and obligations in California, see California Department of Consumer Affairs, *California Tenants: A Guide to Residential Tenants’ and Landlords’ Rights and Responsibilities*, available via www.dca.ca.gov/legal/landlordbook/.

- The California Department of Health Services provides an overview of indoor mold causes, health concerns, and cleanup procedures, titled “Mold in my Home. What Do I Do?”⁷⁸ That document is primarily designed for **homeowners**.
- Texas Cooperative Extension has produced a concise (three-page) guide, “Mold after a Flood,” for **homeowners**.⁷⁹
- The U.S. Environmental Protection Agency has published *A Brief Guide to Mold, Moisture, and Your Home*, a concise, illustrated overview for **homeowners**.⁸⁰
- The Canada Mortgage and Housing Corporation has published “Fighting Mold: The Homeowner’s Guide,” directed to **homeowners**.⁸¹
- The City of New York Department of Health and Mental Hygiene developed a widely cited set of guidelines for mold remediation, “Guidelines on Assessment and Remediation of Fungi in Indoor Environments.”⁸² Those guidelines were intended specifically for use by city personnel in New York City buildings, but the document is widely cited by agencies. The guidelines, while not applicable under all conditions, are useful as a starting point and provide an overview of issues and procedures for **managers of public buildings**.
- Canada’s Federal-Provincial Committee on Environmental and Occupational Health published *Fungal Contamination in Public Buildings: A Guide to Recognition and Management*. Part IV of that document addresses remediation and preventive maintenance of buildings.⁸³ That document is designed for **managers of public buildings**.
- The U.S. Environmental Protection Agency has published *Mold Remediation in Schools and Commercial Buildings* for **managers of school and commercial buildings**.⁸⁴
- The Institute of Inspection, Cleaning and Restoration Certification (IICRC) developed and published *IICRC S520 Standard and Reference Guide for Professional Mold Remediation*. The S520 guide is intended for **professional mold remediators**.⁸⁵
- The U.S. Navy has produced a one-page “Mold Remediation Wheel,” a concise summary of standard recommendations, designed for **Navy personnel** and possibly of reference use for others.⁸⁶

The steps outlined below are selected, summarized, and adapted from the remediation guidelines. Use this outline as a general guide to the kinds of techniques and precautions that go into remediation. For more detailed information, consult the appropriate guidelines listed above. Of related interest, especially to those doing or managing remediation, is *Guidelines for the Protection and Training of Workers Engaged in Maintenance and Remediation Work Associated with Mold*, sponsored by the National Institute of Environmental Health Sciences, the Society for Occupational and Environmental Health, and other organizations.⁸⁷

Where repairs are required (replacement of wall panels, for example), the nature and extent of the repairs may be more important in designing procedures and in determining who is to do the work than is the mold contamination associated with the water damage. Please see “Considerations for Homeowners and Building Managers,” page 45 below, for discussion of this point.

IDENTIFY AND FIX THE CAUSE

The first step is to stop whatever is causing water intrusion or accumulation, if that can be done before beginning cleanup efforts. Sometimes a wall or other compartment must be opened before the cause can be identified, but often the source of the problem can be identified before building repairs are started. For example, the problem might be as simple as a misaimed sprinkler, a leaking pipe under a sink, or plugged drainage.

DETERMINE EXTENT OF MOLD GROWTH

Sometimes it is simple to determine the scope of a mold problem, but often it is not easy or obvious. Leaky roofs or walls, widespread and repeated condensation, or wicking of water through a concrete slab, for example, may lead to extensive hidden mold growth.

For information on assessment methods, see Section 3, Assessing Mold Contamination (page 23).

Once the scope has been determined, a strategy for cleaning and repair may be developed by the homeowner, building manager, or contractor, as appropriate in the specific case. That will be a work in progress if the work uncovers additional affected parts of the building.

The widely cited New York City guidelines suggest categories based on size of visible mold growth on interior surfaces, with procedures designed for each. Although these categories provide a rough starting point, the guidelines also allow flexibility (for example, containment alternatives need not be considered if occupants will not be exposed and the work area will be clean before reentry):

- Level I is a small isolated area, 10 square feet of mold growth or less. Examples include ceiling tiles or small areas on walls.
- Level II is a mid-sized, isolated area, 10 to 30 square feet of mold growth. Examples include individual wallboard panels.
- Level III is a large isolated area, 30 to 100 square feet of mold growth. An example is several wallboard panels.
- Level IV is extensive contamination, greater than 100 contiguous square feet of visible mold growth in an area.
- Level V is for remediation of an HVAC system, and is itself divided into subcategories by size of affected area (up to 10 square feet of visible mold growth, and 10 square feet of visible mold growth or over).⁸⁸

According to the NYC guidelines, mold square footage is determined by room, not a composite of the entire facility. Level I and Level II can be remediated by “regular building maintenance staff” with proper education or training. Level III requires “[p]ersonnel trained in the handling of hazardous materials.” Level IV calls for a “health and safety professional with experience performing microbial investigations . . . to be consulted prior to remediation activities to provide oversight for the project.”

The guidelines outline appropriate personal protective equipment, (PPE), area containment measures, occupant protection measures (such as how much of the building to vacate), and other procedures for each level. (See the NYC guidelines for details.)

The levels may be difficult to interpret where the full extent of contamination by mold and other microbial infestations cannot be assessed simply by visual inspection. It would be easy to underestimate the true scope or extent of a problem if a wall cavity behind a visible area of mold is water damaged and copiously growing mold and bacteria.

Where the extent of the problem cannot reliably be determined through visual inspection, other methods will be needed for assessment. Those might include electronic means discussed earlier (moisture meters, thermal imaging, borescopes) and removal of a portion of a wall or other building material to allow visual inspection of hidden areas. Such invasive actions would themselves best be accompanied by use of at least basic personal protective equipment (PPE) and minimal containment for the safety of workers and other building occupants.

In general, extensive visible mold growth on interior surfaces should be addressed by more detailed control measures.

The NYC guidelines clearly summarize the essential goal of remediation in terms that can be applied to any project:

The goal of remediation is to remove or clean contaminated materials in a way that prevents the emission of fungi and dust contaminated with fungi from leaving a work area and entering an occupied or non-abatement area, while protecting the health of workers performing the abatement.⁸⁹

Any mold remediation project, small or large, home or commercial, can be developed with an eye on that basic advice.

ISOLATE AFFECTED AREAS

Cleaning and repair will stir up and disperse large numbers of particles, and air movement will carry them at least to adjacent rooms (possibly much farther) without isolation. Mold spores are small and easily dispersed into indoor air even on passive air currents. If the area to be cleaned is significant or if the growth is very heavy even in a relatively small area, the area should be sealed off to prevent spores and other particles from moving to other rooms. The New York City guidelines recommend using plastic sheeting for a mid-size isolated contamination area (10 to 30 square feet of visible mold

growth) or larger. That, however, is a rule of thumb designed for New York City government buildings and government employees doing the work. More caution may be appropriate for homeowners or commercial building personnel.

Multiple isolation chambers (air locks) or decontamination chambers are required to allow entry into and exit from the work area while preventing movement of particles outside the work area. The larger and more extensive the contamination, the more need exists for the additional precautions.

Supply air and return ducts should be covered and taped and HVAC (heating, ventilating, air-conditioning system) turned off to prevent microbial particulate contamination from being spread into and through the system.

It may be necessary to establish negative air pressure to assure that particles do not escape from the contaminated rooms into adjacent rooms or ducts. If so, the need for that precaution may itself suggest the need for professional assistance, as the process requires a negative air machine (or machines) and personnel who are trained in the use of that equipment. The larger the affected area and the heavier the contamination, the more appropriate negative air pressure and more elaborate containment procedures become.

USE PERSONAL PROTECTIVE EQUIPMENT

Any project that may subject the individual to harmful particles, chemical emissions, or other airborne hazards requires appropriate personal protective equipment (PPE).

Personal protective equipment is a complex technical topic. Federal and state occupational safety and health regulations govern requirements for workers.⁹⁰ Homeowners and others doing their own work are not covered by those rules, but they may wish to consider the range of available PPE options when deciding upon the level of protection to use during a project.

A project that will generate dust or other breathing hazards calls for a respirator. Where mold or other microbial contaminants will be present, as during mold remediation or repair of a mold-contaminated part of a building, a higher level of protection is appropriate than for less hazardous conditions.⁹¹

PPE is also used by people applying pesticides, painting, and doing other tasks that generate fumes or other contaminants. For that reason, such equipment is widely available for consumers. Home improvement and hardware stores sell some equipment, including breathing masks and basic respirators, but they do not carry more complex and costly PPE designed for professional and industrial use.⁹²

Eye protection is appropriate, with the extent of the protection depending on the type of exposure. A full-face respirator available in retail hardware and home improvement stores provides eye protection as well as breathing protection, but it might not meet regulatory health and safety standards for workers.

Gloves, too, should be worn to prevent skin contact with contamination, as mold (and other biocontaminants encountered in water-damaged environments) can produce skin irritation or more serious conditions.

Evaluation of PPE options should be one factor among many in decisions about whether to undertake a remediation project privately (by a homeowner, for example) or to hire a contractor.

The New York City guidelines advise, “Respiratory protection (e.g., N95 disposable respirator), in accordance with the OSHA respiratory protection standard (29 CFR 1910.134), is recommended. Gloves and eye protection should be worn.” (Note that N95 respirators are available in many home improvement and hardware stores.)

That is suggested by the NYC guidelines for small and mid-size isolated areas and is a *minimum* for large isolated areas (30-100 square feet of visible mold growth). For “Extensive Contamination (greater than 100 contiguous square feet of visible mold growth in an area),” the NYC guidelines advise:

Personnel trained in the handling of hazardous materials equipped with:

- full-face respirators with high efficiency particulate air (HEPA) cartridges
- disposable protective clothing covering both head and shoes
- gloves

At that point, remediation is clearly a matter for fully trained, equipped, licensed professional personnel, as other procedures and requirements of the work are comparably more elaborate and demanding. See page 45 for information on selecting contractors.

PROTECT BUILDING OCCUPANTS

During a mold remediation project, it is important to take steps to protect building occupants from exposure to mold spores and particles and to other contaminants normally stirred up by cleaning, repair, and reconstruction work. Steps in protecting occupants include:

- Inform building occupants of the remediation project, potential risks, and safety precautions.
- Isolate affected areas.
- Remove occupants from adjacent rooms.
- Remove especially susceptible individuals from the site entirely.
- Keep occupants and visitors out of areas being cleaned and repaired.
- Properly dispose of contaminated materials after enclosing them in bags.

Larger projects may require removing occupants from larger areas, such as an entire floor, or even the vacating of an entire building, especially where the problem encompasses more than just isolated parts of a building.

REMOVE DAMAGED POROUS MATERIALS

Moldy porous materials, such as drywall and carpets, are often removed from the premises and discarded. Mold extends filaments (hyphae) into a porous substrate and therefore may not be removed by surface treatments. Exceptions would be limited to high value items, such as artwork and Oriental rugs, that might be successfully cleaned professionally by specialists. Treatment may be considered for some gypsum products (for example, Sheetrock with minor surface mold caused by elevated humidity, or party walls exposed to rain after being framed in).

Safe removal requires bagging in air-tight plastic bags and removal from the building for conveyance to a sanitary landfill. Moldy materials are not considered “hazardous waste” and may be disposed of with other trash, but they should be securely bagged as a precaution as if they contain moldy compost.

