HOME COMFORTS

The Art and Science of Keeping House

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SCRIBNER

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The Air in Your Castle

Effects of inadequate ventilation, signs of inadequate ventilation, desirable levels of ventilation . . . Desirable indoor temperatures, indoor and outdoor methods of cooling using air conditioners, shade trees, awnings, window shades, blinds, solar shades and screens, and other means . . . Desirable indoor humidity levels, effects of excess and insufficient humidity . . . How to measure and control indoor humidity . . . Indoor air pollution caused by household chemicals used for cleaning and other purposes, chemicals used in hobbies and work, pesticides, ozone, formaldehyde, asbestos, radon, lead, off-gassing and fumes produced by fabrics and carpets, microorganisms, house dust . . . Indoor pollution caused by furnaces, stoves, heaters, and fireplaces; combustion by-products, carbon monoxide; unvented heaters, wood stoves, gas stoves . . . Tobacco smoke . . . Air-cleaning devices such as filters and air-cleaning machines; effect of houseplants

Dr. J. H. Kellogg—of Battle Creek, Michigan, Corn Flakes, and a 1994 movie, *The Road to Wellville* (based on T. Coraghessen Boyle's novel), which exploited his eccentric theories about health—wrote a *Household Manual* (1877), which was fierce on the subject of ventilation. Open the windows and let in the sun, he insisted. Airtight houses are unhealthy, and cold air will not make you catch a cold. He scolded about unvented stoves and molds and their spores, and preached that houseplants make the air wholesome. He loathed cigarette smoking, which he said illustrates "the readiness of human nature to

seize upon anything which promises gratification of the senses, no matter how filthy, how disgusting, how pernicious, or how fatal in its ultimate consequences." In 1869, Kellogg's less-fanatical contemporaries, Harriet Beecher Stowe and her sister Catharine Beecher, had also published a book on household management. It too contained long, technical discussions of good and bad air—listed in their table of contents under "Household Murder," a title that nicely sums up their views on unvented stoves and sleeping with the windows closed.

The post-Victorian world denigrated such sermonizing on fresh air as outmoded asceticism based in part on an antagonism to anything physical, including natural body odors. More sympathetic souls pointed out that the Victorians had more odors to worry about than we do; after all, they still usually lacked running water for bathing, and used chamber pots. All agreed in dismissing as unscientific the belief that foul-smelling air carries pestilence. But the winds of change are blowing in the other direction.

Today, the scientific recommendation is again: *ventilate*. Although many airborne dangers are imperceptible, sometimes foul-smelling air really can make us ill. Overheated houses waste energy, make us drowsy, and become too dry for optimal health and comfort. Unvented stoves once more pose public-health problems. We may not find the florid vocabulary of Kellogg and the Beechers to our taste; "putrefaction," "pestilence," "fetid exhalations," and "disagreeable effluvia" do not exactly capture the negative qualities of our modern dirty air. But these writers' recommendations for household health and safety where ventilation is concerned are often sound. The worldwide increase in allergic diseases in the past thirty years appears to be attributable more to poor air indoors than outdoors. We spend more time indoors than people used to—typically, twenty-three of the twenty-four hours; the air indoors is more polluted than it used to be and is many times more polluted than the outdoor air, even in industrialized areas.

Despite this, and despite the cautions on air quality in the home that are set out below, readers will do themselves a favor if, on the subject of indoor air quality, they recognize that the unexciting middle ground is also the solid ground. In the vast majority of cases, any problems that exist are mild ones that should raise mild, rational concern and prompt modest and simple remedial efforts. Unfortunately, almost anything said about the subject tends to arouse excessive alarm and, in some of us (including me), purely psychological symptoms. When I wrote the section below about chemical fumes from common household products, I developed an eerie heaviness in my chest and a heightened sensitivity to chemical smells, even though to the best of my knowledge I was not exposed to any hazardous fumes and was enjoying healthy air blowing in from outdoors. All symptoms disappeared as soon as I did not have to think about volatile organic compounds.

Although some substances, such as carbon monoxide, radon, lead, asbestos, and various hazardous household chemicals, may occur in the home under circumstances that pose either immediate or long-term threats to life and health, for most of us improved indoor air is not a life-and-death matter. Nonetheless it promises real advantages in comfort and health that are well worth striving for. The advantages are greatest for those who spend most of their time in the home—infants and children, sick people (especially those with heart and lung ailments), the elderly, and pregnant women—all of whom tend to be more vulnerable than others to poor air quality.

The Indoor Climate

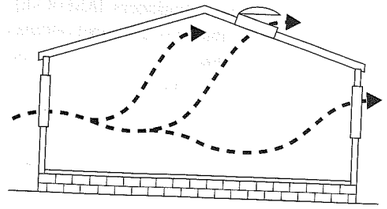
Ventilation. The energy crisis of the 1970s was an occasion for renewed concern about ventilation. When fuel prices rose sky-high, the message went out: build tight and weatherize. As a result, ventilation in many homes and offices decreased, often dramatically, and people began to talk of "sick-building syndrome"—a condition in which occupants of a poorly ventilated office building with windows that don't open develop respiratory and eye complaints and other illnesses. Homes can also suffer from this syndrome. In any tightly sealed structure, pollutants build up in the air when they are not diluted or discharged by outdoor air. These pollutants include volatile organic compounds[1] which are contained in cleaning products, polishes, cosmetics, paints and varnishes, thinners and strippers, glues, and many other household substances, in addition to gases, humidity, dust, smoke, fungi, bacteria, and viruses.

In houses that are not tight, fresh air seeps in at door and window frames, vents, cracks, attics, basements, and many other places. As a result, nontight, uninsulated homes in years past had one or more—some say as many as three or four—complete changes of air each hour. Because all that fresh air requires heating in winter, those who have high air-exchange rates (the rates at which outside air replaces indoor air) have heating bills to match. By having your house weatherized and tightened, you can significantly decrease both. (You can never render a home completely airtight.) But indoor air pollution increases—and available oxygen decreases—as the air-exchange rate goes down. Thus, although weatherizing usually allows enough fresh air to enter for adequate ventilation, and weatherizing your home is almost always safe and beneficial, authorities recommend against tightening homes with inadequate ventilation or specific pollution problems such as unvented gas cooking stoves, unvented heating stoves, potential radon accumulations, or urea-formaldehyde foam insulation or other significant formaldehyde-emitting sources.

The popularity of weatherizing has focused attention on desirable rates of ventilation. For certain living areas in homes—but not high-humidity or high-pollution areas such as kitchens, bathrooms, or workshops—the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard 62-1989, followed in many building codes, recommends at least 0.35 air changes per hour, or at least fifteen to twenty cubic feet of fresh air per person per minute (cfm). Many in the industry regard the ASHRAE standard as inadequate even as a minimum; the ideal would be higher. Consider that 0.35 air changes per hour would amount to eight and a half complete air changes in a day. In your grandparents' drafty old house, there were probably twenty-four to seventy-two air changes per day or more. In homes in Britain, it is estimated that "the rate at which indoor air is exchanged for fresh air is now ten times lower than it was thirty years ago, with a considerable increase both in humidity and in concentrations of indoor pollutants and airborne allergens."[2]

When it comes to good ventilation, not all rooms of your home are equal. Some, such as kitchens, bathrooms, and laundries, are more humid or generate more pollution and thus need more ventilation. The Home Ventilating Institute, a nonprofit, independent industry organization, recommends fifteen air changes per hour for kitchens with fans exhausted to the outdoors. (Kitchens with range hood fans exhausted to the outdoors, however, will need considerably less ventilation because this type of fan is far more effective in the kitchen.) For bathrooms, the Institute regards eight air changes per hour as optimal for controlling moisture build-up and keeping down mold and mildew; more air changes in the bathroom would make people feel chilly, and fewer would not be enough to achieve adequate moisture control. Moreover, it makes sense to be particularly careful about ventilation in rooms in which you spend more time. Harriet Beecher Stowe and her sister were right about bedroom ventilation: you spend so much time sleeping that the quality of air in this room matters more to your health than does the air in your living room.

