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## CREATING HEALTHY INDOOR ENVIRONMENTS

### A Road Map for the Future

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Although we still have much to learn about many types of indoor environmentally related health problems, our current knowledge base is grossly underused. We have the knowledge to identify and correct many of these problem environments that exist today and to prevent their development in the future. However, a number of steps remain to be taken before we can accomplish this task:

1. We must better understand the causes and effects of human illness and discomfort that result from indoor environmental factors. Part of our ignorance derives from a lack of attention to these problems by the *individual* environmental and medical fields that have an impact on the indoor environment, including mechanical engineers, architects, designers, industrial hygienists, duct cleaners, microbiologists, allergists/immunologists, occupational medicine physicians, pulmonologists, dermatologists, neurologists, psychologists, and psychiatrists. And part stems for our lack of knowledge, not so much about the environmental fields and medicine themselves, but more of how environmental factors and social factors interact to cause human illness and discomfort.

2. Funding of research to better determine the relationships between indoor environmental factors and adverse health effects must increase dramatically—as much as tenfold if it is to equal that spent on outdoor pollution. Particular emphasis should be placed on issues that have a major financial and health impact but whose origins are still enigmatic, such as sick-building syndrome (SBS) and chemical sensitivity.

3. Environmental and medical “experts” need to broaden their awareness of information relevant to their expertise in related fields; they need to know what they know, what they don’t know, and what they need to learn to better serve their employer, client, or patient. They are not likely to discover what they don’t know unless they purposefully and intensively seek information available in related fields that affect the hygienic aspects of indoor environments, particularly in the environmental specialties if they are health care professionals and in the medical specialties if they are environmental professionals. The challenge is to find informational programs and, then, to determine if the information to be provided is valid or whether it simply is presented by “experts” who would propagate their own unproven *theories* or misinformation about these topics as facts.

4. Environmental and medical fields that deal with indoor environmental quality and/or related human health issues must train their general representatives *adequately* and their experts *sufficiently*, using the multidisciplinary information that is valid and available. Unfortunately, this information is just beginning to cross-over, and the organizations in environmental fields seem to be ahead of those in the medical fields in their willingness to cross-educate their constituents. Classical training programs in medical, environmental, engineering, and design specialties typically lag far behind their respective professional organizations in their willingness to explore this information. Consequently, would-be indoor environmental quality experts are predominantly self-taught, and there is no quality control for the success or failure of this learning process. The problems of indoor environmental hygiene cannot be solved or prevented globally until training programs develop competent indoor environmental experts *within* their own fields and provide adequate knowledge to their other experts who do not become subspecialists in this area.

5. A credentialing process that is effective in identifying those who possess the additional knowledge in their respective fields to qualify as indoor environmental quality experts must be developed so that clients and patients can find qualified people to meet their needs. This becomes even more pressing in a field where the science not infrequently becomes lost among the speculation presented as science. The problem today is one of leadership, with both the government and the professional sectors unwilling to regulate these experts and provide the security that those who build and maintain homes, offices, and factories, and those who treat illnesses that are caused by our indoor environments are qualified to do so because they possess a sufficient level of expertise. Even if a building owner or manager, or someone who thinks their health has suffered from their indoor environment, seeks someone with sufficient expertise for their problem, the probability of their finding consultants qualified to solve their problem cost-effectively, or at all, is much less than it should be.

6. The judicial process must attend more closely to known valid scientific data in rendering judgments and not assume that medical or environmental experts with opposing views are equally justified in their opinions because they are self-proclaimed experts or even certified by a bona fide organization in their field. In addition, the legal process must be cognizant of the difficulty all specialties have in policing their members and nonmembers who proclaim themselves to be experts in a specialty without appropriate training, knowledge, or requisite credentialing. The justifiable fear of restraint of trade suits (based on past adverse judgments in court) by those who are “restrained” prevents institutions and professional organizations from effectively sanctioning practitioners of ineffective or unproven

practices and warning the public about them. Our society and legal system cannot continue to demand quality assurance from the medical and environmental professions while punishing them as they try to expose or exclude practitioners of questionable methods.

7. The public needs to be kept abreast of valid advances in the field by respected institutions and agencies. Public agencies, in particular, need to be careful to provide a reasonable balance of views when uncertainty exists about a particular issue. However, they must also be careful to scrutinize the information carefully to exclude or qualify views that do not have a reasonable amount of *valid* scientific evidence to support them. In addition, because of inadequate input from knowledgeable experts, many of the publications available through such organizations may unintentionally mislead the public because they do not provide a good understanding of the relative importance and frequencies of occurrence of various health problems created by environmental contaminants and conditions.