CLEANERS AND DISINFECTANTS

For small, minor mold, typically called “mildew,” affecting such areas as shower enclosures, ordinary household cleaning procedures and products are sufficient. In those cases, the mold is growing on a surface layer of grime. Removing that layer of grime also removes the mold. The problem area (assuming the underlying surface is impermeable—tile, for example) may be wiped down with a sponge or cloth and a mild household detergent. A bleach solution (according to package directions) might also be used. (Never mix cleaning products, as some combinations can produce toxic fumes. Bleach and ammonia are specifically not to be used together.) The sponges and cloths used to clean up mold should be discarded.

To take a simple example, a moldy throw-rug on a smooth tile surface can be bagged, removed from the premises, and properly discarded. (It is not considered hazardous waste, but should be bagged—preferably double-bagged—for safety in transit.) Then the tile can be mopped with a mild detergent, rinsed, dried, and ready for use again. If mold has grown on a layer of grime on a smooth surface, the surface can likewise be cleaned.

Even after cleaning, stains might remain on surfaces. The stains are not hazardous.

Cleaners and disinfectants are not suitable for treating moldy porous surfaces.⁹³ Spraying such products onto mold both generates product fumes—themselves a potential hazard, especially in insufficiently ventilated areas—and spreads mold spores. The spores are

hydrophobic (water resistant), and will be blown into the air by the spray. They are not like ordinary dust or soil particles that can be suppressed by sprayed water.*

The NYC guidelines caution:

The use of gaseous, vapor-phase, or aerosolized biocides for remedial purposes is not recommended. The use of biocides in this manner can pose health concerns for people in occupied spaces of the building and for people returning to the treated space if used improperly. Furthermore, the effectiveness of these treatments is unproven and does not address the possible health concerns from the presence of the remaining non-viable mold.⁹⁴

IS ENCAPSULATION AN OPTION?

Encapsulating moldy areas—permanently sealing them off as a substitute for complete removal or effective cleaning of moldy materials such as drywall or interior cavities—is sometimes suggested as an option where other methods are not considered feasible or affordable. Encapsulation might be done through creating an air-tight and inviolable seal between the contaminated space and other parts of the building or might take the form of painting over moldy materials after drying and surface cleaning.

Encapsulation is not a cleaning method, is not a best practice, and is not ordinarily recommended, although there may be specific exceptional circumstances.⁹⁵ The barrier itself can encourage or be subject to new mold growth by trapping moisture. New mold growth can dislodge wallpaper, make paint bubble, and can emit spores and other particles into occupied space through air pressure and eventual deterioration of seals.

CLEAN SURFACES IN ADJACENT AREAS

After the repairs and cleaning have been completed in the affected areas, it is appropriate to HEPA (high-efficiency particulate air filter) vacuum surfaces in adjacent rooms (if not in the entire building) and to wipe down surfaces where vacuuming is not suitable. This step will reduce the number of particles that might otherwise recirculate in the air as a result of movement of building occupants and normal airflow in the building.

Vents and HVAC equipment that may have become contaminated should also be cleaned. (In some cases the HVAC system itself may have been the focus of the remediation.)

Upholstered furniture and carpets may harbor significant levels spores and other particles. They may require professional cleaning or repeated HEPA vacuum cleaning to return them to an acceptable (normal) condition. Normal does not mean antiseptic, as some microbial contamination will be found everywhere.

* Note that pesticides (including fungicides) and pesticide applicators are regulated by the California Department of Pesticide Regulation (CDPR). For information, see the CDPR factsheet “What is a Pesticide,” www.cdpr.ca.gov/docs/factshts/what2.pdf and www.cdpr.ca.gov.

CONSIDERATIONS FOR HOMEOWNERS AND BUILDING MANAGERS

For a moment, think of a mold remediation project simply as a repair job, ignoring the mold and other microbial contamination.

If you, as a homeowner or as a building manager responsible for a commercial or government building, faced the job, would you feel comfortable (prepared, competent) in doing it yourself (as a homeowner) or with your regular maintenance crew (as a building manager)? Do you or your employees have the knowledge and experience and equipment to do the repairs?

If not—if the job is too big or complex or risky, or requires specialized tools and equipment that you do not have—then the job should be turned over to a licensed, experienced contractor. For help in finding a contractor, consult the California Contractors State Licensing Board’s “Consumer Information” website, www.cslb.ca.gov/consumers/default.asp. Among the board’s advice:

- One of the best ways to select a licensed contractor is to seek out personal recommendations from friends or relatives who recently had similar projects completed and were satisfied with the job.
- Before you sign anything, check the CSLB Web site, www.cslb.ca.gov, or call the Contractors State License Board at (800) 321-CSLB, to make sure the contractor is properly licensed in the class for the work to be performed, and the license is in good standing.⁹⁶

Note that California does not currently license contractors specifically for mold remediation.

For a building manager within a large organization, resources might be available elsewhere in the organization, at a regional level, for example. In that case, those resources are the equivalent of an outside contractor.

In such cases, where the job itself is too much, the microbial contamination is not the deciding factor. Instead, the microbial contamination (mold and bacteria) is something that the contractor must manage along with the rest of the repair.

If the job is beyond your capacities—too large, complex, or specialized—then you have to turn to outside assistance for that reason alone.

If the job is within your capacities, what precautions would you take to prevent construction dust (particles of everything stirred up during the work) from spreading beyond the worksite and into other rooms or floors of the building? Are you prepared to seal off the work area and if necessary to provide negative air pressure to confine the dust and to vent it safely away? If you cannot handle the normal precautions, outside assistance might be required. The contractor will have to take the additional precautions that are appropriate to mold remediation (containment barriers and other steps to prevent

the spreading of contamination), so it is important to choose an experienced, licensed contractor.

You might feel that you are willing to accept the spreading of (say) sawdust and drywall particles to other rooms, expecting to dust and vacuum afterwards. In that case, you might still choose to do the job yourself, and accept the spreading of construction dust. But are you comfortable if what is being spread includes not just inert dust, but also spores that will grow as soon as moisture permits and that can infect susceptible individuals (immune-compromised people specifically), allergenic mold particles, bacteria, and possibly mycotoxins that could pose additional risks?

Ordinary construction dust poses risks of allergies (aggravating or causing), asthma (aggravating or possibly causing), and other pulmonary problems. Adding mold products and bacteria to the mix in the air and on surfaces increases risks and may introduce new risks (and additional costs) beyond those presented by ordinary construction dust.

If you are not comfortable with the added level of risk and the added level of precaution resulting from microbial contamination of water-damaged areas, then it is appropriate to seek an outside contractor or other fully qualified assistance in making the repairs.

If you do choose to undertake a mold-involved repair yourself, then it is essential to use appropriate health and safety precautions as described in the outline of remediation procedures and as recommended in widely recognized guidelines. If you decide to do the work yourself, the California Department of Health Services suggests caution:

Try cleaning a test area first. If you feel that this activity adversely affected your health, you should consider paying a licensed contractor or other experienced professional to carry out the work.⁹⁷

Whatever might be the specific source of a perceived health effect (whether it is mold or some other aspect of the work or of the environment), sensible precautions are appropriate to protect your health and that of other people in the building.

ASSISTANCE FOR LOW-INCOME HOMEOWNERS

Home repair assistance for low-income homeowners may be available from local governments. For example, the City of Los Angeles offers the Handyworker Program (www.lacity.org/lahd/hndywrkr.htm):

The Handyworker Program provides free minor home repairs to low income senior (62 years and older) or disabled resident homeowners or homeowners with disabled relatives residing with them. Income limits apply Emergency repairs that directly affect the health and safety of occupants are also provided to other homeowners if their income does not exceed the limits . . . (regardless of age or disability status).

Eligible repairs are limited to work that does not require a City building permit or formal inspection.

Where local governments do not offer this type of assistance, other agencies (public or private) might. Homeowners who might qualify for assistance should ask for guidance to help find resources. A starting place is the city or county community development department. Weatherization grants available through local energy suppliers also can help with some related needs, such as weather-stripping and caulking.⁹⁸

SUMMARY

The California Department of Health Services has concisely summarized the most essential points about indoor mold:

[I]ndoor mold growth is unsanitary and undesirable. Basically, if you can see or smell mold inside your home, take steps to identify and eliminate the excess moisture and to cleanup and remove the mold.⁹⁹

No matter how remediation is to be done, it is essential (a) that those doing the work use appropriate personal protective equipment, (b) that barriers prevent contamination of the rest of the building, (c) that occupants be protected from exposure to contamination, and (d) that moldy porous materials be safely bagged and removed for disposal. Nonporous surfaces may be cleaned, but cleaning agents should be used according to label directions and with appropriate ventilation.

Low-income homeowners may be eligible for assistance with repairs and cleanup, and should contact local agencies and organizations for information on available programs.

6. Hazard Communication

This section considers ways of advising people of the hazards of exposure to mold contamination. After a general look at means of communication, comments are offered regarding different groups, ranging from homeowners and renters to construction workers, maintenance and custodial personnel, and employees in potentially contaminated environments.

MEANS OF COMMUNICATION

Many methods can communicate information about risks and appropriate responses:

- brochures and fliers
- posted signs
- public service announcements on television or radio
- press releases and articles prepared for use by newspapers and magazines
- audio/video presentations on tape, CD, or other electronic media
- websites
- seminars and other public presentations to audiences
- direct consultation with individuals
- elements of worker training programs

The choice of means depends on the specific audience as well as on the specific topic. The choice need not be mutually exclusive. A brochure, for example, can be printed for distribution by mail or in public places while also being posted on a website, adapted for the text of a press release or periodical article, used as the basis for an informative talk at group meetings, or reformatted as an outline for a video presentation. It might be left (as a brochure) with individuals after one-on-one consultations or given out as part of a worker training program. Finally, it might be simplified and condensed down to key points for a sign or poster.

TARGETING COMMUNICATIONS

Following are suggestions for targeting communications to reflect the activities and needs of individuals.

Homeowners

Mold becomes a serious and widespread problem after floods and heavy, prolonged rain. News coverage of the aftermath of Hurricane Katrina has frequently discussed the prevalence of mold in flooded homes in New Orleans and other parts of the Gulf Coast region.

At the time of such events, it is appropriate for public officials to provide information to homeowners and others about mold, the risks it poses, and what to do about it. Methods of communication include broadcast public service announcements, providing information to print and broadcast media for use in developing news stories, and provision of basic information sheets to be handed out by emergency personnel and by merchants who sell goods that homeowners would typically use in cleaning up and repairing after flooding.

Key information for such communications is encompassed in the California Department of Health Services' flier "Mold in My Home: What Do I Do?" and in the U.S. Environmental Protection Agency's *A Brief Guide to Mold, Moisture, and Your Home*. Those documents include basic information on potential health hazards as well as on basic remediation requirements.

Renters

Because of the risks of damage to the dwelling as well as potential health risks from damp indoor environments, landlords and tenants can both benefit from communications about the need to prevent and promptly report water damage. Such communications can be included in rental agreements and posted on the premises.¹⁰⁰

For information on California renters' rights to repairs, see the California Department of Consumer Affairs' guidance for renters in "Having Repairs Made," available at www.dca.ca.gov/legal/landlordbook/repairs.htm.