Signs that ventilation is inadequate in your home include odors, stuffiness, mold or



Using windows effectively for ventilation

mildew, and moisture condensation on walls, windows, or other cool places. Windows and doors are our primary means of controlling ventilation. Air from outside, unfortunately, not only raises the heating bill but often does not enter the parts of the house that most need fresh air. To move air through your house, open the windows, if possible, both on the side of the house from which the breeze is coming and on the opposite side. Keep interior doors between these sites open so the breeze can get through. If there is no consistent breeze from a given direction, you can create a draft by opening windows at the highest and lowest points possible in your home, creating what is called a "chimney effect." (See the illustration above from a Department of Energy booklet.) The higher your high window—for example, a skylight that opens—the better this system works. Reinforce this effect with window fans that draw in the proper direction: in on the side the breeze enters and out on the side you wish the breeze to exit. Control the amount of breeze by raising or lowering the windows. Ceiling fans do not bring in fresh air, but make you feel cool and are effective at mixing new air with old.

Some new homes are built so tightly that when the windows are closed they have as few as one to three air changes per day. In Sweden, where new, tight homes may have only 0.1 air changes per hour, home builders install mechanical ventilation systems; they usually employ "heat exchangers" or "energy recovery ventilators" for this purpose. These are mechanisms that transfer the heat of the indoor air that is being expelled to the cold air coming in. This is energy efficient because much of the heat in the outgoing air is preserved, not lost. At the same time these machines provide all the benefits of ventilation: overly humid indoor air goes out, and indoor pollutants are vented outdoors and diluted indoors with fresh, warmed air. Energy recovery ventilators will also retain humidity to prevent overly dry air. Heat exchangers are sometimes designed to work in summer to cool incoming air, too, but they are said to be most cost-effective in cool climates. Mechanical ventilators are being employed more and more often in the United States. They can be used with air filters, including HEPA filters, but they are not primarily designed to function as air cleaners. (HEPA—High Efficiency Particulate Air—filters are defined as those that remove 99.97% of particles greater than 0.3 microns in diameter.)

Temperature

Desirable Indoor Temperatures. Americans do not need to be advised to keep warm. They keep warmer than any other people whose climate requires them to rely on artificial heat in winter. In the 1970s, they had to be persuaded to lower their thermostats to 65–68°F—the desirable temperature range in the average home that houses healthy adults and children. As always, you must exercise special care for the very old and the very young. Dr. Spock says that babies of eight pounds or more are fine during waking hours at 65° to 68°F, the same temperatures recommended for older children and adults. The World Health Organization recommends 61°F (16°C) as a minimum indoor temperature for healthy adults and older children. It, too, recommends a warmer minimum indoor temperature of 64.4°F for young children, the handicapped, and the sedentary elderly.[3] In my experience, this is still too low for comfort among the elderly. (At 64°F, even young people want a warm

sweater when they are reading or enjoying other quiet activities, but perhaps not when they are physically active.) As low as 60°F is a comfortable sleeping temperature for healthy adults, older children, and, according to Dr. Spock, babies who weigh more than eight pounds. But the very young, the elderly, and vulnerable persons should sleep in rooms warmer than this. (Babies under eight pounds do not yet have effective bodily heat regulators, so consult your pediatrician.) Your doctor should be consulted with respect to desirable sleeping temperatures for these members of the household. Those who sleep too lightly may be surprised to discover the comforts of a cool bedroom. But be careful not to get too cold, however, as this can also cause you to sleep too lightly.

When choosing safe and comfortable room temperatures for your household, do not overlook the interplay between temperature and relative humidity, particularly in winter. In winter, if you bring frigid, dry air indoors and heat it, its relative humidity drops drastically, particularly at temperatures of 70°F and higher. (See the explanation for this at pages 399–400, below.) This is both uncomfortable and less healthy—another reason to keep the thermostat at 68°F or lower in winter. In summer, when homes in most parts of the United States are uncomfortably hot for one or more months, an air conditioner effectively dehumidifies as it cools, and its filter helps clean the air. The dehumidifying effect also helps control mold and mites. However, with air conditioners and central air conditioning, proper service, cleaning, and maintenance are essential to prevent the growth of fungi and bacteria in moisture collected in the condensate pan, on coils, in ducts, and at other sites in the system. You can remove the front of your unit and clean the coils, the area behind them, and the blades on the blower, which can become thickly coated with dirt and mold that may then blow into your room. ("Humidifier fever" and hypersensitivity pneumonitis can be caused by microorganisms that grow in air conditioners and humidifiers.) Filters should be changed or cleaned at intervals recommended by the manufacturer.

Room or "evaporative" coolers consume one-fourth of the energy used by conventional air conditioners, and are effective. They are not placed in windows, so they are often recommended for windowless rooms. They, too, require cleaning and maintenance to prevent the growth of molds and microorganisms.

If you dislike or cannot afford air conditioning, you can still have a livably cool home in most climates. Although nothing but these machines will cool a house in the hottest climates, you can make your home appreciably cooler by other means.

External and Structural Means of Cooling. Some of the most important steps to improve cooling can be taken outside your house.

Shade trees, those miraculously refreshing coolers, can lower temperatures in the surrounding area by as much as 9°F, and deciduous trees do you the favor of dropping their leaves in winter, allowing the sun to penetrate to light and warm your home. Elm, oak, maple, sycamore, and ash, which are deciduous trees that form good umbrellas, are popular choices for shade trees. My grandparents' home was kept pleasantly cool in summer by the shade of catalpa trees. Bushes and vines on trellises near the house are also effective. The dramatic cooling effect of trees and bushes is not entirely due to sun blockage. The process of photosynthesis itself produces water that cools the surrounding air as it escapes the leaves, and trees' leafage also absorbs solar heat.[4]

Shade trees should be planted on the northeast-southeast and the northwest-southwest sides of your home. Avoid planting them on the south side (unless where you live is hot all year), because you will want southern sunlight in winter, and even bare

branches block it considerably. Be careful not to block cooling breezes with your trees by putting them too close to the house. Place trees where their roots will not damage pipes, septic tanks, underground wires, or the foundation of your home.

Artificial shade works too. Awnings, louvers, and shutters are available in great variety. Properly installed awnings, according to the U.S. Department of Energy, can reduce heat gain on southern windows up to 65 percent and up to 77 percent on eastern windows. Like leaves, awnings come down in winter so you can get light and warmth when you need it. Before air conditioning took over American cities, lovely awnings were everywhere. In New York, you could walk for block after block and never leave the shade of the awnings on apartment houses and office buildings except to cross the street. Light-colored awnings reflect more heat and light than darker ones. You can buy slatted awnings that do not block so much of the view.

Shutters, although permanent, can be opened or closed, so you need not worry about losing sun on cold or cloudy days. However, they keep out breezes along with the sun, and when closed block all light. On the plus side, they provide a bit of security and help insulate when it is cold. Rolling shutters and shades can often be controlled from the inside, but will still keep out all light when fully extended.

Insulation, weatherstripping, and caulking are as effective at keeping heat out as they are at keeping it in. Insulating an attic cools a house significantly because that is where much of the heat would otherwise enter. Insulating walls is considerably less important, and insulating floors does virtually nothing. Venting an attic is another excellent means of cooling; according to the Department of Energy, ventilated attics may be up to 30°F cooler than nonventilated ones.[5] Place intake vents low and exhaust vents high. You may need professional help to do this properly.

Heat can be reflected from your home by several means. White-painted exterior walls reflect most solar heat away from your home while dark ones absorb most of it. You can buy reflective roof coatings, and tinted window coatings (which will darken your rooms). Avoid any tinting or cooling coatings on your southern windows if you want light and heat from the sun in winter.

Interior Means of Cooling Without Air Conditioners. Window shades inside your home will help cool it, but—with the possible exception of solar shades—not so much as external shades will. If you cannot have outside shade, you should put up sun- or heat-blocking window coverings: indoor solar shades, window shades, venetian blinds, miniblinds, pleated or accordion shades, shutters, draperies, curtains, or whatever else suits you. In choosing, remember that a tightly woven, opaque fabric admits less heat and light than a loosely woven, transparent one, and that light colors reflect more heat. Two layers of draperies provide more insulation than one, and like all insulation will protect against both cold and heat. The closer the draperies hang to the wall, the more insulation they provide.