8. Members of all relevant governmental bodies and agencies need to be made aware of the complexities of the problems of indoor hygiene. They need to realize that simply because a concept of cause and effect for an environmental stimulus and a human illness makes sense, sounds logical, and is proposed or propagated by "experts," it does not mean that it has been validated by sound scientific methods. Standards sufficient to assist with the recognition of deficient indoor environments need to be established and regulations based on these standards need to be imposed.

9. The media needs to present accurate balanced information to the public. They need to be responsible (not in just a legal sense) for verifying the scientific accuracy of their information and the credibility of their sources. Presenting new or exciting information without verifying the validity and without informing the public of the controversial aspects of some of the theories is sensationalistic and counterproductive.

10. Building owners and builders need to invest only a small fraction of the cost of building or renovating a building to reap the benefits of a healthy buildings after it is built. Somehow, those who determine how much will be spent and for what purposes must become motivated—by regulation, litigation, or economic incentive—to make this investment. Once built, a comprehensive written plan must be implemented and followed so that the indoor hygiene can be maintained throughout the life of the building.

11. When a potential environmental or environmentally related health problem becomes known, it needs to be addressed immediately and adequately. Those charged with the responsibility of evaluating the problem need to assure that this process results in an effective resolution. This means that builders, developers, and design experts must take responsibility for their aspects of the indoor environment—that is, to ensure an environment that is healthy from the start and has a high probability of remaining so with adequate maintenance—and respond immediately to any problem that could be caused by something they created. When a health complaint arises that may be caused by an indoor environmental factor, the department or administrators or clinicians responsible for the health of the building's occupants need to recognize this possibility and investigate it, especially before the health problem starts to spread. If required, outside consultants should be hired based on their knowledge of building-associated illnesses and their ability to evaluate the problem and recognize any potential environmental link. Hiring should not be based on how inexpensively

they will work or how willing they are to limit their scope of investigation to what their client demands. If the consultant or firm is not qualified to investigate the problem, or finds the problem beyond their expertise during the investigation, they should seek appropriate help or defer the evaluation to someone with greater expertise.

12. Recognition must become widespread that the knowledge and technology exist to accurately evaluate and remediate deficient indoor environments and to prevent their development. Building practices and medical practices lag far behind our current knowledge base for the creation of healthy indoor environments and for the evaluation and treatment of individuals whose health they may affect. Effective solutions for problems of indoor hygiene usually require input from representatives of several different fields and of varying degrees of expertise, depending on the complexity of the problem. These problems can be prevented or successfully resolved in most cases with foresight and a knowledgeable approach to relevant aspects of building design and operation and medical pathophysiology. A proactive approach at the beginning and throughout the operation of the building is much less costly to everyone than the typical reactive approach currently taken in most buildings.

### **Improving the Knowledge Base**

The complex nature of the indoor environment is the most prominent obstacle to effectively creating, maintaining, and remediating "sick" environments and treating occupants who become ill. The indoor environment is the product of numerous indoor and outdoor systems, including ventilation, microbiologic, toxicologic, and physical systems, which result in several different classes of contaminants, each class containing tens to hundreds of individual contaminants that have the potential to adversely affect human health. These systems interact extensively, each one often dependent on or directed, partly or in whole, by several others. This interdependence, which is the origin of the multifactorial nature of virtually all indoor environmental problems, means that our current paradigm of enlisting the help of an expert or a single field of expertise does not solve problems; research limited to knowledge in one or two fields may be reproducible in the laboratory, but it may not accurately explain human health problems that result from several interacting contaminants, such as humidity, bacteria, fungi, volatile organic compounds (VOCs), and organic materials, as they impact on the human substrate. Not surprisingly, a lack of adequate knowledge in evaluating indoor environmental problems tends to confuse rather than clarify, thus delaying the implementation of any effective solutions.

Ignorance of the nature of some forms of poorly understood human illnesses and discomforts that seem to be caused by environmental factors, such as sick-building syndrome, to a great degree stems from a lack of sufficient funding for enough research to understand these problems: How do physical stressors, particulate, and vapor mixes affect human health? What makes certain people susceptible to the development of neurobehavioral symptoms after exposure to strong concentrations of chemicals? To what degree do primary or secondary psychological factors contribute to these problems? Can properties of the environment result in an increased susceptibility to respiratory or other types of infections? Which animal models, if any, can be used to study these phenomena? In addition, confusion created by the terminology used by different groups to categorize types of illness or discomfort sometimes limits the ability to thoroughly