Construction Workers and Maintenance and Custodial Personnel

Construction workers, including those doing home and commercial building remodeling and repair, are subject to OSHA and Cal/OSHA hazard communication rules.¹⁰¹ Although the regulations are designed primarily with a view to chemicals and other manufactured substances, the principle of hazard communication could be extended to include risks from naturally occurring contamination, such as molds. The "safe and healthful workplace" standard could be understood to extend to those risks.¹⁰²

Similar considerations to those for construction workers apply to maintenance and custodial personnel whose work exposes them to such biological contaminants as bacteria, viruses, fungi, dust mites, and cockroaches.

Building Occupants (Commercial and Government)

The California Department of Health Services and California Department of Industrial Relations have published a four-page flier titled "Molds in Indoor Workplaces." That flier, available from the Hazard Evaluation System & Information Service (HESIS), concisely summarizes how exposure can happen and what health effects might be associated with it.¹⁰³

The Texas Department of Health issued a “Review of Practices for Mold Remediation,” April 2002.¹⁰⁴ The hazard communication section of that document summarizes guidance applicable to workers and building occupants:

Information about the potential hazards associated with mold growth in a building and remediation activities should be communicated to both the workers involved in the remediation and the occupants of the building. NYC DOH recommends training building maintenance staff who will conduct remediation work on the potential health hazards of mold. This training can be conducted as part of the training needed to comply with the OSHA Hazard Communication Standard (29 CFR 1910.1200). Health Canada suggests that building maintenance personnel and maintenance staff be aware of potential problems associated with contaminated indoor air, and USEPA indicates that remediation workers, and particularly those with health-related concerns, might wish to consult with a health-care provider before working on mold remediation or investigating potentially moldy areas.

Both USEPA and NYC DOH recommend communication with building occupants throughout the remediation process. When mold contamination requiring a large-scale response is found, building occupants should be notified of that fact and given a description and timetable of the activities that will take place. The form (e.g., memos, meetings) and extent of communication will depend upon the degree of contamination and nature of the remediation work. USEPA notes that frequent and open communication maximizes the amount of time available for remediation work by addressing issues and concerns as they arise.

At least two levels of communication are appropriate. The first—basic, general information—is of the type in the HESIS flier, and is suitable for distribution at any time for public information purposes. The second, incident-specific information before and during a remediation, as described in the Texas Department of Health document, is appropriate whenever the need arises and is an obligation of building managers, supervisors, and remediation personnel.

SUMMARY

There is no single means of communication that is suitable for the many kinds of individuals and circumstances that might be affected by indoor mold or other risks of a water-damaged indoor environment. Nor is there any one agency that is responsible for designing or conducting such communications.

Communications for workers can be handled in the normal course of work as required under state and federal law relating to occupational health and safety. For people working in remediation, construction and remodeling, or facility maintenance, communications about hazards are standard procedure. Risks posed by mold exposure are only part of the spectrum of risks relating to such workplaces, including chemical exposures, construction dust, and other safety hazards.

For workers in commercial or government buildings with known mold contamination, it is appropriate to post notices advising awareness of potential health risks and warning workers away from seriously affected areas. During remediation, additional cautions are appropriate with respect to areas that should be off limits to those not conducting the cleanup and repair and to the risk of additional airborne contamination stirred up by the activity.

Public health officials already provide information that is available to homeowners and others who may face water-damaged environments. For example, the California Department of Health Services has published a document summarizing facts and cautions about indoor mold. Public officials who may be contacted with inquiries should be prepared to direct those inquiring to that and similar documents or to provide copies on request.

It is important in all such communications to present information factually and clearly without causing unnecessary alarm or overstating risks that in most cases of ordinary exposures to indoor mold are relatively minor. At the same time, persons who may be at added risk as a result of microbial contamination (fungal or bacterial) in such environments should be advised to inform their physicians of the possible exposure in the event of health problems requiring medical attention.

7. Policy Options

The Legislature might wish to consider some issues discussed in this report for future legislation or inquiry.

EPIDEMIOLOGICAL ANALYSIS AND HEALTH IMPACT STUDIES

There is a need for continuing study of the possible effects on human health of indoor mold and other water-damage-related contamination.

The Legislature could consider authorizing or requesting public health officials to conduct epidemiological analysis of possible mold-related illnesses when conditions (such as post-flood conditions) provide sufficient cases for meaningful analysis. The Legislature might likewise consider requesting scientific researchers in public institutions of higher education to undertake analysis of health impacts of exposures to mold and mold byproducts indoors, with emphasis on conditions encountered in California.

LICENSING

Where water damage has caused mold growth, homeowners and building managers may need to turn to outside contractors for inspection, assessment, and remediation. Currently, California has no requirements for licensing or certification of mold inspectors or remediators as such. Some other states have such requirements.¹⁰⁵

The Legislature might wish to evaluate whether similar licensing or certification programs are appropriate for California and might help homeowners and building managers to secure qualified assistance when needed to assess or remediate a mold problem.

LISTING OF SERVICE PROVIDERS

The Minnesota Department of Health publishes a list of providers of mold testing services and other air-testing services. (See www.health.state.mn.us/divs/eh/indoorair/contractors.pdf). The Legislature might wish to authorize an agency of the State of California to develop a comparable list of service providers for California, encompassing one or more of the following: air quality services, mold assessment, mold remediation.

That could be done even without licensing of service providers and without certification of licensed contractors specifically to provide the named services, although some standards are appropriate for placement on the published list to assure at least a minimum level of competence.

The Legislature could consider authorizing a State agency to develop procedures and policies and to carry out the task.

BUILDING STANDARDS

Indoor water damage and dampness are damaging and costly and can pose health risks.

The Legislature might wish to examine or request appropriate review of building standards to identify changes that can help to prevent leaks and chronic dampness in buildings.

Issues to be examined might include strengthening architectural and engineering emphasis on dampness control and leak prevention, strengthening methods to assure that waterproofing measures are properly installed during construction, and assuring that energy efficiency measures do not result in indoor water accumulation.¹⁰⁶

EXPLICIT HAZARD WARNING REQUIREMENTS

Molds (and other microbial contaminants) present risks to persons working in contaminated environments. Those risks are different from the chemical risks typically addressed by workplace hazard communications.

The Legislature might wish to consider enacting a requirement that workers and building occupants be advised explicitly of hazards posed by mold and other microbial contamination affecting work areas.

That could be accomplished by requiring that the HESIS “Molds in Indoor Workplaces” flier or comparable information be posted in workplaces along with other normal workplace health and safety communications. Alternatively, this need might be met through administrative regulation on the subject of workplace health and safety notices.¹⁰⁷

REVIEW OF RENTERS’ RIGHTS

Renters can face the results of water damage in the form of mold and other microbial contamination even after the cause, such as a plumbing leak, has been repaired. Although current California law and regulation provide certain rights to renters when repair or maintenance is required, the Legislature might wish to initiate an inquiry as to whether the specified rights encompass cleanup and repair of such results of water damage as well as repair of the cause itself, and if not, to address that omission.

8. Recommended Reading and Additional Resources

A. RECOMMENDED READING FOR GOVERNMENT OFFICIALS AND ENVIRONMENTAL HEALTH OFFICERS

This section lists selected recommended reading and resources for local government officials, including public health officers. Some of these items will also be of value and accessible to interested homeowners, building managers, and others interested in the issue of indoor mold. This list includes some books and other resources written for general readers as well as a limited set of technical and specialized works.

These resources have been selected from a far larger set of books, articles, reports, and reference materials consulted or otherwise identified during the preparation of this report. Unavoidably, many worthwhile items were omitted in order to keep the lists within a reasonable limit and to allow a diverse listing with emphasis on widely cited items. These lists are intended to be helpful, but not comprehensive.

Some items cited via Web link lack dates. All were accessed during preparation of this report, August to October, 2005. Items may have been changed, moved, or deleted since they were accessed for this report.

General/Background

California. Legislature. Senate. Committee on Health and Human Services. *Public Health Effects of Toxic Mold: Informational Hearing of the Senate Committee on Health and Human Services*. Sacramento: the Committee, [2001]. Hearing on S.B. 932. Includes background documents and printed testimony submitted by witnesses, as well as the hearing transcript.

CDC Mold Work Group. *Mold: Prevention Strategies and Possible Health Effects in the Aftermath of Hurricanes Katrina and Rita*. U.S. Centers for Disease Control and Prevention, October 2005;
www.bt.cdc.gov/disasters/mold/report/pdf/2005_moldreport.pdf.

Davis, Pamela J. *Molds, Toxic Molds, and Indoor Air Quality*. Sacramento: California Research Bureau, California State Library, 2001;
www.library.ca.gov/crb/01/notes/v8n1.pdf.

Macher, Janet, editor. *Bioaerosols: Assessment and Control*. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1999. This frequently cited work encompasses a wide range of information on bioaerosols and their assessment and control. The book includes an extensive list (pp. xi-xvii) of

abbreviations, acronyms, units, and Latin names encountered in scientific books, articles, and reports in the field.

U.S. Environmental Protection Administration. IAQ Tools for Schools Kit - IAQ Coordinator's Guide, Appendix E - Typical Indoor Air Pollutants, www.epa.gov/iaq/schools/tfs/guidee.html. Concise guide to common indoor pollutants, summarizing description, sources, standards and guidelines, health effects, and control measures for each.

Fungi/Mold

American Industrial Hygiene Association. "The Facts about Mold," www.aiha.org/content/accessinfo/consumer/factsaboutmold.htm.

Burge, Harriet A., and James A. Otten. "Fungi," chapter 19 of Janet Macher, editor. *Bioaerosols: Assessment and Control* (Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1999).

Levetin, Estelle. "Fungi," chapter 5 (pp. 87-120) of Harriet A. Burge (ed.), *Bioaerosols* (Boca Raton, Florida: Lewis Publishers, 1995).

Money, Nicholas P. *Carpet Monsters and Killer Spores: A Natural History of Toxic Mold*. Oxford: Oxford University Press, 2004. Wry, readable, and wide-ranging discussion of molds, their biology, their health risks, and the legal disputes they have inspired, by a mycologist. The book is written for general readers, but it is well documented with references to scientific literature and includes a section of color illustrations.

Storey, Eileen, and others. *Guidance for Clinicians on the Recognition and Management of Health Effects Related to Mold Exposure and Moisture Indoors*. Farmington, Connecticut: University of Connecticut Health Center, 2004; <http://oehc.uchc.edu/clinser/MOLD%20GUIDE.pdf>. Chapter 3, "About Fungus and Mold."

U.S. Center for Disease Control and Prevention, National Center for Environmental Health, Air Pollution and Respiratory Health Branch, "Facts about Molds and Dampness," www.cdc.gov/nceh/airpollution/mold/mold_dampness_facts.htm. Also see related links at that site.

Health Effects

American College of Occupational and Environmental Medicine. *Adverse Human Health Effects Associated with Molds in the Indoor Environment*. ACOEM Evidence-based statement, October 27, 2002; www.acoem.org/guidelines/article.asp?ID=52.