Venetian blinds are less good as insulators, but they have the advantage of being adjustable to permit different levels of light and air to enter. If you put up two layers of draperies, each with its own drawstring, and venetian blinds, you will have the best of all worlds: insulation, light, and air as and when you want them. Your home will look like a grandmother's—my grandmother's, in fact. But her home was pleasantly cool all summer and warm and draft-free all winter. Pleated and accordion shades are attractive, and you can order them in a range of light-admitting levels, from translucent to opaque. They can be raised and lowered easily. However, unlike venetian blinds, they block a fixed degree of light, they block some air, and when the wind blows, they clack against the window frames. Plain, old-fashioned window shades, although sometimes less pretty in the lower price brackets, do nearly as well for less money and provide somewhat less clacking, although they, too, will flap noisily when the wind is strong.

Proper ventilation can also help cool your home, but only when the air is cooler outside than inside. The Department of Energy recommends that you ventilate in the cool of the morning and evening, and shut windows and employ shade devices in the heat of the afternoon. If you have cool nights where you live, let in the night air; according to the Department of Energy, if, the next day, outside temperatures rise to 85° or 90°F, a well-insulated house will warm up by only 1°F per hour.

In addition to shading and ventilating, you might also attempt to reduce heat from indoor sources, such as appliances and lights. Do not use a conventional oven at all in hot weather. Try to use dishwashers, clothes dryers, and stoves as little as possible, and close the doors to the rooms in which they are operated. Fluorescent lights produce much less heat than incandescent lights do. Window and room fans are also effective at making you feel cool, and they can be used to increase ventilation. Ceiling fans can make you feel four degrees cooler.

Humidity. The humidity levels that feel most comfortable are also, usually, the most healthful. Most homes will do well if they maintain a relative humidity of between 40 and 50 percent. According to the Environmental Protection Agency (EPA), 30 to 50 percent is best for controlling many biological contaminants in the home.

The best measure of moisture in the air is relative humidity, the percentage of moisture actually present in the air compared to the maximum amount the air could hold at a given temperature. Hot air can hold more moisture than cold air can. Thus if the outside air is 30°F and has a relative humidity of 90 percent, and that same air is sent in-

SOLAR SCREENS AND SHADES

You can buy solar screens, solar shades, solar films, and various types of treated glass to block the sun's heat, light, or UV rays, or all three. When considering window treatments, take into account the climate where you live, and consult a window professional before making any big purchases or changes. Think carefully before buying any type of window or window shade that will permanently reduce the level of natural light in your home.

The most expensive choice is to buy window glass that has already been tinted to block solar radiation. Products that have a low shading coefficient block the sun's UV rays. The lower the shading coefficient, the better the product is at blocking heat and UV rays. If the glass also has a low "coefficient of heat transmission" or "U" value, it will block heat; double-paned and insulated glass has this property. Other solar-protection products can be applied directly to the surface of windows. Usually they are difficult to apply. Have a professional do it or the coating may bubble. Even when the coating is properly applied, bubbling or peeling can develop if the coating is exposed to excessive heat. The benefits of any type of treated, tinted, or coated glass vanish when the windows are open.

Solar screens and solar shades are practical choices. Sun screens placed outside the windows typically are made of a vinyl-covered woven synthetic material. Interior sun shades, which may be pulled down, are often made of Mylar. Both are effective, the exterior screens somewhat more so. Exterior screens will also keep out insects and let breezes and light in. They can block 70 to 80 percent of the sun's heat, or more, and they work even if the windows are open. Both types come in different sizes and colors, and in materials of different thickness.

side and warmed to 72°F, it now has a relative humidity of 19 percent. If the air outside is 15°F with a relative humidity of 70 percent, inside at 72°F its relative humidity will be 8 percent. The natural humidity level in my home in winter is a too-low 25 percent. (As heating and cooling experts have been fond of pointing out for at least seventy years, the relative humidity in the Sahara Desert is 25 percent.)

The humidity level in any house or room is determined partly by indoor factors, partly by outdoor ones. For example, kitchens and bathrooms in most homes generate a lot of moisture. Tight construction can trap this moisture in a house just as it traps smoke and dust. In buildings that are not particularly tight, or in any ordinary house when the windows are open, the humidity level indoors is largely determined by the level outdoors.

Very high and very low relative humidities can affect your comfort and your home adversely. At high relative humidities, the body has a reduced capacity to cool itself by perspiring when the weather is warm and a harder time feeling warm when the weather is cool. Low relative humidities may cause eye and nose irritation and itchy, dry skin. Low relative humidities increase static electricity in carpets and woolen and synthetic fabrics used for clothes and upholstery, and they also increase the production of ozone, an eye and lung irritant. Furniture, pianos, violins, other musical instruments, and almost anything made of wood, leather, or other organically derived material will fare ill at both high and low humidities. Wood can shrink and crack when dry, and swell when damp.

High relative humidities promote rust, water condensation (which in turn promotes dry rot and the deterioration of wood), stains on walls and ceilings, the growth of fungi (mildew and mold) and the proliferation of their spores, dust mites, the off-gassing of pressed woods, carpets, furnishings, and other materials, and increased numbers of some airborne viruses and bacteria. Several studies have confirmed a connection between damp homes and increased occurrences of respiratory symptoms such as coughing, phlegm, wheezing, and asthma. Dampness may produce such symptoms by promoting increased levels of allergens, irritants, and infectious agents, or by reacting with substances in the air. Higher levels of airborne dust particles (which may contain allergens) were found, in one study, in homes with relative humidities exceeding 45 percent.[6] It is hypothesized that moisture in the air may combine with nitrogen dioxide and sulfur dioxide (combustion by-products commonly present in the air of the home) to produce acids that help cause respiratory problems.

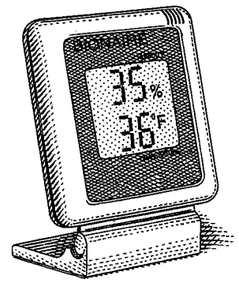
Fungi, which are a major source of allergens in the home, flourish at relative humidities of 75 percent or more; they will grow, but more slowly, when the humidity is lower. Several studies have found a significant connection between the presence of mold and respiratory and allergic complaints. Dust mites, which are widely recognized as one of the key causes of asthma, thrive in moderate to high relative humidities (over 50 percent) but decrease markedly in number at relative humidities of 45 percent or lower. Mites may disappear entirely at the low winter humidities experienced in many homes. (But their allergens may linger. See chapter 33, "Dust and Dust Mites.") The quantities of animal and cockroach allergens in the air may also increase with the humidity.

Low humidity, on the other hand, is generally associated with an increased incidence of colds and flu, and studies indicate that humidifying dry buildings reduces the number of respiratory illnesses. Some studies suggest that many airborne bacteria and viruses that cause flu and colds (for example, when a sneeze produces aerosols laden with the infectious agent that are breathed in) tend to be inactivated quickly at room temperature when the humidity is in the middle range

(between 40 and 60 percent). (Such infectious microorganisms are also transmitted by direct contact. See chapter 30, "Peaceful Coexistence with Microbes.") Thus rates of colds and flu infections are believed to increase both when the humidity is below 40 percent and when it is above 70 percent. Although there have been few studies of the effects of relative humidity on pathogenic bacteria, what evidence there is suggests that the same rule of thumb may hold for many pathogenic bacteria as for viruses: the mid-range of relative humidity appears to be less favorable for their survival than extremes of dryness or moisture.[7]

Indoor relative humidities can thus affect how frequently people acquire infectious diseases, but the frequency will be greatly influenced by a number of other factors. Many infectious diseases are transmitted by routes that are not affected in the same way by relative humidity, so far as we know. The incidence of airborne infection will tend to be greater when more than one person in the household has the infection (because more of the infectious agents will be cast into the air). The incidence of airborne transmission—but not transmission by other routes, such as direct contact—will tend to decrease or be nonexistent where there is a high ventilation rate with fresh air.