understand or search for causative factors. For example, use of the term *sick-building syndrome* may halt investigations of potential environmental factors because the symptoms are typically subjective and the prescribed treatment is often "move out of your house" or "work at home." Because our knowledge of the causes of sick-building syndrome is somewhat limited, and because correcting minor deficiencies in the ventilation systems of nonresidential buildings sometimes ameliorates the problem, the building owners or employers frequently institute quick and inexpensive fixes without adequate investigation. If they then insist there is nothing wrong with the environment in the face of persisting complaints, they obstruct resolution of the problem regardless of the cause. On the opposite end of the spectrum, blindly accepting a medical diagnosis (e.g., of multiple chemical sensitivity made for someone suffering neurobehavioral symptoms such as forgetfulness, dizziness, and fatigue) limits the search for other unrelated potentially causative medical problems, which may or may not be due to environmental factors, that *can* be diagnosed and treated successfully.

The terms *building-associated illness*, *sick-building syndrome*, and *building-related illness* are used frequently by indoor air quality experts. Building-associated illness refers to any illness caused by indoor environmental factors; it includes two categories: sick-building syndrome and building-related illness. Excluded from these categories are illnesses that have a long latency period, such as lung cancer from radon exposure. Sick-building syndrome describes a complex of vague predominantly subjective complaints consisting of neurobehavioral symptoms such as memory loss, headache, depression, dizziness, as well as respiratory complaints such as chest tightness, coughing, and shortness of breath. Burning eyes, nose, throat, and sinuses are symptoms of mucous membrane irritation that are frequently associated with "sick" building complaints. Itching of the skin and rashes may occur. Building-related illness refers to reasonably well characterized human illnesses caused by indoor environmental factors that can be related to clinical and laboratory findings in occupants with health complaints based upon *validated* principles of pathophysiology.

Physicians frequently develop a working diagnosis for a patient and then evaluate and treat accordingly. Part of the process involves establishing possible or probable links between exposures and illness in cases that may involve an environmental stimulus. For many infectious and immunologic diseases, for which the pathophysiology is well understood, valid criteria exist for determining if the illness fits the contemplated diagnostic category, such as legionnaires' disease or allergic or nonallergic asthma. Frequently, one important diagnostic criterion is the temporal relationship between the exposure to the suspected agent and the onset and time course of the disease. Another is how well the markers (findings) found on physical examination and on laboratory testing fit the suspected disorder. Many of the illnesses with suspected or possible environmental etiologies that have not been well defined remain so because of a poor understanding of the time course of these disorders and/or a lack of *scientifically validated* objective criteria that can be found during the evaluation of the affected individuals. This is particularly true for various types of neurobehavioral disorders.

Some environmental scientists, including physicians, determine cause and effect based on objective criteria found in animal studies (some of which have followed valid scientific research principles and others which have not), which they then extrapolate to human illness. Unfortunately, unless such data has been validated for human disease, this type of extrapolation is fraught with the

potential for erroneous conclusions. In addition, physicians who lack sufficient knowledge about environmental factors and adverse human health relationships not infrequently come to erroneous conclusions of cause and effect. These errors of commission or overdiagnosis and/or overtreatment occur because the physician usually assumes that if the patient says the symptoms (which are often difficult to evaluate objectively) are new or exacerbated and that they developed at some reasonable time after the environmental exposure (which they don't understand thoroughly), the environmental exposure must be, or is likely to be, causing the illness. While a patient's history is sometimes accurate, a careful review of medical records from all caregivers for the past 3-5 years frequently indicates that the symptoms were preexisting and may have been the same or worse before the environmental exposure. Also, other medical diagnoses may be suggested by a review of the medical record or by a history and physical examination by an expert. A lack of sufficient valid scientific data or clinical correlation to support some diagnoses and treatment regimens does not deter some clinicians from rendering opinions. Adding to the problem, the many different individuals who create indoor environments and who maintain the environment once the building is built often lack an adequate knowledge of the valid established effects of indoor environmental factors on health. This contributes to the construction and maintenance of suboptimal indoor environments.