Ammann, Harriet. "IAQ and Human Toxicosis: Empirical Evidence and Theory," in Eckardt Johannung, editor, *Bioaerosols, Fungi, and Mycotoxins: Health Effects*,

- Assessment, Prevention and Control* (Albany, N.Y.: Eastern New York Occupational & Environmental Health Center, ©2001), 84-93.
- Burge, Harriet. "Fungi: Toxic Killers or Unavoidable Nuisances?" *Annals of Allergy, Asthma & Immunology*, Vol. 87, No. 6, Supplement 1 (December 2001), 52-56.
- Curtis, Luke, and others. "Adverse Health Effects of Indoor Molds." *Journal of Nutritional & Environmental Medicine*, Vol. 14, No. 3 (September 2004), 261-274; www.coem.com/images/AdverseHealthEffectofIndoorMolds.pdf.
- Institute of Medicine (U.S.), Committee on Damp Indoor Spaces and Health. *Damp Indoor Spaces and Health*. Washington, D.C.: National Academies Press, 2004. Executive Summary (pages 1-16). An electronic version may be viewed at www.nap.edu/books/0309091934/html/. This report is significant because of its source and scope. Some of the findings are more cautiously phrased than suggested by the details in the text.
- Putus, Tuula. "Health Effects of Moisture Damage Associated Microbes," in Eckardt Johannig, editor, *Bioaerosols, Fungi, Bacteria, Mycotoxins and Human Health: Patho-physiology, Clinical Effects, Exposure Assessment, Prevention and Control in Indoor Environments and Work* (Albany, New York: Fungal Research Group Foundation, Inc., 2005), 94-107. Concise review with extensive bibliography.
- Storey, Eileen, and others. *Guidance for Clinicians on the Recognition and Management of Health Effects Related to Mold Exposure and Moisture Indoors*. Farmington, Connecticut: University of Connecticut Health Center, 2004; <http://oehc.uchc.edu/clinser/MOLD%20GUIDE.pdf>. "Appendix B: Health Effects; Reactions to Mycotoxins," is a concise, well documented overview. Also see Chapter 2, "Illustrative Clinical Experience," for brief case examples of mold-related illnesses.
- U.S. Chamber Institute for Legal Reform and the Center for Legal Policy at The Manhattan Institute (sponsors). *The Growing Hazard of Mold Litigation*. Includes (1) "A New Plague—Mold Litigation: How Junk Science and Hysteria Built an Industry," by Cliff Hutchinson and Robert Powell, and (2) "A Scientific View of the Health Effects of Mold," by Bryan D. Hardin and others. July 2003. These papers present a skeptical view of, and question evidence for, health effects of typical indoor exposure to mold. The entire document is available for download in pdf format at www.uschamber.com/publications/reports/030717_ilr_mold.htm.

Prevention

- Allen, Edward. *How Buildings Work: The Natural Order of Architecture*, Third Edition. NY: Oxford University Press, 2005. Chapter 12, "Keeping Water Out," 109-127.
- Building Science Corporation. "Drainage Planes and Air Spaces," www.buildingscience.com/resources/walls/drainage_planes.htm. "Joe's Top Ten," www.buildingscience.com/topTen/default.htm. "What's New,"

www.buildingscience.com/whatsnew.htm. “Technical Resources,”
www.buildingscience.com/resources/default.htm.

Building Science for Architects, Residential BuildBoston 2005, April 7, 2005, Betsy Pettit, AIA, Presentation,
www.buildingscience.com/resources/presentations/buildboston/default.htm.

Institute of Medicine (U.S.), Committee on Damp Indoor Spaces and Health. *Damp Indoor Spaces and Health*. Washington, D.C.: National Academies Press, 2004. Chapter 2, “Damp Buildings,” esp. pp. 29-41. An electronic version may be viewed at www.nap.edu/books/0309091934/html/.

Morey, Philip R. “Poor Building Design Leads to Fungal Growth.”
www.inspiredliving.com/airpurification/a~fungalgrowth.htm

U.S. Environmental Protection Agency and U.S. Department of Health and Human Services. *Building Air Quality: A Guide for Building Owners and Facility Managers*. Washington, D.C.: U.S. Government Printing Office, 1999. Appendix C, “Moisture, Mold, and Mildew.” Available in pdf format at www.cdc.gov/niosh/pdfs/appenc.pdf.

Remediation

American Industrial Hygiene Association. *Report of Microbial Growth Task Force*. Fairfax, Virginia: AIHA Press, 2001.

Canadian Mortgage and Housing Corporation. “Fighting Mold: The Homeowner’s Guide,” www.cmhc-schl.gc.ca/en/burema/gesein/abhose/abhose_ce08.cfm.

California Department of Health Services. “Indoor Air Quality Info Sheet, Mold in My Home: What Do I Do?,” Revised June 2004;
www.dhs.ca.gov/ps/deodc/ehlb/iaq/Mold/MIMH_2004-06.htm.

Institute of Inspection, Cleaning and Restoration Certification (IICRC). *IICRC S500 Standard and Reference Guide for Professional Water Damage Restoration*, Second Edition. Vancouver, Washington: IICRC, 1999.

Institute of Inspection, Cleaning and Restoration Certification (IICRC). *IICRC S520 Standard and Reference Guide for Professional Mold Remediation*, First Edition. Vancouver, Washington: IICRC, 2003.

Lstiburek, Joseph; Nathan Yost; Terry Brennan. “Mold: Causes, Health Effects and Clean-Up.” Building Sciences Corporation, 2002;
www.buildingscience.com/resources/mold/mold_causes.pdf. Brisk summary.

New York City Department of Health and Mental Hygiene. “Guidelines on Assessment and Remediation of Fungi in Indoor Environments,”
www.nyc.gov/html/doh/html/epi/moldrpt1.shtml. Widely cited.

Texas Department of Health. "Review of Practices for Mold Remediation," April 2002, www.tdh.state.tx.us/beh/iaq/Mold_Rem3.htm. This report summarizes and compares recommendation from several sources.

U.S. Environmental Protection Administration. *A Brief Guide to Mold, Moisture, and Your Home*. Washington, D.C.: EPA, 2003; www.epa.gov/mold/images/moldguide.pdf.

U.S. Environmental Protection Administration. *Mold Remediation in Schools and Commercial Buildings*. Washington, D.C.: EPA, 2001; www.epa.gov/iaq/molds/mold_remediation.html.

Hazard Communication

California Department of Health Services and California Department of Industrial Relations. "Molds in Indoor Workplaces" (flier). March 2001; www.dhs.ca.gov/ohb/HESIS/molds.pdf.

New York City Department of Health and Mental Hygiene. *Guidelines on Assessment and Remediation of Fungi in Indoor Environments*—section on hazard communication. Available at www.nyc.gov/html/doh/html/epi/moldrpt1.shtml.

U.S. Department of Labor, Occupational Health and Safety Administration. OSHA Fact Sheet, "Fungi Hazards and Flood Cleanup," www.osha.gov/OshDoc/data/Hurricane_Facts/Bulletin3.pdf.

B. ADDITIONAL RESOURCES

Following are selected specialized or technical works, standards, and websites of organizations relating to mold and its effects and remediation or providing background. Notes and references in these works and available through the websites lead to thousands of additional reports and studies. These items supplement those listed above.

Books, Reports, and Articles

Benjamini, Eli; Geoffrey Sunshine; Sidney Leskowitz. *Immunology: A Short Course*, Third Edition. New York: Wiley-Liss, 1996.

Bennett, J. W., and M. Klich. "Mycotoxins." *Clinical Microbiology Review*, July 2003, 497-516; <http://cmr.asm.org/cgi/content/full/16/3/497>. Detailed overview of several categories of mycotoxin. (Emphasis is on ingestion rather than inhalation as route of entry.)

Environmental Health Perspectives Supplements, Volume 107, Number S3, June 1999: "Children's Environmental Health and Disease Prevention Research: Indoor Mold and Children's Health." Series of monographs; <http://ehp.niehs.nih.gov/docs/1999/suppl-3/toc.html>.

Fung, Frederick, and Richard F. Clark. "Health Effects of Mycotoxins: A Toxicological Overview." *Journal of Toxicology*, Vol. 42., No. 2, 217-234 (2004).

[Health Canada.] *Fungal Contamination in Public Buildings: Health Effects and Investigation Methods*. [Ottawa, Ontario, Canada]: Health Canada, 2004; www.hc-sc.gc.ca/ewh-semt/pubs/air/fungal-fongique/index_e.html.

[Health Canada.] *Indoor Air Quality in Office Buildings: A Technical Guide*, section 5.2.8, "Microbials." Ottawa, Ontario, Canada: Health Canada, revised 1995; www.hc-sc.gc.ca/ewh-semt/pubs/air/office_building-immeubles_bureaux/microbials-microbes_e.html.

[Health Canada.] Federal-Provincial Committee on Environmental and Occupational Health. *Fungal Contamination in Public Buildings: A Guide to Recognition and Management*. Ottawa, Ontario, Canada: Health Canada, 1995; www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/air/tools_school-outils_ecoles/fungal-guide-mgmt-fongique_e.pdf. This report includes a helpful glossary. Appendix D, an introduction to mold sampling methodology, outlines the complexities of sampling.

Health Effects Institute. "Understanding the Health Effects of Components of the Particulate Matter Mix: Progress and Next Steps." *HEI Perspectives*, April 2002, www.healtheffects.org/Pubs/Perspectives-2.pdf.

Institute of Medicine (U.S.), Committee on Damp Indoor Spaces and Health. *Damp Indoor Spaces and Health*. Washington, D.C.: National Academies Press, 2004. An electronic version may be viewed at www.nap.edu/books/0309091934/html/. This work is significant because of both its source and its scope. Readers should consider the chapter-by-chapter findings in context of the text of the respective chapters, as the findings tend to be cautiously phrased and may, in some cases, understate relationships suggested by the full text.

Institute of Medicine (U.S.). Committee on the Assessment of Asthma and Indoor Air. *Clearing the Air: Asthma and Indoor Air Exposures*. Washington, D.C.: National Academy Press, 2000. An electronic version may be viewed at www.nap.edu/openbook/0309064961/html/.

Johanning, Eckardt, editor. *Bioaerosols, Fungi, and Mycotoxins: Health Effects, Assessment, Prevention and Control*. Albany, N.Y.: Eastern New York Occupational & Environmental Health Center, c2001. Proceedings of the Third International Conference on Fungi, Mycotoxins and Bioaerosols, September 23-25, 1998, Saratoga Springs, NY.

Johanning, Eckardt, editor. *Bioaerosols, Fungi, Bacteria, Mycotoxins and Human Health: Patho-physiology, Clinical Effects, Exposure Assessment, Prevention and Control in Indoor Environments and Work*. Albany, New York: Fungal Research Group Foundation, Inc., 2005. Proceedings of the Fifth International Scientific Conference on Bioaerosols in Indoor and Work Environments. This volume, like

its predecessor from the 1998 conference (above), encompasses a wide range of peer-reviewed and well documented reports. Topics include health effects, assessment, reports from transitional countries, remediation, and prevention and control.