For comfort, for avoiding damage to home, furnishings, and possessions, for reducing dust, irritants, and air pollutants, and for reducing the incidence of many allergies and infections, a relative humidity of between 40 and 50 percent is probably best for the home. If you want to minimize allergies from dust mites, aim at the bottom of this range. (See chapter 33, "Dust and Dust Mites.") Even lower relative humidities are sometimes recommended for allergic children, but you should consult your doctor about this. If you are more concerned about dry skin, you will prefer the upper end of this humidity range.



Hygrometer

How to Measure and Control Humidity in the Home. To create the proper relative humidity in your home, in summer you may wish to try a dehumidifier in your basement or other damp areas, and in dry seasons a humidifier in dry areas. You should also buy a hygrometer—an inexpensive device that measures humidity—if your humidifier does not have one built in. (Hygrometers are sold in hardware stores and home centers.) Because relative humidity can vary greatly from room to room, you may want more than one hygrometer in order to monitor each room where you are concerned about the humidity level. Without a hygrometer, you must rely on the weather report, your own sensations of dryness or dampness, or obvious signs of excess moisture such as condensation on windows and other cold surfaces, or mold growth.

If your home lacks a vapor barrier—waterproof material inserted in a wall behind the plaster that prevents moisture from penetrating and condensing inside the wall—a humidifier can overhumidify your home, damaging your walls and causing fungi to grow inside them. Excess humidity can also wreck your plaster. I know of two families who caused the plaster to crack and fall off the ceiling by humidifying or steaming for a croupy child pursuant to a doctor's orders. Some experts recommend that whenever you

use an artificial means of humidifying your home, you aim at the bottom of the recommended range (40 to 60 percent relative humidity) so as to avoid pockets of overhumidity and the consequent danger of mites, molds, or structural damage.[8] But if someone in the home has allergies it would be wise to consult your doctor before using a humidifier.

Air conditioners automatically dehumidify air as they cool it. Because cool air holds less moisture, when steamy outside air is cooled, some of the moisture it contains condenses speedily. Thus air conditioners can help reduce molds and mites by depriving them of needed moisture to grow and, in the case of molds, by enabling you to keep the windows shut against spores. You can dehumidify closets, cupboards, cabinets, and other small, enclosed areas with silica gel crystals or other moisture-absorbent materials or desiccants. See chapter 58, "Closets for Clothes and Linens." Home centers and hardware stores sell bags of absorbent crystals you can hang in closets or other problem areas. A lightbulb left burning in a damp closet will help dry it out. But don't create a fire hazard; be sure nothing is left touching or near the bulb. Exhaust fans vented to the outdoors effectively remove excess humidity and indoor air pollutants in bathrooms and kitchens. Every home should have these, but many do not. Ventilating or placing moisture barriers in crawl spaces, basements, and attics can prevent excessive humidity buildup. Dehumidifiers are said to help significantly anywhere in the home, including the basement. Like most other air-treating machines, dehumidifiers have trays that must be emptied and cleaned at recommended intervals to prevent molds and microorganisms from growing.

When excess dampness in your home cannot be remedied by these or other means, call in expert help for diagnosis and treatment. You may need better drainage in the vicinity of your basement, or a mechanical ventilating system. In any event, persistent dampness is not a problem you can safely ignore.

In the Air

You can ensure that the air in your home is wholesome only if you know what substances tend to take up residence there, their effects, and whether and how they should be removed.

Housekeeping and Other Household Chemicals. Housekeeping has always made use of strong chemicals. One main difference between the households of today and those of a hundred years ago is that today's housekeeper need not mix and prepare polishes and soaps. Here, for example, are recipes for polishes given in the housekeeping manual my great-grandmother used:

> *Furniture Polish.* One and a half ounces each alcohol and butter of antimony, one-half ounce muriatic acid, eight ounces of linseed oil, one-half pint vinegar. Mix cold.
>
> *Stove Polish.* Add to one pint benzine, one ounce pulverized resin; when dissolved, mix any good and finely ground black lead, using the above just the same as you would water for mixing stove polish. Apply with a small paint brush, and rub it smooth, as it dries rapidly; when dry, polish with a soft stove brush; very little rubbing is required. For sheet-iron use the benzine and resin alone, apply with soft rags, and rub rapidly until dry and shining.

My grandmother's stove polish was a stew of poisons. Yet my great-grandparents and grandparents, most of whom lived to ripe old ages, really did keep muriatic acid (hydrochloric acid) and powdered lead in their sheds and cabinets, along with lye, mercury, paris green (used as a pesticide), spanish fly (used against flies in the barn), and benzene, as well as substances commonly seen in many homes today—kerosene, turpentine, paint thinner, ammonia, sodium hypochlorite (ordinary chlorine bleach), and others. In their drafty houses, fumes probably dissipated quickly. Chilblains were the problem.

The sensible attitude, according to most authorities, is to be careful and restrained in the use of chemicals of all sorts in the home, to follow manufacturers' instructions precisely, and to ventilate the home thoroughly, especially when you are using chemical products in a workshop or when cleaning. When used in improperly ventilated rooms and contrary to manufacturers' instructions, some household chemicals can induce symptoms ranging from mild headaches, nausea, and eye irritation to dizziness, faintness, and heart attacks and other potentially fatal effects. In our far tighter houses, the fumes and vapors of housekeeping chemicals—polishes, solvents, waxes, cleaners, and sprays of all sorts—tend to lead to higher concentrations of chemical pollutants, and more kinds of them, than before. (On the potential dangers of fire and explosions from some household chemicals, see chapter 60, "Fire," and chapter 64, "Poisons, Hazardous Substances, and Proper Disposal of Hazardous Household Wastes.")

Oven, drain, and toilet cleaners are among the most powerful chemicals used in the home. Powdered oven cleaners, when mixed with water, release ammonia vapors, which can be dangerous to inhale. Many oven cleaners contain lye, a dangerous caustic that can injure the skin, eyes, and internal organs. Household drain cleaners, too, are often composed mostly of lye. These can be extremely hazardous if by accident they should be ingested, or spilled on skin or clothing. When lye is sprayed (for example, in a spray oven cleaner), some of it gets into the air, and may be inhaled. *If alkaline or acidic cleaners are mixed with chlorine bleach (sodium hypochlorite), they create toxic or deadly by-products. Never mix chlorine with any other cleaning substance.* (See chapter 30, page 432.) Avoid using them in the same area (so as to prevent their fumes from mixing in the air). In a recent study of causes of hospitalization for chemical-related respiratory diseases, it was found that exposure to the fumes of a household cleaning product, or to fumes created by the improper mixing of household cleaning products, accounted for 24 percent of all those hospitalized who were not exposed at work.

Other household products such as some cleaning products, moth balls, spot removers, fabric or rug and upholstery cleaners, dry-cleaning fluids, air fresheners, wood and floor cleaners, paints, spray paints, varnishes, strippers, thinners, glue, and adhesives leave vaporous traces in your home's air—of paradichlorobenzene, naphthalene, benzene, methylene chloride, trichloroethylene, tetrachloroethylene, perchloroethylene, toluene, and other volatile organic compounds and petroleum distillates. Such substances are potentially harmful and must be used carefully; some may damage the brain, central nervous system, liver, kidney, or lungs. All are extremely dangerous or fatal if ingested. Exposure to high levels of their fumes can be irritating, painful, or harmful to eyes, mucous membranes, lungs, and other organs. (Their labels suggest other dangers, including flammability and explosiveness.) Some, such as toluene (found in glue, among other products), are neurotoxins; that is, they cause various ill effects in the brain and central nervous system. In addition, some, such as benzene and trichlororethylene, are known to be carcinogens; methylene chloride, paradichlorobenzene, and perchloroethylene cause cancer in animals. The sources of benzene in indoor air include tobacco smoke, fuels, solvents, detergents, ink, and paints. The most effective moth treatments use paradichlorobenzene. Trichloroethylene, tetrachloroethylene, and perchloroethylene are dry-cleaning fluids. They are used in spot removers, and enter the air in your home from dry-cleaned clothes. Trichloroethylene is also used in other household products, as

well as in copying and printing machines. At exposure levels too low to cause acute poisoning and death—say, the levels one might experience using paint stripper in an unventilated area—methylene chloride, found in such products as paint strippers, aerosol propellants, spray paints, and air fresheners can cause depression of the central nervous system, confusion, memory loss, and lethargy, as well as complications for people with preexisting heart disease or coronary artery disease.