### **Better Funding for Research**

Over the past 2 decades much more money has been committed to research for understanding and solving high-profile, outdoor, health-related environmental problems than those that develop from indoor environments. While many building-related illnesses have been discovered or better defined, such as legionnaires' disease, our understanding of other building-associated illnesses, such as SBS, has been slow to advance. Equally important is that lack of delineation of exact pathophysiologic mechanisms, dose-response relationships, or interaction relationships for adverse human health effects produced by chemical, particulate, and physical stimuli in the indoor environment has greatly hampered our understanding of how these contaminants affect health. A number of animal models have been proposed, e.g., the effects on mice of VOCs exuded by carpets, but many of these have either not been reproducible or the appropriateness of the model for human disease has not been established. Human challenge studies with VOCs (singly or in mixtures) have had difficulty demonstrating much objective change with exposures. Human pulmonary responses to ubiquitous inhaled contaminants such as the nitrogen oxides and ozone have not demonstrated clinically significant physiologic changes except at high concentrations that usually exceed most human indoor exposures. Challenge studies that adequately represent the "real world" require equipment, such as challenge chambers, that is expensive to build and maintain; as a result, few chambers have been built and used for any length of time to investigate these relationships. Finally, development of a cohesive research agenda has been hampered by disagreement among various parties concerning what constitutes adequate rigor of scientific methods and valid interpretation of results, especially with respect to controversial and difficult-to-prove theories. For instance, it is difficult to prove or disprove that the lack of detecting chemicals in excessive concentrations indoors does not eliminate the possibility that levels of some chemicals too small to detect are causing illness. Such arguments can only be resolved by designing and conducting

research studies, both in animals and humans, that are scientifically sound and properly interpreted.

Money must go mainly to research so that we can understand these problems; it must not be proportioned equally (as it seems to be currently) or even less than equally between research and the formation of administrative committees, hotlines, and publications that seek to provide answers and funds for problems about which we remain largely ignorant, such as the building of "safe" buildings for individuals who are chemically sensitive. Congress must pass an indoor air quality act (these have been sitting in committee for several years in both houses) that provides adequate funding to address current needs in this field. Such an act not only needs to provide sufficient funds for research, but it needs to clearly establish (1) that funding is to be provided only for research conducted with the highest standards of the scientific method, (2) that mechanisms are established to proportion this funding to answer a full spectrum of questions, and (3) that this information is shared with all specialties that have an impact on the quality of indoor environments in all types of buildings. The funding must have guidance and purpose to provide practical, effective answers. The delegation of responsibility by Congress or other granting agency for the execution of any indoor air quality or indoor environmental quality act must be carefully thought out to accomplish its desired ends.

While valid scientific efforts continue to discover the causes of these controversial yet truly debilitating disorders, they are extremely limited in scope because of lack of funding. We can only hope that, as funding becomes available for indoor environmental issues, most of it will be spent to first delineate the problems before attempting to educate the public or blindly provide solutions before the causes are clearly defined.

#### **Many Experts Aren't Expert Enough**

Existing building deficiencies are aggravated by the tendency of experts to pursue their evaluations and remedies using only what their training has taught them, so that they miss the forest for the trees. This lack of expertise compounds existing deficiencies in our understanding of the nature of some of the more common human illnesses or discomforts that may be caused by indoor environmental factors. These deficiencies are particularly true of the subjective complaints that are commonly grouped under the term *sick-building syndrome* and even more so for the more speculative linking of real or alleged health problems such as immune dysfunction, chemical sensitivity, and recurring infections to environmental factors.

Certain medical practitioners frequently diagnose and treat suspected environmentally induced illnesses because they are recognized as the experts to care for the skin and respiratory tract disorders suspected to be of environmental origin: allergists and immunologists, occupational medicine physicians, pulmonologists, and dermatologists. These practitioners are not exempt from the deficiencies noted earlier; however, their opinions may carry more weight because of their recognition as experts. These and other experts need to be mindful of their greater responsibilities to provide accurate scientifically sound opinions, not only so that the patient can obtain the best possible medical care, but also to alleviate the potential for frivolous litigation. Attorneys rely on medical experts to determine the merits of a case, and they can be readily misled by erroneous unsupportable medical opinions. Reports from occupational dermatologists opining that fiberglass exposure at work has caused a worker's skin condition and that treatment should

include the possibility of desensitization shots, or from a pulmonologist that a fiberglass inhalation challenge test is positive (when no standardized inhalation test has been defined for fiberglass) can produce major undesirable ramifications for the patient, the employer, the insurance company, and the attorney.

Because practicing physicians are so busy, the research of past medical records and relevant medical and environmental literature that is necessary to solve these complex problems often is not completed. Even when it is reviewed, this information may not be thoroughly understood. Unless the right combination of experts is brought together to complement each other's deficiencies, and unless someone consolidates the various experts' opinions into a cohesive, valid explanation of what did or did not happen, the result is likely to be analogous to that in the parable of the three blind men and the elephant.

Nonphysician environmental scientists and contractors often make some of the same mistakes of commission made by physicians: (1) erroneously finding elevated concentrations of contaminants in the environment because of poor technique or use of inappropriate tests for the environment being assessed, (2) incorrectly interpreting accurate levels of contaminants found upon sampling the environment, (3) erroneously concluding that an environmental stimulus has caused an adverse health effect because (a) the former preceded the latter in a plausible way and (b) chronic or recurring symptoms may fit with established acute transient effects that have been shown to be caused by acute high-level exposures. Combining these errors with a lack of understanding of the pathophysiology and time course of disease processes, the affected individual or the environmental expert may also attribute the development of other symptoms or illnesses months and even years after the exposure back to the initial exposure.