- Kendrick, Bryce. *The Fifth Kingdom*, Third Edition. Newburyport, MA: Focus Publishing, R. Pullins Co., 2000. Fungi and their ecological and economic roles.
- Kuhn, D. M., and M. A. Ghannoum. "Indoor Mold, Toxigenic Fungi, and *Stachybotrys chartarum*: Infectious Disease Perspective." *Clinical Microbiology Reviews*, Jan. 2003, 144-172; <http://cmr.asm.org/cgi/content/full/16/1/144>.
- Mold Medicine & Mold Science: Its Practical Applications for Patient Care, Remediation & Claims, May 13-14, 2002, Georgetown University Convention Center, Washington, D.C. Conference sponsored by International Center for Toxicology and Medicine (ICTM) and the Department of Pharmacology at Georgetown University. Conference materials are posted at <http://phys4.harvard.edu/~wilson/soundscience/mold/mold.html>.
- Nielsen, Kristian Fog. "Mycotoxin Production by Indoor Molds." *Fungal Genetics and Biology*, 38 (2003), 103-117; <http://tinyurl.com/ca88r>*. Summary of molds found indoors, water activity levels that promote the growth of each and that promote production of mycotoxins, and analytical methods and issues.
- Pope, Andrew M.; Roy Patterson; and Harriet Burge, editors. *Indoor Allergens: Assessing and Controlling Adverse Health Effects*. Washington, D.C.: The National Academy Press, 1993. An electronic version may be viewed at <http://books.nap.edu/books/0309048311/html/>. See especially pages 108-111, on fungi as microbial allergens.
- Terr, Abba I. "Stachybotrys: Relevance to Human Disease." *Annals of Allergy, Asthma & Immunology*, Vol. 87, 57-63 (December 2001).
- Newport Partners, LLC, *Building Moisture and Durability: Past, Present and Future Work* (Washington, D.C.: U.S. Department of Housing and Urban Development, 2004). This report includes an extensive review of literature on moisture and building durability, a review of ongoing research, and an introductory overview. This may be the single most useful starting point for inquiry. The report is available via www.huduser.org/publications/destech/MoistDurability.html.
- World Health Organization. *Assessment of Exposure to Indoor Air Pollutants*. WHO Regional Publications. European Series, No. 78. Copenhagen: World Health Organization, Regional Office for Europe, 1997; www.euro.who.int/eprise/main/WHO/InformationSources/Publications/Catalogue

* The "tinyurl" redirects the user to the full URL (Web page address).

[/20040906_1](#). “Biological Contaminants” (including fungi and bacteria) are addressed on pages 99-111.

Standards

California Department of Industrial Relations. *Guide to the California Hazard Communication Regulation*. [Sacramento]: California Department of Industrial Relations, 2000; www.dir.ca.gov/dosh/dosh_publications/hazcom.pdf. This guide includes information that can be adapted to communications about mold hazards affecting workers.

Institute of Inspection, Cleaning and Restoration Certification (IICRC). *IICRC Standard and Reference Guide for Professional Mold Remediation S520*, First Edition. Vancouver, Washington: IICRC, 2003. Widely cited standards and detailed guidance. Note that Chapter 2 (pp.40-51) addresses “Health Effects from Indoor Mold Contamination.”

International Society of Indoor Air Quality and Climate (ISIAQ). *Control of Moisture Problems Affecting Biological Indoor Air Quality*. [Espoo, Finland]: ISIAQ, 1996. (Not reviewed in the preparation of this report, but frequently cited. For more information, see www.ie.dtu.dk/isiaq/publications.asp?Menu=Publications&FileName=TFI1996.txt&PubType=Other&ID=TFI1996.)

U.S. Environmental Protection Agency and U.S. Department of Health and Human Services. *Building Air Quality: A Guide for Building Owners and Facility Managers*. Washington, D.C.: U.S. Government Printing Office, 1999. Available in pdf format at www.cdc.gov/niosh/pdfs/iaq.pdf.

Agencies and Organizations

California Indoor Air Quality Program, www.cal-iaq.org/.

Doctor Fungus, www.doctorfungus.org/thefungi/index.htm. Website devoted to information on fungi, including descriptions, illustrations, and commentary. Sponsored by pharmaceutical companies.

Indoor Air Quality Association, www.iaqa.com/.

Institute of Inspection, Cleaning and Restoration Certification, www.iicrc.org/.

Rhode Island Department of Health. Office of Environmental Risk Assessment. Indoor Air Quality. Mold, Mildew, Fungus & Other Indoor Air Quality Problems [directory of resources], www.health.ri.gov/environment/risk/mold_indoor.php. Includes links to information on special topics as well as to more general information.

Texas Department of State Health Services, Links to Web Sites about Mold Growth in Buildings, www.tdh.state.tx.us/beh/iaq/MoldLinks.htm. Also see Texas Mold Assessment and Remediation Rules, www.tdh.state.tx.us/beh/mold/.

U.S. Environmental Protection Agency. Asthma and Indoor Environments, www.epa.gov/iaq/asthma/molds.html.

U.S. Environmental Protection Agency. Indoor Air — Mold, www.epa.gov/iaq/molds/. Also: Mold Resources, www.epa.gov/iaq/molds/moldresources.html.

U.S. National Library of Medicine. Medline Plus, mold information, www.nlm.nih.gov/medlineplus/molds.html.

Assembly Bill 284

(Chapter 550, Statutes of 2001)

Following are the pertinent portions of Assembly Bill 284 (Chapter 550, Statutes of 2001), authorizing this report and outlining its scope.

FUNGAL CONTAMINATION REVIEW PANEL AND RESEARCH PROGRAM

SECTION 1. The Legislature finds and declares all of the following:

- (a) The problem of indoor air pollution has generated concern among the scientific and public health communities around the world.
- (b) Bioaerosols, airborne particles emitted by fungi and bacteria, are among the more than 1,500 indoor air pollutants that pose potential hazards to public health.
- (c) The occurrence of adverse health effects on humans from fungi can range from relatively minor symptoms, such as headache, sore throat, and fatigue, to more serious effects.
- (d) While the inhalation of fungal spores is believed to contribute to allergic reactions, infections, and other adverse health effects, there is also considerable debate about practical options for the prevention and control of fungi in indoor environments.
- (e) Because fungi are ubiquitous in indoor environments, the control of fungi poses a special difficulty for homeowners, building owners, tenants, and public health officers.
- (f) Therefore, the State of California needs to promote a more thorough understanding of the options for addressing fungal contamination within the context of a wide array of indoor air pollutants that are frequently inadequately understood.
- (g) By convening a review panel of experts to examine potential hazards, their prevention, and their remediation, the state can provide guidance to a growing public concern about options for avoiding and remediating problems posed by fungal contamination.

SEC. 2. Chapter 19 (commencing with Section 26200) is added to Division 20 of the Health and Safety Code, to read:

26200. (a) The California Research Bureau, in consultation with the State Department of Health Services, shall perform a study and publish findings on fungal contamination affecting indoor environments, in accordance with this chapter.

(b) The California Research Bureau shall organize meetings of a review panel to assist in the preparation of appropriate content for the study.

(c) The California Research Bureau shall appoint to the review panel a diverse group of professionals including, but not limited to, representatives of the following:

- (1) Health officers.
- (2) Environmental health directors.
- (3) Experts on the health effects of fungi.
- (4) Medical experts.
- (5) Mold testing experts.
- (6) Industrial hygienists.
- (7) Engineers.

26201. The review panel shall examine the following areas relating to fungal contamination in indoor environments:

- (a) Medical and public health.
- (b) Evaluation and monitoring.
- (c) Remediation and prevention.
- (d) Educational materials.
- (e) Hazard communication.
- (f) Any other area identified by the review panel.

26202. The panel shall review and, to the extent resources and expertise permit, make findings on all of the following:

- (a) The health effects of exposure to fungi, based on a review of the literature addressing immunology, infectious disease, and medical evaluation.
- (b) The practices for assessing fungal contamination, including the use of visual inspection, surface sampling, air monitoring, and the proper analysis of environmental samples.
- (c) To the extent feasible, the appropriateness of commercially available methods for identifying fungal contamination of building components including, but not limited to, walls, ventilation systems, and support beams.
- (d) The options for preventing and remediating fungal contamination in indoor environments. The findings are intended as a practical guide regarding options for building managers, homeowners, and members of the general public who may have concerns about fungal contamination in living and working environments.
- (e) Recommendations on hazard communication for distinct subpopulations, including workers employed in high-risk occupations.
- (f) The development of a recommended reading list related to molds, their health effects, their impacts on indoor air quality, and related topics for local government officials, including environmental health officers.

(g) Any additional topical areas deemed appropriate by the review panel.

26203. (a) By January 1, 2003, the California Research Bureau shall submit to the Legislature and the Director of Health Services the published findings of the study.

(b) (1) The findings may provide relevant information to the State Department of Health Services for the purpose of establishing standards and guidelines on fungal contamination affecting indoor environments pursuant to Chapter 18 (commencing with Section 26100).

(2) This subdivision may serve as a source of information for department programs relating to fungal contamination, including those provisions that become operative if Senate Bill 732 is enacted and adds Chapter 18 (commencing with Section 26100).*

* S.B. 732 was enacted as Chapter 584, Statutes of 2001.

Review Panel Members

This report is not a consensus document. Approval of its contents by any panel member should not be inferred, nor should approval by the organizations with which the panel members are associated. Panel members are not responsible for any conclusions or opinions expressed other than direct, explicit quotation from their published work or explicitly attributed comments included in the report.

The California Research Bureau thanks the following individuals who, as the AB 284 Review Panel, have provided advice and comment during the research for and preparation of this report.

Those marked with an asterisk (*) commented specifically on the draft of this report. To the extent feasible, their comments have been reflected in this version of the report.

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Research for this report, development of the list of review panel members, and consultation with panel members was done by Pamela Davis. The report was written by Ken Umbach, drawing from the accumulated research resources, from additional published sources, and from conversations with and comments by the panel members.

The authors wish to thank Jim Holland for allowing them to audit mold remediation training provided by Restoration Consultants.

Thanks also to Kathy Low, Patricia de Cos, and Charlene Simmons, all of the California State Library, for comments on a draft of this report.

Finally, thanks to Pat Kinnard, Brian Cote and Ivy Branaman for proofing and preparing this report for publication.

Notes

Citation of a source does not necessarily imply that the California Research Bureau agrees with the entire content of the cited document or endorses the site.

Mention of businesses or commercial products or services, whether in the text or in the notes, should not be taken as endorsement.

“Accessed on” dates are generally omitted, as most of the cited sources are considered to be stable. Where access dates are not provided below, it may be assumed that the items were accessed on one or more dates during July to November, 2005.

¹ Philip Morey, in comment on draft of this report, January 5, 2006.

² For a discussion of the Cleveland cases and references to related studies, see Institute of Medicine (U.S.), Committee on Damp Indoor Spaces and Health, *Damp Indoor Spaces and Health* (Washington, D.C.: The National Academies Press, 2004), especially pp. 238-243 and 146-149. Also see *MMWR Weekly*, March 10, 2000, “Update: Pulmonary Hemorrhage/Hemosiderosis Among Infants -- Cleveland, Ohio, 1993-1996,” www.cdc.gov/mmwr/preview/mmwrhtml/mm4909a3.htm.

³ Dorr G. Dearborn and others, Pulmonary Hemorrhage and Hemosiderosis in Infants,” <http://gcrc.meds.cwru.edu/stachy/default.htm> (Case Western Reserve University).

⁴ For Ms. Brockovich’s testimony, see California Senate Committee on Health and Human Services, *Public Health Effects of Toxic Mold: Informational Hearing of the Senate Committee on Health and Human Services* (Sacramento: the Committee, [2001]). For a summary of Mr. McMahon’s cases, see *Los Angeles Business Journal*, “McMahon mold suit settlement reaches \$7M,” May 7, 2003, www.bizjournals.com/losangeles/stories/2003/05/05/daily48.html.

⁵ For one summary of the kingdoms of life, see Wayne’s World, “The Five Kingdoms of Life,” <http://waynesword.palomar.edu/trfeb98.htm>. For a thorough study of fungi, see Bryce Kendrick, *The Fifth Kingdom*, Third Edition (Newburyport, Massachusetts: Focus Publishing, 2000). Kendrick states, “organisms are now divided up among no fewer than **seven** kingdoms.” (Page 1, emphasis in original.)