Aerosol products offer insignificant added convenience, and they cost more and pollute the air in your home far more powerfully than spray pump and plain bottle or can dispensers. Aerosols often contain such propellants as propane and nitrous oxide, which are themselves air pollutants. Propane is a flammable gas used in fuels. Nitrous oxide is laughing gas, used by dentists because of its effect on the central nervous system. The amounts of these substances that enter the air when you use an aerosol spray according to manufacturers' instructions are not going to kill you, or even make you feel sick in a well-ventilated room. But you cannot avoid breathing them in; it is natural to wonder whether they have adverse long-term health effects. It is prudent, therefore, to do without aerosols in favor of liquid dispensers and spray pumps.

Some people resort to aerosols to solve odor problems. Air fresheners, however, aerosol or nonaerosol, are not a good solution. Some air fresheners contain chemicals that are toxic in varying degrees. In the past, some air fresheners contained chemicals that did nothing to remove odors but instead reduced your ability to smell by affecting receptors in your nose. (It is dangerous to be unable to smell; you should be able to detect smoke, rot, and other odors that indicate a threat to health or safety.) Other air fresheners contained paradichlorobenzene.

According to the Chemical Specialties Manufacturers Association (CSMA), at present air fresheners for the home contain fragrance as their main ingredient, and no home air fresheners contain paradichlorobenzene, xylene, naphthalene, benzene, or ingredients such as formaldehyde that deaden the capacity to smell. Paradichlorobenzene is sometimes used as a crystalline deodorizing block in urinals in public restrooms or toilet bowls, however, and paradichlorobenzene and naphthalene are still used in moth repellents. When they are present in a product, the label will say so, according to the CSMA, and will prescribe appropriate cautions.[9] Some investigators say that air fresheners for the home still may contain toxic substances. Whatever the truth, you cannot effectively mask an undesirable odor with another odor, so you should not buy air fresheners to solve odor problems. It would probably also be wise to use no air perfumes, fragrances, or scents unless you feel sure you know what they contain. The most pleasant way to scent the air is with fragrant plants or flowers. There are also potpourris of herbs, flowers, and spices; just read labels carefully to see that these are the sole ingredients. Use all air fragrances sparingly; you can inadvertently use too much because your nose may become so accustomed to the scent that you do not notice it even when it is so strong that your guests are overwhelmed.

The Centers for Disease Control (CDC) does not recommend the use of disinfectants sprayed in the air to kill germs or odors in hospitals. New homes and those that have undergone renovations have elevated emissions from paints and other building and installation materials for the first few months. If you are moving into a new home, ventilate well during this period, or, if any member of the household is sensitive, try to arrange for a waiting period before you move in.

Working and Playing. Hobbies and arts and crafts can contribute serious pollutants to the air. Welding, soldering, and sanding can burden the air with dust or fumes and should be done only outdoors or in extremely well-ventilated areas. Glue, epoxy, paint, varnish, shellac, polyurethane, and paint strippers and removers can emit fumes containing such dangerous substances as benzene, methylene chloride, and toluene. Methylene chloride, used in spray paints, solvents, and paint and adhesive removers, vaporizes when used, and can be inhaled. Paint strippers should not be used indoors at all, and persons with heart and lung problems should avoid them altogether.

Excellent ventilation is crucial when using any of these substances. Follow all manufacturers' cautions and safety instructions to the letter. *Never* use paint, varnish, polyurethane, or paint stripper in a closed space. Allow ample time for rooms that have been painted or varnished to air—several days at a minimum. If you paint or varnish furniture (with any type of varnish), let it air in a garage or some other place separate from your living quarters before using the furniture in your home.

Avoid storing containers of fuel, unused paints, and other organic supplies in your home. They can leak fumes or cause dangerous accidents. But do not throw them out with the garbage. Follow proper procedures for hazardous-waste disposal in your area. (See chapters 60 and 64)

Pesticides. Commercial pesticides are almost always composed of substances that can be dangerous to people as well as insects. Try to keep your exposure to any pesticide to a minimum. Pesticide poisonings and exposures are extremely common, and the typical victim is a child. If you must have your home treated for insects, carefully air it afterward until no trace of fumes remains before you reenter. Chlordane, which is carcinogenic in animals, was applied until 1987 to the soil below and around the foundations of buildings to protect them against termites. Its vapors can sometimes rise into the air of the home, even years after treatment. Another pesticide, pentachlorophenol (PCP), which is used to preserve wood, has been found to continue to vaporize for years after application. People have become sick in PCP-treated houses. Mothballs contain paradichlorobenzene or naphthalene. The EPA suggests that you store clothes with moth repellents containing this substance only in separately ventilated areas such as attics or garages.

Dispose of pesticides on a toxic-waste pickup date, at a special toxic-waste disposal site, or in the manner directed by your local sanitation department. Do not throw them out with the garbage. (See chapter 64.)

Ozone. Ozone is good when it is up in the stratosphere protecting us from dangerous ultraviolet radiation. It is unwelcome here on the ground, where it harms trees and crops, or inside buildings, where it harms our lungs, eyes, and mucous membranes. You may have smelled it around some electrical appliances and after lightning storms. It is also produced by some types of air ionizers and air cleaners that, for this reason, are not recommended. Electrical discharges from these sources in effect oxidize oxygen, producing ozone (O_3) out of oxygen gas molecules (O_2) and oxygen atoms (O). Ozone problems appeared in the home in the 1980s when many people set up home offices with copiers and laser printers whose operation produced small amounts of ozone. More recent models, however, are usually designed to be low-ozone or ozone-free.

Ozone production is increased as relative humidity decreases, and the combination of ozone and low relative humidity is particularly unhealthy. The solutions to ozone problems include investing in the latest low-ozone-producing equipment, turning off equipment that is not in use, humidifying, and, as always, ventilating.

Formaldehyde. Formaldehyde is a gas with an easily recognizable smell that enables most

people to detect its presence at low concentrations. It is used as a disinfectant and as a preservative, and is found in a wide variety of resins, wood products, furniture, and paper products such as grocery bags, waxed paper, paper towels, and facial tissues. Formaldehyde is also emitted from fabrics that have been treated for wrinkle resistance, and occurs in various other household products and furnishings. It was the subject of scandal some years ago when many people were made sick by the off-gassing of formaldehyde from building materials used in their homes. Formaldehyde is found in urea-formaldehyde foam insulation and in adhesive resins used in plywood, particleboard, furniture, and carpeting.

Urea-formaldehyde foam insulation was the first formaldehyde culprit to be publicized. This substance is an effective and relatively inexpensive insulator when blown into walls and then sealed. But formaldehyde gas can be released from these walls into the air of the home. The quantity released depends on a variety of factors, including the care with which the foam was made and the injection and sealing were performed. Even when properly used, however, this type of insulation will leak some formaldehyde; high temperatures and humidity seem to increase this effect. Urea-formaldehyde foam insulation was banned for a while by the Consumer Product Safety Commission, but this ban was overturned in the courts. Although legally it may now be used again, except where banned by local laws, adverse publicity and a flood of lawsuits by homeowners have effectively precluded its use in the United States since the early 1980s. Emissions of formaldehyde from foam insulation decline over the years, eventually reaching negligible levels.

Formaldehyde is a carcinogen in animals and produces illness in people. Exposure to formaldehyde can cause eye, nose, and throat irritation, coughing, respiratory distress, headaches, and dizziness, and some people will become allergically sensitized to it. Anyone who experiences illness that may be attributable to formaldehyde should seek medical advice.