In addition, society's desire for plausible answers and its willingness to accept plausible explanations, regardless of their scientific validity, motivate some "experts" to develop seductive logical explanations for these phenomena without the benefit of an adequate amount of *valid* scientific data to support them. We should encourage new theories, but theories should not be presented to the public and scientific communities as valid explanations for building-associated illnesses. In particular, the use of these unproven theories to support the diagnosis and treatment of affected individuals, the filing of law suits alleging damage from environmental factors of a toxic or hypersensitivity nature, and recommended solutions to indoor hygiene problems has little validity and needs to be effectively discouraged through better recognition of the unproven nature of these hypotheses. The public has become so inundated by information and misinformation about this issue that it has become a major concern, which is good, because this concern may drive the search for valid answers and healthier environments. However, it is just this recognition that has motivated physicians, private sector environmental experts, and judicial and government workers to develop premature or incomplete responses, which is ineffective, sometimes counterproductive, and costly.

Insufficiently critical acceptance of unproven theories wastes precious resources that could be spent on finding valid solutions; instead, careful scrutiny of the scientific merits of hypotheses is required. While an abundance of valid data are available to assist with the tasks related to keeping environments and people healthy as well as evaluating potential problems, these data are scattered across the literature of many different medical and environmental specialties. Because of the complexity of the problem, unless contractors or "experts" have available *and use* a sufficient understanding of the many medical and environmental fields that

relate to their area of expertise, their product has a good probability of being faulty. Unfortunately, the required multidisciplinary approach frequently does not occur, and the result, to varying degrees, is or eventually becomes suboptimal and cost-ineffective. Medical and environmental experts inclined to try to find solutions to indoor environmental hygiene problems should know and must stop at the limits of their expertise and seek help when they are beyond these limits, or turn the problem over to someone who can find an effective solution.

### **Training Programs Are Deficient**

Physicians practice medicine primarily using the information they received in their specialty (primary care and subspecialty) training and, to some degree, from continuing medical education. Subjects studied through continuing medical education are largely selected by each physician; however, for most physicians, the menu of subjects from which they choose comes from their individual specialty societies. Unfortunately, virtually all training programs and specialty societies have neglected, to varying degrees, the subject of sick buildings and many of the building-related illnesses, especially those not involving classical infectious or immunologic agents. Medical specialty organizations have argued that not enough valid scientific information is available to teach to their constituents. This misconception stems from three factors. First, there is a paucity of research by specialists in any given field that clarifies the issues. Consequently, there is a paucity of information in each specialty's literature to refer to and teach from. Secondly, there is little cross-fertilization between the environmental and the medical literature (and often between specialty literatures), so that specialists are unaware of the vast body of valid information that does exist that could provide them with a better understanding of the environmental factors that may cause human disease or discomfort. Finally, because of this relative dearth of good information and the lack of awareness of what does exist, specialty societies and CME organizations frequently place a very low, if not negative, priority on disseminating this information. As a result, unless a specialist is willing to look hard to find relevant data outside of his or her field and, once found, critically evaluate the validity of this data, he or she is not likely to develop sufficient skills to evaluate and treat health problems accurately. Combining this deficiency with the willingness of some physicians to render opinions of cause and effect before they actually understand a problem creates a setting not only for ineffective treatment and inaccurate diagnosis, but also for lawsuits of questionable merit.

### **Governmental Regulation**

Ironically, portions of a number of legislative initiatives and governmental (local, state, and national) administrative decisions and actions have devoted effort and money toward implementing indoor environmental policies without the support of sufficient valid scientific evidence. Even more disturbing, especially given the questionable basis for this spending, there is little, if any, follow-up to assess the effectiveness of these efforts. One such effort took place recently in San Rafael, California, where a housing complex named Ecology House was built with an additional contribution of \$1.5 million from the Department of Housing and Urban Development to provide low-income housing for individuals suffering from "multiple chemical sensitivity." Materials were selected by allegedly knowledgeable building experts, associated with the project to minimize the occupants' exposure to contaminants that cause multiple chemical sensitivity. (While the annual

granting procedure for such funds is competitive, proposals such as this one are reviewed by an inexpert panel of HUD staff using the "expert" information provided by the applicant, which must be a nonprofit organization.) Since moving in, a number of the occupants have complained of the same or even worse health problems than they had previously. Yet, there is no provision for HUD to follow up on the effectiveness of their generous contribution.