⁶ Peter Landers, “How One Scientist Intrigued by Molds Found First Statin,” *Wall Street Journal*, January 9, 2006, A1.

⁷ New York City Department of Health and Mental Hygiene, “Facts about Mold,” www.nyc.gov/html/doh/html/epi/epimold.shtml.

⁸ Chin Yang, in comment on draft of this report, January 6, 2006.

⁹ *Damp Indoor Spaces and Health*, 10-11. For a thorough exploration of the issue, see Institute of Medicine (U.S.), Committee on the Assessment of Asthma and Indoor Air, *Clearing the Air: Asthma and Indoor Air Exposures* (Washington, D.C.: National Academy Press, 2000), and Andrew M. Pope, Roy Patterson, and Harriet Burge, editors, *Indoor Allergens: Assessing and Controlling Adverse Health Effects* (Washington, D.C.: The National Academy Press, 1993.)

¹⁰ American College of Occupational and Environmental Medicine (ACOEM), *Adverse Human Health Effects Associated with Molds in the Indoor Environment*, ACOEM Evidence-based

statement, October 27, 2002; www.acoem.org/guidelines/article.asp?ID=52. Some experts believe that the ACOEM statement understates risks and effects. We have quoted it here as part of the diverse range of views on the subject. In a personal communication commenting on draft of this report (December 19, 2005), Dr. Yang cited, as conflicting with the quoted paragraph, M. Sure, and others, "Sensitization of Airborne Moulds and Severity of Asthma: Cross Sectional Study from European Community Respiratory Health Survey," *BMJ* 325, (7362): 4240414. For abstract, see

www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=12193354&dopt=Citation. In part: "CONCLUSIONS: Sensitisation to moulds is a powerful risk factor for severe asthma in adults. This should be taken into account in primary prevention, management, and patients' education."

¹¹ ACOEM, *Adverse Human Health Effects*.

¹² ACOEM, *Adverse Human Health Effects*.

¹³ *Damp Indoor Spaces and Health*, 148.

¹⁴ Andrew M. Pope, Roy Patterson, and Harriet Burge, editors, Institute of Medicine (U.S.), Committee on the Health Effects of Indoor Allergens, *Indoor Allergens: Assessing and Controlling Adverse Health Effects* (Washington, D.C.: National Academy Press, 1993), 110.

¹⁵ *Damp Indoor Spaces and Health*, 91.

¹⁶ Andrew M. Pope, Roy Patterson, and Harriet Burge, editors, *Indoor Allergens: Assessing and Controlling Adverse Health Effects* (Washington, D.C.: National Academy Press, 1993), 108.

¹⁷ *Damp Indoor Spaces and Health*, 67-68. Notwithstanding the quoted observation and extensive discussion within the text of the report of published literature on the subject, the IOM committee's report's findings took a very cautious stance as to sufficiency of evidence for mold-related allergic illness. However, the committee did recognize the potential for synergistic effects among characteristics of environments conducive to mold growth (pp. 254-5). The committee also noted "gaps in scientific knowledge" related to the issue (p. 255). The committee's apparent hesitancy in its findings might reflect the findings' being put in terms of relationship between symptoms and "Presence of Mold or Other Agents [emphasis added]," not *exposure* or *inhalation*. Key to what may seem to be contradictions between text and findings may be the difficulty of proving and quantifying direct exposure to and inhalation of spores and fragments. No current techniques of sampling air or surfaces in an indoor environment can quantify actual, individual, direct exposure to specific mold products, so the committee's findings reflect the limited conclusions that can be drawn from uncertain and incomplete information, especially as that information lacks dose-response measures.

¹⁸ For a summary of farmer's lung, see for example Canadian Center for Occupational Health and Safety, "Farmer's Lung," www.ccohs.ca/oshanswers/diseases/farmers_lung.html; in part: "Farmer's Lung is an allergic disease usually caused by breathing in the dust from moldy hay. However, dust from any moldy crop--straw, corn, silage, grain, or even tobacco--can also cause Farmer's Lung. The technical name for Farmer's Lung is 'extrinsic allergic alveolitis,' 'hypersensitivity alveolitis' or more generally 'hypersensitivity pneumonitis.'" The likelihood of this disease in a moldy non-agricultural indoor environment may be remote, but cannot be excluded where contamination is severe. See Sandra V. McNeel and Richard A. Kreutzer, "Fungi

& Indoor Air Quality,” www.dhs.ca.gov/ps/deodc/ehib/EHIB2/topics/fungi_indoor.html (from *Health & Environment Digest*, Vol. 10, No. 2, pages 9-12, May/June 1996).

¹⁹ *Damp Indoor Spaces and Health*, 254. For the full discussion, see chapter 5 of that report, pages 183-269. The reference list alone for that chapter, “Human Health Effects Associated with Damp Indoor Environments,” fills 14 pages of small print.

²⁰ Glucans, in turn, are a subset of a larger class of cellular molecules called “glycans.” *The Encyclopedia of Molecular Biology* (Blackwell Science, 1998; paperback edition), various entries.

²¹ Chin Yang, in comment on draft of this report, December 19, 2005.

²² “What is Asthma?,” www.nhlbi.nih.gov/health/dci/Diseases/Asthma/Asthma_WhatIs.html.

²³ Institute of Medicine (U.S.), Committee on the Assessment of Asthma and Indoor Air, *Clearing the Air: Asthma and Indoor Air Exposures* (Washington, D.C.: National Academy Press, 2000), 398.

²⁴ *Clearing the Air*, 298.

²⁵ *Damp Indoor Spaces and Health*, 254.

²⁶ See National Foundation for Infectious Diseases, “Fungal Infections in Immunocompromised Hosts: Focus on Epidemiologic Aspects of Infection,” *Clinical Updates Fungal Infections*, Volume 1, Issue 4 (February 1998), www.nfid.org/publications/clinicalupdates/fungal/fungal.html. Of related interest, “Most systemic fungal infections are acquired through the respiratory route, then the organism moves to extrapulmonary sites in the body. Frequently the organisms localize in certain tissues where they remain until cleared by the host.” The Fourth NIAID Workshop in Medical Mycology: Host Responses to Fungi, Mucosal and Lung Resistance in Infectious Disease, www.niaid.nih.gov/dmid/meetings/mycology97/resistance.htm, last updated September 25, 2003. In other words, the most common route of entry is via the lungs, with the infection normally cleared by the body’s immune mechanisms in the sites to which the infection has moved.

²⁷ For a discussion of aspergillosis, see Health A to Z, “Aspergillosis,” www.healthatoz.com/healthatoz/Atoz/ency/aspergillosis.jsp; also, from the National Institute of Health’s Medline, www.nlm.nih.gov/medlineplus/ency/article/001326.htm.

²⁸ According to Dr. Chin Yang (in comment on draft of this report, December 29, 2005), *A. fumigatus* “seldom actually grows in indoor environments but it is common in outdoor air in the fall and accumulates indoors. There is text on this in the most recent edition of the AIHA Field Guide.”

²⁹ Of related interest, see the “Hyphal Interactions” section of “Competition between Fungi,” in the “Introduction to Fungal Biology” of the University of Sydney, Australia, <http://bugs.bio.usyd.edu.au/Mycology/Ecology/competition.shtml>. In part: “Several fungi have been found to produce a range of antibiotics, each produced under specific conditions. The specific action in nature of the diverse array of molecules is unclear in most cases, though their action can be understood in anthropogenic terms. For instance, soil fungi such as *Trichoderma*, *Penicillium* and *Aspergillus* produce a diverse range of antibiotics. Penicillic acid is an antibacterial. Aflatoxins have mammalian toxicity. Trichodermin may have broad antifungal activity. However, many compounds appear to have such broad potential activity that their role in

the survival of the producer is unclear. Some disrupt DNA and protein synthesis, others disrupt ribosomal activity or the cytoskeleton, making them extremely broad and general toxins. Frequently, a fungus known to produce one important secondary metabolite with bioactivity, will have a diverse array of secondary metabolites with unknown activity and benefit to the producer.” Also: “Tricothecenes and the other toxins are examples of secondary metabolites . . . Tricothecenes are highly toxic compounds, and it would seem reasonable to suggest that *Stachybotrys* and its friends make them to poison other organisms . . .” Nicholas P. Money, *Carpet Monsters and Killer Spores: A Natural History of Toxic Mold*, (NY: Oxford University Press, 2004), 69.

³⁰ Harriet M. Ammann, “Mold Toxicity: Risk Assessment for Humans Exposed Indoors,” in Eckardt Johanning, editor. *Bioaerosols, Fungi, Bacteria, Mycotoxins and Human Health: Pathophysiology, Clinical Effects, Exposure Assessment, Prevention and Control in Indoor Environments and Work* (Albany, New York: Fungal Research Group Foundation, Inc., 2005), 54.

³¹ Nicholas P. Money, *Carpet Monsters and Killer Spores: A Natural History of Toxic Mold*, (NY: Oxford University Press, 2004), 138-39 (in an endnote). Money is a mycologist and author of a previous book on mycology and mycologists.

³² For example: Frederick Fung and Richard F. Clark, “Health Effects of Mycotoxins: A Toxicological Overview,” *Journal of Toxicology*, Vol. 42, No. 2 (2004), 217-234; Harriet A. Burge, “Fungi: Toxic Killers or Unavoidable Nuisances?” *Annals of Allergy, Asthma, & Immunology*, Vol. 87 (December 2001), 52-56.

³³ For example, James Craner and Linda D. Stetzenbach, “Diagnosing the Cause of a ‘Sick Building’: A Case Study of an Epidemiological and Microbiological Investigation,” in Eckardt Johanning, editor, *Bioaerosols, Fungi, and Mycotoxins: Health Effects, Assessment, Prevention and Control* (Albany, N.Y.: Eastern New York Occupational & Environmental Health Center, c2001), 158-165 ; James Craner, Stuart Alderman, and Neil Willits, “Epidemiological Investigation of a Mold-Contaminated ‘Sick’ Building,” in Eckardt Johanning, editor, *Bioaerosols, Fungi, Bacteria, Mycotoxins and Human Health: Pathophysiology, Clinical Effects, Exposure Assessment, Prevention and Control in Indoor Environments and Work* (Albany, New York: Fungal Research Group Foundation, Inc., 2005) 132-139.

³⁴ U.S. Office of the Surgeon General, Department of the Army, *Textbook of Military Medicine: Medical Aspects of Chemical and Biological Warfare*, Chapter 34: “Tricothecene Mycotoxins,” by Robert W. Wannemacher and Stanley L. Wiener; www.bordeninstitute.army.mil/cwbw/Ch34.pdf. T-2, a tricothecene mycotoxin, has been among the mycotoxins proposed as biowarfare weapons and has been described as more potent than mustard gas, a chemical weapon used by the Germans during World War I. For a brief article on mustard gas, see the *Columbia Encyclopedia* article at www.encyclopedia.com/html/m/mustardg.asp. For a brief background on T-2, see Factsheets on Chemical and Biological Warfare Agents, CBWInfo.com, www.cbwinfo.com/Biological/Toxins/T2.html. From the latter, “T-2 and most of the other tricothecene mycotoxins considered for use as weapons act by inhibiting protein synthesis. They do this by reacting with components of the ribosomes: the structure within the cell where proteins are made. The specific site of action of T-2, which is a reaction with a critical site on the ribosomal RNA (rRNA) is known. . . . Tricothecenes are different from most other potential weapons toxins because they can act through the skin. . . . Tricothecenes are actually very

effective blister agents. The minimal dose of T-2 toxin required to produce skin injury is about 400-fold lower than it is for mustard. Blistering and eye damage are likely well below exposure to a lethal dose. Inhalation toxicity is comparable to that of mustard or Lewisite [a poison gas blistering agent].” For more information, see the Textbook of Military Medicine, Chapter 34.