A variety of steps may be taken to reduce formaldehyde emissions in the home: remove whatever product is emitting the formaldehyde; increase ventilation; wash permanent-press clothes immediately after purchase; thoroughly air out permanent-press draperies in a ventilated basement or unused room or outdoors until a day or two after you detect no odor; apply varnish, paint, or polyurethane to unfinished furniture or pressed-wood products. Over time, formaldehyde off-gassing will subside, but this usually takes a number of years. Some state and local health departments will test homes for the presence of formaldehyde.

Asbestos. Asbestos is a powerfully carcinogenic mineral that causes such deadly diseases as lung cancer, mesothelioma (cancer of the lining of the chest and abdominal cavity), and asbestosis when tiny, invisible fibers of it become airborne and are inhaled. Such diseases have long been recognized: insurance companies stopped issuing policies for asbestos workers in 1918. The process is insidious; disease may not appear for twenty or more years after exposure. Smokers are at much greater risk for developing disease from asbestos exposure than are nonsmokers.

Asbestos in the home is not likely to become airborne unless it is damaged, crumbling, or deteriorating, or it has been tampered with. Even when it does become airborne, its levels in the home are usually quite low. But because the risk of disease increases with the quantity of asbestos inhaled, all authorities recommend extreme caution when dealing with asbestos, and urge you to call in professionals to handle asbestos hazards. Your job is simply and solely to recognize a potential asbestos problem and take it immediately to the right helpers. Reliable identification of asbestos requires laboratory testing, and should be done before you attempt expensive repairs that you may not need. Before you begin any repairs or remodeling in your home, evaluate the possibility that doing so will pose an asbestos problem.

If you think you have found asbestos, *stay away, seek professional advice, and in the meantime do nothing to disturb it. Only professionals can safely sand, drill, cut, saw, hammer, scrape, sweep, dust, vacuum, or remove materials containing asbestos.* Vacuuming, sweeping, and dusting always cause an increase of airborne particles, and you don't want to increase the number of airborne asbestos particles. If the asbestos is in good condition, you will usually be advised that the best course of action is simply to leave it alone. If remediation is required, however, it generally takes the form of removal or repair by encapsulating, sealing, or covering the asbestos.

Stringent regulations now control products that use asbestos, but this was not true in the past. Asbestos was often used for insulation, fire protection, and soundproofing until 1973, when the EPA prohibited its use for these purposes. In 1975, the EPA also prohibited its use in pipe covering if the material would easily crumble after drying. The Consumer Product Safety Commission (CPSC) forbade the use of respirable asbestos in patching compounds and artificial fireplace ash and embers in 1977. In 1986 the CPSC promulgated a labeling requirement for all products that contain asbestos: asbestos paper and millboard; asbestos cement sheet; dry-mix asbestos furnace or boiler cement; asbestos wood or coal stove-door gaskets; asbestos stove mats and iron rests; central hot-air furnace duct connectors. Finally, in 1989, the EPA instituted a phased-in ban on almost all asbestos products by 1996. The following advice on where and when asbestos in the home is likely to be a problem comes from "Asbestos in Your Home," a pamphlet prepared by the American Lung Association in conjunction with the EPA and the CPSC:

> Common products that might have contained asbestos in the past, and conditions which may release fibers, include:
>
> *Steam pipes, boilers,* and *furnace ducts* insulated with an asbestos blanket or asbestos paper tape. These materials may release asbestos fibers if damaged, repaired, or removed improperly.
>
> *Resilient floor tiles* (vinyl asbestos, asphalt, and rubber), the backing on *vinyl sheet flooring,* and *adhesives* used for installing floor tile. Sanding tiles can release fibers. So may scraping or sanding the back of flooring during removal.
>
> *Cement sheet, millboard,* and *paper* used as insulation around furnaces and wood-burning stoves. Repairing or removing appliances may release asbestos fibers. So may cutting, tearing, sanding, drilling, or sawing insulation.
>
> *Door gaskets* in furnaces, wood stoves, and coal stoves. Worn seals can release asbestos fibers during use.
>
> *Soundproofing* or *decorative material* sprayed on walls and ceilings. Loose, crumbly, or water-damaged material may release fibers. So will sanding, drilling, or scraping the material.
>
> *Patching* and *joint compounds* for walls and ceilings, and *textured paints.* Sanding, scraping, or drilling these surfaces may release asbestos.
>
> *Asbestos cement roofing, shingles,* and *siding.* These products are not likely to release asbestos fibers unless sawed, drilled, or cut.
>
> *Artificial ashes and embers* sold for use in gas-fired fireplaces. Also, other older household products such as *Fireproof gloves, stove-top pads, ironing board covers,* and certain *hairdryers.*
>
> *Automobile brake pads* and *linings, clutch facings,* and *gaskets.*

This pamphlet and other materials on asbestos and indoor air pollution are available from your local chapter of the American Lung Association (check the telephone directory in the nearest large town or city) and from the United States Consumer Product Safety Commission, Washington, DC 20207. For further information, call your state environmental protection department or contact the regional office of the EPA in your area. There is a CPSC hotline that can give you information on certain appliances and products that contain asbestos, including brands and models: (800) 638-CPSC. Or call your state or local health department. When hiring a contractor, choose only a certified asbestos-removal professional.

Radon. Radon is a dangerous radioactive gas naturally produced by the breakdown of uranium in the ground. It is a potent cause of lung cancer, as the tragic experience of uranium miners exposed to elevated levels of this gas proves. Radon risks, like asbestos risks, are greatly increased in smokers.

In many homes radon is found in concentrations many times higher than those found outdoors. When radon develops in the soil, it sometimes seeps into cracks in foundations and other openings, and thus enters the air in houses and buildings. More infrequently, radon present in well water is drunk, is released into the air during showers and other household activities, or is emitted by building materials derived from the earth. But radon is believed to be less dangerous when swallowed than when breathed in.

The EPA hypothesizes that low-level radon exposure in the home produces as many as fourteen thousand lung cancer deaths per year. One recent study estimated that 11 percent of lung cancer deaths in smokers and 30 percent of lung cancer deaths in those who have never smoked are attributable to radon. Critics of such claims argue that there is no evidence that at low levels radon has any measurable ill effects. Nonetheless, at present the EPA recommends testing all homes below the third floor for radon. (Apartment dwellers above the third floor need not worry.)

Never decide that your home is safe because your neighbor's is. Two adjacent houses may have different radon test results. You may also have heard that radon problems tend to be specific to particular neighborhoods or geographical regions. That is true, but individual homes may have radon problems in areas where other homes do not. Nor should you decide against testing because you believe that your house is too well sealed or too well ventilated or too new. The only basis for feeling confident about the absence of radon problems is a proper radon test.

You can have your home tested by a professional or a state-licensed tester, or you can test it yourself with a radon-testing kit. Use only a kit whose package states that it meets EPA requirements. In order to achieve an accurate result, follow the guidelines and instructions for radon testing established by the EPA and your state or local health department. Because radon levels in a home can vary from day to day and season to season, some of these guidelines aim at making your test results reflect average radon levels, and because radon levels tend to be higher in the lowest parts of the home and to be affected by breezes and other factors, the tests contain instructions intended to preclude results that will either exaggerate or understate the typical radon levels in your home. Both long-term and short-term testing kits are available, as are many different passive and active testing devices. (The latter require power to function.) When you have completed the test at home, you send the testing device to a laboratory for analysis. A written report of the results will be returned to you.

Once testing is completed, you must decide whether to take action. The EPA currently recommends that you act if the results of one long-term test or the average of two short-term tests show radon levels of four picocuries per liter (4 pCi/l) or greater. The EPA advises that remedial steps can generally reduce the levels to below 2 pCi/l. The average home in the United States has 1.3 pCi/l, and the average outdoor level is 0.4 pCi/l. The Indoor Radon Abatement Act of 1988 specified that in the long term we should aim to achieve indoor levels that are no higher than those outdoors.

Given that the risks increase with the level of radon, you may wish to take action to reduce the radon in your home even if its concentration is below the EPA's action level. Modest and inexpensive steps to improve your home's ventilation rate seem prudent, and can be as simple as opening the windows or installing fans or ventilation systems. When you are tightening your house for energy-conservation purposes, moreover, keep in mind that if you cut the ventilation rate in half, you will double the radon concentration.