HUD accepted the application because it met the requirements for the grant: building housing for individuals with a disability legitimized by the American Disabilities Act of 1990. Section 504 of this act specifies that any physical or mental impairment that substantially limits a major life activity qualifies as a disability. If any physician states that an individual or class of individuals is so impaired, this class qualifies for housing support from HUD. HUD then evaluates the needs of those with the disability and the recommended remedies proposed in the grant proposal (supported by the experts supplied by the applicant) for merit for funding. Also, the need to follow up on the effectiveness of HUD's grant money is generally not necessary when granting funds for the application of building technology for established disabilities, because HUD relies on doctors who care for these patients to evaluate any benefit and is not charged with the responsibility of such follow-up.<sup>1</sup>

It is this author's opinion that public resources should not be spent on fixes for problems whose causes are not understood. Public policy should not be made until valid scientific information supports it. Nor should public policy or the spending of public resources be predicated upon a sense of urgency by constituents if there is no supporting data. Most importantly, a fix should only be implemented if appropriate follow-up is guaranteed to determine the effect and benefit of the fix. The Occupational Safety and Health Administration (OSHA), which has recently proposed rules for the regulation of indoor air quality, and Congress, with its consideration of an indoor air quality act, are taking steps in the right direction, provided that the final products reflect valid scientific principles and are sufficiently complete to address the majority of indoor air quality problems. Unfortunately, the current efforts of OSHA, Congress, and other governmental regulatory agencies fall substantially short of what is needed. Adequate funding must be provided for research *and* regulation, which has not been the case to date. Regulations must provide a comprehensive net to include valid knowledge from every field of expertise to achieve the healthiest indoor environments possible, which they haven't. Regulations must hold those who create and maintain indoor environments, such as building owners and developers, accountable for the results of their actions without having to go to court as the only recourse, which they do not yet do.

### **Creating and Maintaining Healthy Buildings**

Building owners and developers have historically assumed that if the design of their building meets building codes they are providing a reasonably healthy indoor environment. They rely on mechanical engineers and design experts to meet building code standards and often mandate this compliance, along with the aesthetics of the building, as the only design features for which they will pay. Unfortunately, building codes have been designed to ensure the structural integrity and energy efficiency of the building, as well as to supply adequate fresh air to *the building* (not the breathing zone of the occupant). Unlike the development process used to regulate the first two issues, the determination of standards of "adequate

Building owners and developers need to learn from their errors of the past and plan hygienic environments for their buildings. This will not happen by serendipity. Rather, careful attention must be given to the many aspects of the construction process described above that have the potential to produce an environment that can cause discomfort or ill health either immediately or in the near future. Those who control the fate of the building need to ask themselves why they are building it. If their answer is honest, they cannot deny a careful evaluation by experts who have the skill to assess the building plans, HVAC system specifications, and material specifications for potential health hazards *from the very start of the construction process*. Asking the architect to carve out the 0.5% or less of the design budget that it would cost to pay for these experts seems extremely cheap in view of the potential savings that the owners and occupants may accrue from taking a proactive approach. Part of these proactive tactics include the use of less volatile compounds in building the structure and applying finishes and furnishings; assuring that areas that have the potential for moisture intrusion are sealed and that grading and drainage reduce this risk further; and providing adequate effective ventilation and lighting for the employee density and the type of activities occurring in each area.

### **Expeditious Handling of Problems**

Building owners should have a competent staff member screen a problem immediately upon discovery, and they then should determine if they can fix the problem themselves or if they need to call in expert consultants to assist them. When appropriate, such as in commercial buildings, owners need to periodically assess their indoor environmental quality for compliance not only with existing regulations, which are inadequate, but also with the current knowledge base we do have that is valid but elusive. If an environmental deficiency is uncovered, even if no one is complaining of illness or discomfort, the problem should be addressed expeditiously to prevent anyone from becoming ill.

Investigations of possible indoor environmental quality problems by inhouse staff and many outside consultants often find little or nothing of consequence or, when something is found, it may incorrectly be identified as the cause of the problem. Errors of omission frequently occur for three reasons: (1) a lack of knowledge by the environmental assessment team or individual, with testing inappropriately selected or performed or with results misinterpreted; (2) a limited scope of investigation, so that information relevant to the problem under investigation is not discovered; and (3) failure to report past or present environmental or health problems. In the second situation, the mandate of the investigative team may be limited by federal or state law or by the client hiring the team, who may restrict funding and access or otherwise limit the scope of the investigation. The third scenario may occur either from intentional or unintentional underreporting by the building owner, manager, or their representative, or by the employee or homeowner. Underreporting may result from either an intentional attempt to conceal potentially damaging information, fear by an employee of ridicule from peers or of termination or retribution from the employer, or simply a lack of recognition of the association of the adverse health consequence(s) and environmental factors. Various building-related illnesses, including Legionella pneumonia, contact dermatitis, chronic sinusitis, and asthma are frequently underdiagnosed or misdiagnosed.<sup>3</sup> In addition, many people can work or go to school every day despite discomfort from physical "contaminants" in the environment