³⁵ See, for example, Harriet M. Ammann, “IAQ and Human Toxicosis: Empirical Evidence and Theory,” in Eckardt Johannning, editor, *Bioaerosols, Fungi, and Mycotoxins: Health Effects, Assessment, Prevention and Control* (Albany, N.Y.: Eastern New York Occupational & Environmental Health Center, ©2001), 84-93; at p. 86, citing Jarvis, et al. (1995).

³⁶ See *Damp Indoor Spaces and Health*, 234: “Although it has been referred to as pulmonary mycotoxicosis . . . , the relevant exposure is a complex mixture of bacteria, fungi, their byproducts, and other contaminants; the components responsible for the syndrome are not known”

³⁷ The question of whether health effects result from indoor exposure to mycotoxins is controversial, as stated in the text and in notes above. The conclusion in the present report that such effects are *at least* plausible reflects, for example (in addition to sources already cited), Luke Curtis, and others: “There is an accumulated weight of evidence linking indoor airborne mold and/or mycotoxin exposures to multisystem adverse human health effects. “Adverse Health Effects of Indoor Molds,” *Journal of Nutritional & Environmental Medicine*, Vol. 14, No. 3 (September 2004).

Also see Chapter 4 of *Damp Indoor Spaces and Health*, among the findings of which is this (not *specific* to mycotoxins): “In vitro and vivo studies have demonstrated adverse effects—including immunotoxic, neurologic, respiratory, and dermal responses—after exposure to specific toxins, bacteria, molds, or their byproducts.” The finding that follows that one is stated with more reserve than is reflective of the body of the chapter: “In vitro and in vivo research on *Stachybotrys chartarum* suggests that effects in humans may be biologically plausible; these observations require validation from more extensive research before conclusions can be drawn.” (P. 170.) It is not clear whether editorial caution led to the tentative view in that finding, as plausibility does appear to have been established through the studies and findings cited in that chapter. Because water-damaged indoor environments exhibit not only mold and mold products (spores, mycelial fragments, cell wall components, and mycotoxins adsorbed to other particles) but also microbial volatile organic compounds (MVOCs), bacteria, dust mites and their products, possibly other insect infestations and their products, and possibly particulate matter resulting from decomposition of substrates, it may be that human health effects (and animal health effects) may reflect the combined exposures, possibly over an extended period and possibly with intermittently high concentrations, including complex synergistic interactions among airborne contaminants that cannot be attributed solely to any one factor, including mycotoxin(s). Further research is unquestionably appropriate to elucidate paths of action and the roles of specific factors or combinations of factors, but the general question of plausibility, at a minimum, appears settled. However, as mycotoxins produced by molds in water-damaged indoor environments are unavoidably accompanied by other particles (and possibly gasses), it may be futile to attempt to cite only *mycotoxins* in such environments as cause of health-related symptoms.

For a case review of related interest (and expanding on the brief discussion in this note), see James Craner, “Building-Related Illness in Occupants of Mold-Contaminated Houses: A Case Series,” in Eckardt Johannning, editor, *Bioaerosols, Fungi, and Mycotoxins: Health Effects, Assessment, Prevention and Control* (Albany, N.Y.: Eastern New York Occupational &

Environmental Health Center, c2001), 146-157. Craner proposes the term “non-infectious fungal indoor exposure syndrome” (NIFIES) for the effects of such combined exposure.

For an extensive contrasting view of the health effects of exposure to indoor mold, see U.S. Chamber Institute for Legal Reform and the Center for Legal Policy at The Manhattan Institute (sponsors) *The Growing Hazard of Mold Litigation*, which includes (1) “A New Plague—Mold Litigation: How Junk Science and Hysteria Built an Industry, by Cliff Hutchinson and Robert Powell, and (2) “A Scientific View of the Health Effects of Mold,” by Bryan D. Hardin and others; July 2003.

³⁸ See Joseph Q. Jarvis and Philip R. Morey, “Allergic Respiratory Disease and Fungal Remediation in a Building in a Subtropical Climate,” *Applied Occupational and Environmental Hygiene*, Vol. 16(3): 380-388 (2001). The reported case study included environmental and clinical follow-up with “[n]o new or recrudescant cases of illness . . . known to have occurred after building [remediation] and reentry.” The remediation cost \$45 million and took three years (Philip Morey, in comment on draft of this report, January 10, 2006).

³⁹ Joseph Lstiburek, Nathan Yost, and Terry Brennan, “Mold: Causes, Health Effects and Clean-Up” (Building Sciences Corporation, 2002), www.buildingscience.com/resources/mold/mold_causes.pdf. The Minnesota Department of Health is another source that cautions against testing: “The Minnesota Department of Health does not recommend testing for mold. Instead, you should simply assume there is a problem whenever you see mold or smell mold odors. Testing should never take the place of visual inspection and it should never use up resources that are needed to correct moisture problems and remove all visible growth.” “Mold in Homes,” www.health.state.mn.us/divs/eh/indoorair/mold/Home, accessed October 26, 2005. (The file location has since been changed to www.health.state.mn.us/divs/eh/indoorair/mold/index.html.) Mold testing kits are nonetheless for sale on the Internet. *Caveat emptor*.

⁴⁰ Canada Mortgage and Housing Corporation, “Fighting Mold — The Homeowners’ Guide,” undated, http://www.cmhc-schl.gc.ca/en/burema/gesein/abhose/abhose_ce08.cfm.

⁴¹ See Janet Macher, editor, *Bioaerosols: Assessment and Control* (Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1999).

AB 284 review panel member Philip Morey notes the following (in comment on draft of this report, January 5, 2006, quoted by permission):

“There are . . . valid reasons for carrying out air sampling for molds and other microbial agents (ACGIH, Chapter 5, 1999). These reasons include evaluation of indoor bioaerosols to determine if exposure is ‘normal’ or ‘problematic.’ Also indoor bioaerosol sampling has been used to document the presence of hidden microbial growth in building components (Miller et al., 2000; Morey et al., 2003). The investigator carrying out air sampling for molds must always understand the limitations on data interpretation associated with sampling and analytical methods (ACGIH chapters 5, 6, & 7, 1999). It should also be clearly understood that because of absence of TLVs® [Threshold Limit Values, ACGIH] and PELs [Permissible Exposure Limit, OSHA] for bioaerosols, sampling data alone cannot be used by itself to determine if adverse health effects have (are) occurred.

“Studies in one Southern California building showed that air sampling was useful in documenting that spores (mainly *Penicillium* species) from hidden mold growth were entering indoor air and

degrading IAQ [indoor air quality] (Morey et al. 2003). This study also showed that rooms with hidden mold growth were those rooms where extensive moisture damage was reported. Thus, the initial inspection for water damage is always of critical importance in locating hidden mold growth. Similar studies have been carried out in a Honolulu building (Miller et al. 2003).”

⁴² See the guidelines cited in the section on remediation.

⁴³ Janet Macher, editor, *Bioaerosols*, 1-1.

⁴⁴ For example, American Academy of Allergy, Asthma, & Immunology, NAB Pollen and Mold Counts, www.aaaai.org/nab/index.cfm?p=pollen.

⁴⁵ Harriet M. Ammann, “Mold Toxicity,” 54.

⁴⁶ See Janet Macher, editor, *Bioaerosols*, chapter 5.

⁴⁷ For one overview of methods, see George Morris, Maarit Kokki, and Malcolm Richardson, “Methods for Sampling *Aspergillus* Spores in Air,” September 1999, www.aspergillus.man.ac.uk/secure/articles/richard.htm. Also see Julie Buddemeyer, “Air Sampling 101,” *Food Quality*, undated article accessed September 26, 2005, www.foodquality.com/mag/06072005/fq_06072005_IL5.html. Also of value, Ling-Ling Hung, J. David Miller, and H. Kenneth Dillon, editors, *Field Guide for the Determination of Biological Contaminants in Environmental Samples*, 2nd edition (Fairfax, Virginia: American Industrial Hygiene Association, 2005).

⁴⁸ *Damp Indoor Spaces and Health*, 7. Further reading in related literature has found no challenge to that conclusion, nor has it found agreement on best practices for measuring indoor air mold contamination.

⁴⁹ Janet Macher, editor, *Bioaerosols*.

⁵⁰ Edward Light, in comment on draft of this report, January 6, 2006.

⁵¹ The case in question involved a Hawaiian building. P. R. Morey, M. C. Hull, M. Andrew, “El Niño Water Leaks Identify Rooms with Concealed Mould Growth and Degraded Indoor Air Quality,” *International Biodeterioration & Biodegradation* 52 (2003) 197-202.

⁵² See Janet Macher, editor, *Bioaerosols*, chapter 12.

⁵³ See Hung, Miller, and Dillon, *Field Guide*.

⁵⁴ American Industrial Hygiene Association, *Report of Microbial Growth Task Force* (Fairfax, Virginia: AIHA Press, 2001).

⁵⁵ IEQ, “Infrared Thermography,” www.germology.com/infrared.htm, accessed October 26, 2005.

⁵⁶ Institute of Inspection, Cleaning and Restoration Certification (IICRC), *IICRC Standard and Reference Guide for Professional Mold Remediation S520*, First Edition (Vancouver, Washington: IICRC, 2003), 109.

⁵⁷ U.S. Environmental Protection Agency, “Mold Remediation in Schools and Commercial Buildings,” www.epa.gov/mold/i-e-r.html.

⁵⁸ IICRC, *S520*, 109.

⁵⁹ See [Health Canada,] *Fungal Contamination in Public Buildings: Health Effects and Investigation Methods* ([Ottawa, Ontario, Canada]: Health Canada, 2004).

⁶⁰ However, see Janet Macher, editor, *Bioaerosols*, chapter 7, for limitations on data interpretation.

⁶¹ James Craner and Linda D. Stetzenbach, "Diagnosing the Cause of a 'Sick Building': A Case Study of an Epidemiological and Microbiological Investigation." In Eckardt Johanning, editor, *Bioaerosols, Fungi, and Mycotoxins: Health Effects, Assessment, Prevention and Control* (Albany, N.Y.: Eastern New York Occupational & Environmental Health Center, c2001), Proceedings of the Third International Conference on Fungi, Mycotoxins and Bioaerosols, September 23-25, 1998, Saratoga Springs, NY, pp.158-65.

⁶² See for example James Craner, Stuart Alderman, and Neil Willits, "Epidemiological Investigation of a Mold-Contaminated 'Sick' Building," Fifth International Conference on Fungi, Mycotoxins and Bioaerosols, September 10-12, 2003.

⁶³ Philip Morey, in comment on draft of this report, January 5, 2006. See www.environmental-expert.com/magazine/elsevier/ibiod/ for information on the journal.

⁶⁴ *Damp Indoor Spaces and Health*, 44.

⁶⁵ Edward Allen, *How Buildings Work: The Natural Order of Architecture*, Third Edition (NY: Oxford University Press, 2005), 109.