Once you have determined that you must take action to reduce radon, the EPA advises that you seek the assistance of a professional who is state certified, or listed in EPA's Radon Contractor Proficiency (RCP) Program, or both. Remedial steps that a qualified contractor might take include using fans, vents, pipes, and soil suction (in which radon is routed away from your house by pipes in the ground that vent the gas to the air above your house), repairing cracks in your basement floor and walls, and performing subslab depressurization (in which suction pipes are inserted in the slab under the house), sealing, natural ventilation, and mechanical ventilation.

Lead. Most people know that lead poisoning is serious business, especially where children are concerned. Most are also aware that lead can occur in paint, water, food, china and crystal. But some people are surprised to learn that lead can contaminate the air in

ASBESTOS DOS AND DON'TS FOR THE HOMEOWNER

- Do keep activities to a minimum in any areas having damaged material that may contain asbestos.
- Do take every precaution to avoid damaging asbestos material.
- Do have removal and major repairs done by people trained and qualified in handling asbestos. It is highly recommended that sampling and minor repairs also be done by asbestos professionals.
- Don't dust, sweep, or vacuum debris that may contain asbestos.
- Don't saw, sand, scrape, or drill holes in asbestos materials.
- Don't use abrasive pads or brushes on power strippers to strip wax from asbestos flooring. Never use a power stripper on a dry floor.
- Don't sand or try to level asbestos flooring or its backing. When asbestos flooring needs replacing, install new floor covering over it, if possible.
- Don't track material that could contain asbestos through the house. If you cannot avoid walking through the area, have it cleaned with a wet mop. If the material is from a damaged area, or if a large area must be cleaned, call an asbestos professional.

—American Lung Association, with the U.S. Consumer Product Safety Commission and the U.S. Environmental Protection Agency

Radon gas detector

their homes. Sometimes the source of indoor lead dust is outdoors. This happened in 1990 in Lynn, Massachusetts, when a sandblasting operation on a railroad bridge spread lead-contaminated dust throughout the neighborhood where the bridge was located; the lead was carried indoors in the air and on shoes and clothes. Sometimes the source of the problem is indoors. Leaded paint may have been used in any home built before the 1970s and may still exist hidden under newer layers of paint. When this paint peels, crumbles, or deteriorates, or is sanded, rubbed, scraped, or disturbed in any way, it can be ground up into lead-containing dust that becomes airborne. Breathing in such dust is one of the most common sources of lead poisoning in children.

Inexpensive kits are available for lead testing of hard surfaces in your home. There are also kits for testing tap water in your home for lead; or you can send samples of your water to your public health department (or other local authority) or to a private laboratory for testing. In the meantime, if you are not sure whether you have lead in your pipes, run the water for a minute—until it runs cold—when you get up in the morning and any other time the tap has been unused for a long period. This ensures that you do not drink water that has had many hours to leach lead from the pipes. Do not drink or cook with water from the hot tap; hot water dissolves lead more readily.

Finding out whether you have lead in the air of your home is less simple, unfortunately. You can hire a trained professional to come to your home for a thorough inspection and analysis. Your doctor can test you and your children. If elevated levels of lead are found in the blood, you will probably be visited by your local department of health. If lead paint is discovered, you may or may not have to do something about it, depending on its condition and location, whether you have young children, and whether they have elevated lead levels in their blood. Remedial steps include removal, encapsulation or effective covering, and simple cleaning techniques. Some authorities claim that simply cleaning up any lead dust that forms is as good as or better than engaging in an expensive and possibly dangerous lead-abatement program. You cannot choose the proper response without expert advice, and neither can you carry out the remedial work safely on your own. Note that some studies show that vacuuming carpets with HEPA vacuums does not help reduce the lead-dust levels because these vacuums suck as much new dust up from the lower reaches of the carpet as they remove.

Encapsulation techniques, such as wallpapering or painting over the problem areas, are intended to prevent lead-containing dust from forming. Encapsulation techniques must take into account potential danger spots, such as doors and windows, which may stick and rub against floors or door or window frames and cause the formation of lead dust at the sticking points. They also require attentive maintenance; sometimes lead dust forms anyway and must be removed.

When lead paint must be removed, or when you intend to renovate, remodel, or remove walls or plaster containing lead paint, hire professionals trained in lead abatement. They are hard to find and charge high fees, but the work is dangerous. Such projects—or any repairing, sanding, scraping, or sawing of any areas or objects containing leaded paint—can create airborne dust contaminated with lead. Dust produced from renovations will have to be kept from seeping into the rest of the house by sealing off work areas with thick plastic sheets and duct tape. I know from sad experience, however—fortunately with lead-free dust—that despite such efforts you can end up with dust coating your entire house. Children and pregnant women may be advised to stay out of the home entirely until any lead dust unavoidably created has been removed. When the work has been completed, you may face a major cleanup operation throughout your home, not just in the painted or renovated area.

For information on how to find qualified lead-abatement contractors in your area, call your local or state health department. Some locales keep lists of qualified contractors. The EPA has designed training courses in lead abatement that are administered by many states, and some contractors will be able to show you a certificate stating that they have completed this course. Postings of people offering to do lead abatement are also available on the Internet.

Off-Gassing and Fumes Produced by Fabrics and Carpets. Draperies, upholstery, rugs and carpets, and clothes can put out irritating gases, such as formaldehyde or dry-cleaning chemicals. Some synthetics and plastics may let off gas if heated by the sun or otherwise. Newly installed synthetic fiber carpeting, and carpeting adhesives in particular, may sometimes produce shockingly strong odors for periods lasting from a few days to weeks, rendering a room unlivable in the interim. Be sure to inquire about such problems before you purchase and install carpeting. Low-emission alternatives are available. Look for the green and white label of the Carpet and Rug Institute, indicating low-emission levels; and see the discussion and suggestions on pages 468–69 in chapter 35, "Textile Furnishings."

Microorganisms. When there is inadequate ventilation in the home, the concentrations of all microorganisms in the air, including pathogenic ones, increase proportionately. This can increase the incidence of infections and allergic reactions such as flu, colds, chicken pox, allergic rhinitis, and asthma in members of the household. Increasing your ventilation is an obvious first step. But you can also reduce the number of microorganisms polluting the air by controlling indoor humidity and keeping clean all machines that affect your air: air conditioners, humidifiers, vaporizers, dehumidifiers, heating and cooling systems, ventilators, and refrigerators. Pay special attention to their drip trays. If you have water-damaged or soaked carpets, upholstery, or building or other materials from leaks, floods, or accidents, you may have to consider getting rid of them or replacing them if you cannot dry them within a day or so. After that, molds and bacteria will have begun to grow, and they are difficult to eradicate. After a flood or other natural disaster or water damage from other causes, seek and follow the advice of your local public health department.

House Dust. House dust, which can contaminate the air and surfaces in the home, presents a number of housekeeping issues that are addressed separately in chapter 33, "Dust and Dust Mites."

Furnaces, Stoves, Heaters, and Fireplaces

Any fire that burns in your home is in competition with you for the oxygen in the air, and produces by-products that become harmful above certain concentration levels. The basic principles governing the use of fire in the home are these: first, supply an adequate source of oxygen for the fire, and second, supply a method of venting combustion by-products.

All effective and well-maintained furnace systems are set up to do just this. Intake vents supply air for oxygen, and exhaust pipes and vents carry off the smoke and gases produced when fuel of any kind burns. Fireplaces draw air from the room and, if all goes well, send the by-products up the chimney. Vented heating stoves, whether they burn wood, pellets, oil, kerosene, or any other fuel, have vents that permit them to draw air from the room; the air exits through pipes to the outdoors. Almost all clothes dryers have outdoor exhausts too. But some people use space heaters and room heaters that have flames but lack vents; gas and wood-burning cook-

ing stoves and ovens often lack outdoor exhausts. Inadequate air supply and malfunctioning or nonexistent exhaust systems can produce extremely serious air problems.