such as heat, light, and noise or even illness, such as allergic rhinitis and contact dermatitis. Although they become adapted to the discomforts produced by these environmental stimuli and may not complain to their employer or doctor about them, their health, quality of life, and productivity frequently are adversely affected.

Errors of omission or underdiagnosis and/or undertreatment of medical problems derive from a lack of knowledge of basic disease processes. At times the primary care physician and even the specialist may lack sufficient knowledge about a disease, yet continue to evaluate and treat patients. In such situations, the diagnosis may be headed in the right direction but is incomplete. While the treatment may be adequate, unless the physician has arrived at an accurate diagnosis and has accurately identified all of the relevant environmental factors, affected individuals often will continue to have recurring or chronic health problems that prevent them from functioning at an optimal level.

If symptoms truly stem from an environmental problem or some other medical problem that is not readily apparent, and if no objective signs or tests are obtained or are evident to define the illness better and permit the practitioner to make an accurate diagnosis (given the limits of his or her knowledge), the illness usually will continue. Patients are then frequently referred to other specialists to evaluate their complaints, often including the inability to concentrate, headaches, chest tightness, malaise, and fatigue. If the primary care physician, occupational medicine physician, neurologist, pulmonologist, allergist, or other specialists find no cause, they may be referred to a psychiatrist or psychologist. This "specialist of last resort" may diagnose these patients (who have often now been ill for several months) as having secondary depression from their chronic illness, but usually finds no primary psychological disorder to explain the initial illness. In desperation, these patients may then seek proponents of nonvalidated hypotheses to explain their illness. Once they are provided with a diagnosis—regardless of whether it is valid—especially if it does not imply that they are imagining their symptoms, these people usually have a definite improvement in their symptoms (from the relief of knowing that they are not crazy). However, they usually continue to remain ill and disabled to varying degrees until the environmental agent is identified and removed or they remove themselves from the offending environment. If their current illness has no environmental cause, they tend to remain ill until an accurate diagnosis is made and appropriate treatment has been given.

The significant increase in morbidity that accompanies suboptimal medical care of affected individuals extends beyond their health issues. They may lose wages because of absenteeism, lose opportunities to advance in their workplace or education, and suffer significant emotional and family problems. They may even lose their jobs or unwillingly be divorced by a spouse. Employers and insurance companies, in particular, need to be especially cognizant of the preventable nature of workers' compensation claims and lawsuits due to incomplete or misdiagnosed health problems caused by indoor environmental factors. Inadequacy or delay in addressing these types of complaints and the suspected indoor environments continues to be a significant factor in generating claims and litigation.

### **Sufficient Knowledge Does Exist**

We *do* have the knowledge base to understand a number of indoor environmentally induced illnesses, such as legionnaires' disease, many types of occupational dermatitis and occupational asthma, and common allergic disorders. Yet, because this knowledge base is not used well by many environmental and medical

practitioners, the effective control or elimination of the agents causing or exacerbating them remains suboptimal. More importantly, despite our knowledge of the pathophysiology of these building-related illnesses, their diagnosis and treatment also continue to be suboptimal, resulting in unnecessary increases in morbidity and mortality despite advances that have been made in their detection and treatment.

Estimates of the proportion of buildings that provide suboptimal environments and the degree to which those who are charged with building and maintaining the structures lack adequate knowledge to do their jobs approaches 60–70%. While these figures do not say that 70% of buildings present major health hazards for their occupants, estimates of the number of buildings that can be considered “sick” or are likely to have undetected indoor environmental problems approach 50%.<sup>4</sup> What it does imply, however, is that the majority of people, who often spend time in more than one environment on a daily basis, are at risk for the development of discomfort and illness caused by the buildings in which we live, work, or attend school. This risk and the cost resulting from these illnesses and discomforts could be dramatically reduced if the expertise that does exist today to build, design, and maintain environmentally sound buildings was employed *effectively* from the beginning of planning to the end of the building’s life span. It is not sufficient to meet local or regional building codes, because these codes are designed primarily to ensure structural integrity and energy efficiency, sometimes to the detriment of indoor environmental quality. In addition, many of the industrial hygiene and engineering requirements and recommendations (e.g., for airborne levels of VOCs and for ventilation) for commercial buildings of all kinds were developed initially for industrial buildings and then with the goal of satisfying the comfort and health of only 80% of the occupants. You can rarely satisfy all of the occupants of a building all of the time. However, to apply standards for industrial plants that aim for a tolerance level of 80% to commercial office buildings or homes seems to ask for problems. This fact has been well recognized recently, and ASHRAE and OSHA in particular have begun to reestablish guidelines that predate the energy crisis of the 1970s and provide for more effective ventilation. Regulatory agencies have begun to set lower acceptable levels for indoor air contaminants, such as formaldehyde, because indoor air research has established that not only were the previously established levels too high, but that differential sensitivity exists to some degree for many contaminants and varies with the physiologic response being measured.