⁶⁶ Newport Partners, LLC, *Building Moisture and Durability: Past, Present and Future Work* (Washington, D.C.: U.S. Department of Housing and Urban Development, 2004), 5. Illustrating the complexity of the topic, the literature review portion of this report fills 70 pages, and the review of ongoing research fills another six. See www.huduser.org/publications/destech/MoistDurability.html for the report.

⁶⁷ See abstract of "Building Shrinkage and Microbial Damage: Plumbing Failures and Water Infiltration from Joint Failures," paper 104 of "Podium Session 114: Building Construction Mold Issues ('Don't Build Wet Buildings,'" www.aiha.org/abs05/po114.htm).

⁶⁸ Sources for this list include: Allen, *How Buildings Work*; Lew Harriman, "Preventing Mold through Better Design, Construction," *HPAC Engineering*, December 2003, 41-47; Joe Lstiburek, "Joe's Top Ten List of Dumb Things to do in the North," and "Joe's Top Ten List of Dumb Things to do in the South," posted at Building Science Corporation, www.buildingscience.com/topten/ (also see the Building Science Glossary at that site, www.buildingscience.com/resources/glossary.htm); Lew Harriman, "Preventing Mold Through Better Design, Construction," *HPAC Engineering*, December 2003. The "top ten" lists include several kinds of issues, including those related to moisture, and only touch on topics, but they will provoke thought. Also consulted, Joseph Lstiburek, "Moisture, Building Enclosures, and Mold," *HPAC Engineering*, December 2001 and January 2002 (two-part article).

⁶⁹ See photos on pages 41-43 of the Harriman article for illustrations of the point.

⁷⁰ For a brief explanation, see "About EIFS, Synthetic Stucco," http://homebuying.about.com/cs/syntheticstucco/a/eifs_facts_p.htm (accessed October 31, 2005). EIFS without a drainage plane is among Joe Lstiburek's "Dumb Things to Do" and is discussed as a water-damage cause in *How Buildings Work*, 122. See, for example, "Santa Clara County

gets \$12 Million settlement in EIFS case,” www.stuccolaw.com/news/santaclara.html (accessed October 31, 2005).

⁷¹ Appendix C of *Building Moisture and Durability* shows the range of such work actively underway in the public and private sectors.

⁷² Lew Harriman, “Preventing Mold Through Better Design, Construction, 47.

⁷³ For more information, see, for example, National Association of Home Builders Research Center, *Toolbase Technotes*, April 2002, “Helping your Buyers Understand Mold during the Building Process,”

www.toolbase.org/Docs/ToolBaseTop/Research/3464_HelpingHomebuyeresUnderstandMold.pdf.

⁷⁴ For summaries of some case studies, prepared for the American Industrial Hygiene Association, see “Podium Session 114: Building Construction Mold Issues (‘Don’t Build Wet Buildings’),” www.aiha.org/abs05/po114.htm. Also see: Foundation of the Wall and Ceiling Industry, *Preventing Losses from Moisture and Mold During Construction* (Itasca, Illinois: FWCI, 2003); Lewis G. Harriman III, “Preventing Mold by Keeping New Construction Dry,” *ASHRAE Journal*, September 2002, 28-34.

⁷⁵ Edward Light, in comment on draft of this report, January 1, 2006.

⁷⁶ See, for example, the California State Administrative Manual section on operational recovery planning, <http://sam.dgs.ca.gov/TOC/4800/4843.htm>. That document focuses on information technology (IT) issues, but the principles are more widely applicable.

⁷⁷ Lynn Andrews and Judith Whitehead, editors, *Fungal Contamination in Public Buildings: Health Effects and Investigation Methods* (published by authority of the [Canadian] Minister of Health [Health Canada], 2004); www.hc-sc.gc.ca/ewh-semt/pubs/air/fungal-fongique/index_e.html, in Section 3.2 (www.hc-sc.gc.ca/ewh-semt/pubs/air/fungal-fongique/principles-principes_e.html), footnote 7.

⁷⁸ California Department of Health Services, “Indoor Air Quality Info Sheet, Mold in My Home: What Do I Do?,” Revised June 2004; www.dhs.ca.gov/ps/deodc/ehlb/iaq/Mold/MIMH_2004-06.htm.

⁷⁹ The document, dated October 2005, is available in HTML and pdf formats via <http://texashelp.tamu.edu/001a-hot-topics/web-2005-sept/mold-after-floods-and-flooding.php>.

⁸⁰ U.S. Environmental Protection Administration, *A Brief Guide to Mold, Moisture, and Your Home* (Washington, D.C.: EPA, 2003); www.epa.gov/mold/images/moldguide.pdf.

⁸¹ Canada Mortgage and Housing Corporation, “Fighting Mold: The Homeowner’s Guide,” www.cmhc-schl.gc.ca/en/burema/gesein/abhose/abhose_ce08.cfm. Undated.

⁸² New York City Department of Health and Mental Hygiene, “Guidelines on Assessment and Remediation of Fungi in Indoor Environments” (cited below as “NYC guidelines”), www.nyc.gov/html/doh/html/epi/moldrpt1.shtml.

⁸³ [Health Canada.] Federal-Provincial Committee on Environmental and Occupational Health, *Fungal Contamination in Public Buildings: A Guide to Recognition and Management* (Ottawa, Ontario, Canada: Health Canada, 1995); www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/air/tools_school-outils_ecoles/fungal-guide-mgmt-fongique_e.pdf.

⁸⁴ U.S. Environmental Protection Administration, *Mold Remediation in Schools and Commercial Buildings* (Washington, D.C.: EPA, 2001; www.epa.gov/iaq/molds/mold_remediation.html).

⁸⁵ Institute of Inspection, Cleaning, and Restoration Certification, *IICRC S520 Standard and Reference Guide for Professional Mold Remediation*, First Edition (Vancouver, Washington: IICRC, 2003). It is available for purchase from IICRC.

⁸⁶ Posted at http://www-nehc.med.navy.mil/Downloads/IH/IHFOM/MR_wheel.pdf.

⁸⁷ National Clearinghouse for Worker Safety and Health Training, editor, *Guidelines for the Protection and Training of Workers Engaged in Maintenance and Remediation Work Associated with Mold*, May 20, 2005, available at www.wetp.org/wetp/newsbriefs/may05/Final_NIEHS_Mold_Guide_05-20-05.pdf.

⁸⁸ Adapted (quoted and paraphrased) from New York City Department of Health and Mental Hygiene, “Guidelines on Assessment and Remediation of Fungi in Indoor Environments.”

⁸⁹ NYC guidelines, section 3. For more information on this issue, the guidelines refer the reader to Janet Macher, editor, *Bioaerosols: Assessment and Control* (Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1999). That is a frequently cited volume.

⁹⁰ U.S. Occupational Safety and Health Administration (OSHA) information on workplace-related PPE is available at www.osha.gov/SLTC/personalprotectiveequipment/.

⁹¹ See U.S. Department of Health and Human Services, NIOSH [National Institute for Occupational Safety and Health] *GUIDE TO INDUSTRIAL RESPIRATORY PROTECTION*, September, 1987, DHHS (NIOSH) Publication No. 87-116, www.cdc.gov/niosh/87-116.html. Also see related information at www.cdc.gov/niosh/npptl/topics/respirators/.

⁹² For example, see Lowe’s list of respiratory equipment, www.lowes.com/lowes/lkn?action=productList&catalogId=B100740. Other hardware and home improvement stores also offer safety equipment in their stores and via their websites.

⁹³ One recent study suggests that a spray of sodium hypochlorite disinfectants, such as household bleach, kills *Aspergillus fumigatus* and may inhibit its allergens. John W. Martyny and others, “Aerosolized Sodium Hypochlorite Inhibits Viability and Allergenicity of Mold on Building Materials,” *Journal of Allergy and Clinical Immunology*, vol. 116, no. 3, 630-635.

⁹⁴ NYC Guidelines, section 3.

⁹⁵ According to Edward Light (in comment on draft of this report, January 6, 2006): “Encapsulation may be effective where the surface is dried and moisture is permanently controlled. For example, framing wood with minor mold growth can be wiped with a 10% bleach solution (killing surface mold), dried and then encapsulated.”

⁹⁶ California Contractors State Licensing Board, “Before You Begin,” www.cslb.ca.gov/consumers/beforehiring.asp.

⁹⁷ California Department of Health Services, “Indoor Air Quality Info Sheet, Mold in My Home: What Do I Do?”

⁹⁸ See California Department of Community Services and Development, Low-Income Home Energy Assistance Program (LIHAO), www.csd.ca.gov/LIHEAP.html. One element is “The Weatherization Program [which] provides free weatherization services to improve the energy

efficiency of homes, including attic insulation, weatherstripping, minor housing repairs, and related energy conservation measures.” The same kinds of improvements can also help to prevent water leaks into the home.

⁹⁹ “Mold in my Home. What Do I Do?”

¹⁰⁰ A sample warning to be included in a rental agreement, “Addendum Regarding Mold Contamination and Agreement to Maintain Premises,” may be viewed at www.trueforms.com/pdf_forms/APP30-PM_PDF_DRAFT/105-M.pdf. Copyright restrictions prohibit quoting the document here. Similar documents are listed among standard legal forms available from stationers.

¹⁰¹ See, for example, California Code of Regulations, Title 8, Section 5194, Hazard Communications, www.dir.ca.gov/title8/5194.html. Also see the Cal/OSHA *Guide to the California Hazard Communication Regulation*, www.dir.ca.gov/dosh/dosh_publications/hazcom.pdf. Other health and safety related Cal/OSHA publications are available via www.dir.ca.gov/DOSH/puborder.asp. For federal OSHA hazard communication information, see www.osha.gov/SLTC/hazardcommunications/. Also, for an example specific to fungal exposure, see OSHA Fact Sheet, “Fungi Hazards and Flood Cleanup,” www.osha.gov/OshDoc/data_Hurricane_Facts/Bulletin3.pdf.

¹⁰² Also see National Clearinghouse for Worker Safety and Health Training, editor, *Guidelines for the Protection and Training of Workers Engaged in Maintenance and Remediation Work Associated with Mold*, May 20, 2005, available at www.wetp.org/wetp/newsbriefs/may05/Final_NIEHS_Mold_Guide_05-20-05.pdf.

¹⁰³ The flier is available at www.dhs.ca.gov/ohb/HESIS/molds.pdf or from the California Department of Health Services Occupational Health Branch by phone or via the form at www.dhs.ca.gov/ohb/HESIS/hesispub.htm.

¹⁰⁴ The document is posted at www.tdh.state.tx.us/beh/iaq/Mold_Rem3.htm.

¹⁰⁵ Texas and Louisiana have such programs. (Texas: Texas Occupational Code, Chapter 1958. Louisiana: Act No. 880, regular session 2003.) Registration of mold remediators was proposed in New Jersey legislation in 2005 (Assembly, No. 3895, introduced March 1, 2005).

¹⁰⁶ One starting point, recommended by review panel member Philip Morey, is the widely cited set of lists of design and construction issues developed by Joe Lstiburek (who is also a review panel member) and available at the Building Science Corporation website, www.buildingscience.com/topten/.

¹⁰⁷ Edward Light commented that this option is impractical, and noted: “There are no standards distinguishing contaminated from normal background or healthy from unhealthy. Furthermore, mold concentrations vary constantly.” Comment on draft of this report, January 6, 2006.