In addition, greater awareness of susceptible populations has resulted in more attention to the adverse health effects from exposure to indoor air contaminants for the young, the elderly, and the immunosuppressed. This increased susceptibility has particular relevance for hospitals, day care centers, and skilled nursing facilities. Moreover, as the adverse health effects of passive smoking have been more completely described, greater attention to reducing environmental tobacco smoke exposure in public buildings has resulted in more restrictions on smoking in public, especially in states such as California. Many local and state governments have instituted measures, such as prohibiting smoking, to reduce indoor air contaminants in public buildings and private buildings frequented by the public.

It should be clear that effective solutions for the environmental and medical problems related to indoor environments often require the contribution of both environmental and medical experts. Generally, illness cannot be treated effectively

without reducing or eliminating causal environmental factors, and it may be difficult to establish the diagnosis without data from the affected person's environment. The lack of an effective multidisciplinary approach occurs for several different reasons, which are not always the fault of the contractor or "expert": (1) restriction of use of resources or access to information by the client, e.g., the building owner, insurance company, or building manager; (2) lack of sufficient knowledge in their own field relating to indoor hygiene; (3) failure to use relevant data in related fields; and (4) an inadequate knowledge base of the multidisciplinary *team* for the problem. All of these factors can result in misinterpretation of environmental and medical findings, misguided efforts to resolve or prevent problems, and cost-ineffective or completely ineffective approaches to indoor environmental hygiene and related health issues.

### Other Global Issues

Space prevents more detailed discussion of some of the other key requirements noted earlier: credentialing of experts, legal system impediments, public information issues, and media responsibility. An additional issue that I have alluded to is the lack of expertise among medical and environmental specialists and subspecialists that frequently work with these problems: allergists, immunologists, pulmonologists, dermatologists, occupational medicine physicians, industrial hygienists, mechanical engineers, architects, and interior designers. In some cases, the near blind expert leads the blind client. While knowledgeable experts do exist in these key fields, they can be difficult to find; and when found, it may be difficult to determine their level of expertise. Finally, because the focus of this book is to provide practical information, I have avoided any in-depth discussion of environmental controversies, such as multiple chemical sensitivity or electromagnetic fields.

It also should be clear that the economic impact of adverse health effects from indoor environmental contaminants is substantial. Notwithstanding the cost related to the building structure, ventilation systems, finishing materials, and contents, the cost in human discomfort and debility likely exceeds \$1.5 billion annually for health care, excluding that caused by environmental tobacco smoke, and \$12 billion in lost productivity.<sup>4</sup> These estimates do not include other substantial costs that are more difficult to determine: lost learning opportunities for children and adults and the resulting future productivity loss, and increases in insurance premiums for contractors and design professionals, medical coverage, workers' compensation, disability, and liability for facilities. The costs for litigation related to indoor environmental problems are growing every year. Even excluding these more nebulous costs, one cannot come close to accurately measuring the cost to individuals and families for the emotional turmoil related to unaddressed or poorly addressed health problems that might be caused by indoor environments.

Because most people spend more than 90% of their time indoors, the quality of the indoor environment and how it affects health should be a top priority for everybody who has an impact on this environment. Some of the solutions to adverse health effects that are produced by our indoor environments are at hand, and others will require a great deal more research to clarify the confusion. The urgency of solving these problems is incontestable. Whether we are successful depends on our willingness to form effective multidisciplinary teams to further scientifically delineate the relationships between environmental agents and their suspected health effects, the cause of some illnesses of suspected environmental causation, and our ability to obtain for people who are affected prompt and expert

evaluation and effective treatment. In addition, environmental deficiencies in existing buildings need to be identified and remediated regardless of the presence or absence of adverse health effects. Establishment of valid standards for indoor environmental quality will be of great benefit in facilitating the correction of existing deficiencies and the prevention of future deficiencies. Let's get to work!

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