Carbon Monoxide. The by-products given off by stoves and heaters depend on the type of fuel, how hot the fire is, how much air is supplied, and other factors. All fires, however, produce carbon dioxide (CO_2), a colorless, odorless gas normally present in the atmosphere and usually harmless. (At high concentrations, carbon dioxide can cause headaches, loss of judgment, and suffocation; at lower but still elevated levels it is also considered unhealthy.) Carbon monoxide (CO) is produced only when there is inadequate oxygen, a situation that results in incomplete combustion of the carbon present in fuel so that carbon monoxide rather than carbon dioxide forms. Carbon monoxide is a deadly, odorless, colorless gas. It can produce grogginess or confusion, fatigue, headache, nausea or vomiting, dizziness, blurred vision, rapid breathing, and, in great enough quantities, unconsciousness and death. In many instances, its symptoms are confused with those of the flu or food poisoning.

If flues and dampers on furnaces and heating stoves are not properly set or are blocked, if there are cracks in pipes, loose gaskets, or other entry points for combustion by-products, or if chimneys are blocked, carbon monoxide may be produced and build up inside the home. Every year, more than two hundred fifty people in the United States die from carbon monoxide poisoning in incidents involving combustion appliances. The EPA recommends that you have all fuel-burning appliances inspected by a trained professional at the beginning of every heating season: oil and gas furnaces, gas waterheaters, gas ranges and ovens, gas dryers, gas or kerosene space heaters, fireplaces, and wood stoves. All should be installed, maintained, and operated in accordance with all manufacturer's instructions, especially the warnings, cautions, and safety tips. Have flues, vents (including the dryer's outside vent opening), and chimneys inspected and cleaned. If they are blocked or malfunctioning, this can cause carbon monoxide build-up. Avoid having any unvented fuel-burning stove, heater, or appliance in your home. But if you do have one, never operate it unless you open a window a couple of inches—at least; keep the doors to the room open too.

Carbon monoxide is also present in car and lawn mower exhaust fumes, and each year some people die when cars or mowers are left running in an attached garage and their fumes penetrate the home. When starting your car, first open the garage door, then turn on the motor and immediately drive out; likewise, turn the motor off immediately upon entering the garage. Do not warm up the car in the garage, even with the garage door open. Do not turn on the motor while you are doing maintenance or repairs on your car in the garage. Do not turn on or store lawn mowers in the garage. Remember that weed trimmers, snow blowers, chain saws, generators, and small motors can also create carbon monoxide problems. In all cases, be alert to the possibility of a carbon monoxide problem, particularly if you notice headaches, grogginess, fatigue, dizziness, nausea, vomiting, confusion, or flulike symptoms.

WHAT TO DO IF YOU SUSPECT CARBON MONOXIDE POISONING

If you or anyone in your family experiences symptoms that you think could be caused by carbon monoxide, get fresh air immediately; open doors and windows, turn off combustion appliances, and leave the house. Call the fire department. Seek medical attention. Tell the doctor that you suspect carbon monoxide poisoning. If your carbon monoxide detector goes off, you should immediately ventilate: open your doors and windows. Check everyone for symptoms of carbon monoxide poisoning, especially infants and others who have trouble communicating.[10]

WARNING SIGNALS OF CARBON MONOXIDE PROBLEMS WITH FURNACES, HEATING SYSTEMS, OR FUEL-BURNING APPLIANCES*

The following situations are possible signs of carbon monoxide danger:

- streaks of carbon or soot around the service door of your fuel-burning appliances;
- absence of a draft in your chimney (indicating blockage);
- excessive rusting on fuel pipes or appliance jackets;
- moisture collecting on the windows and walls of furnace rooms;
- fallen soot from fireplace;
- small amounts of water leaking from the base of the chimney, vent or flue pipe;
- damaged or discolored bricks at the top of your chimney;
- rust on the portion of the vent pipe visible from outside your home.

*Excerpted from "Questions and Answers About Carbon Monoxide and CO Detectors," Underwriters Laboratories.

Carbon monoxide poisoning frequently occurs when charcoal is used indoors for cooking or heating. In the past, sentries in the British Army, who warmed themselves outdoors with charcoal burners, would sometimes place the burners in the open doorways of their sentry boxes, only to die of carbon monoxide poisoning. Never burn charcoal or operate a barbecue grill indoors—not even in a fireplace or basement—or near doors or windows.

Carbon monoxide detectors are recommended by all safety experts. But, as the EPA cautions, they are no substitute for proper use and maintenance of your fuel-burning appliances and should not lull you into a false sense of security. Carbon monoxide detectors show a wide range of reliability in tests, with some failing to alarm even when carbon monoxide levels reached high levels. Others alarmed even at very low levels that pose no health risk. This can be particularly frustrating in that, unlike the situation with smoke alarms, you cannot easily confirm that there is no danger from an odorless, colorless gas such as carbon monoxide. Be sure to read consumer publications for advice and look for the Underwriters Laboratories certification on any detector you buy.

Like smoke alarms, carbon monoxide detectors make a shrieking noise when set off. Be sure that you get one that sounds an alarm, not one that just measures the level of carbon monoxide; otherwise you will not be alerted to danger while you sleep or at any other time unless you go and read the indicator. Remember that a carbon monoxide detector does not detect smoke or fire!

Read your manufacturer's brochure carefully and install and place carbon monoxide detectors in accordance with the manufacturer's instructions. Generally, you will be advised to put at least one on every level of your home. Be sure to put one in your bedroom or just outside your bedroom where you are sure to hear it while you are sleeping. Various household chemicals and cleaning substances can damage the carbon monoxide detector's sensing device, so you will be advised to install it at a distance from these. You may get false alarms if you install one in your kitchen, garage, or furnace room. Your man-

Carbon monoxide detector

KNOW YOUR ALARMS

A safe home probably contains smoke alarms, a carbon monoxide detector, and perhaps a burglar alarm. Thus it behooves you to become familiar with the alarm sound that each makes, and to make sure that each member of the household is familiar with the sounds too. If you wake up to a shrill alarm in the middle of the night, you do not want to be guessing at whether the danger is fire, carbon monoxide, or intruders.

ufacturer's instruction booklet will contain additional important cautions about placement and use of your carbon monoxide detector.[11]

If your carbon monoxide detector is wired into your electrical system, test it monthly; if it is battery-operated, test it weekly and replace the battery once a year or more frequently if your manufacturer recommends this. Leave the battery in the detector; don't use it in your Walkman or your child's toy. You can make the yearly change of batteries at the same time as you change your smoke detector batteries—in the fall when you set your clock forward at the end of daylight savings time.

Unvented Space Heaters. Unvented kerosene and gas space heaters, which increased in popularity when fuel prices rose dramatically in the 1970s, should not be used in the home. Kerosene heaters are banned in some states. California requires unvented kerosene heaters to bear a label stating "not for residential use." Nonetheless, the vast majority of the fifteen to sixteen million of them now in use are in people's homes. *They pose serious fire and burn hazards in addition to creating potentially dangerous gases.* See chapter 60, "Fire." Newer, improved models, which are safer in several respects, are considerably less likely to produce carbon monoxide than are the older ones, but the older ones are still in use in many homes. Moreover, studies show that kerosene and gas heaters produce excess amounts of carbon dioxide, nitrogen oxides (nitrogen dioxide and nitric oxide), formaldehyde, and carbon monoxide. One study showed that sulfur dioxide (SO_2) was also produced by kerosene heaters.

Nitrogen dioxide (NO_2) is a colorless, odorless gas that irritates mucous membranes in the eyes, nose, and throat. Exposure to high concentrations can cause shortness of breath; low levels can increase the risk of respiratory infections. Nitrogen dioxide may affect lung function in young children, and some animal studies suggest that it contributes to the development of emphysema. Sulfur dioxide is a pungent, toxic gas that forms one of the destructive ingredients in smog. The Consumer Products Safety Commission warns that unvented kerosene heaters, particularly in closed rooms, can cause health problems in asthmatics and people with lung disease and heart disease. Others are not likely to suffer harm from these heaters' combustion by-products, however, so long as the heaters are used in well-ventilated rooms and are not used for long periods of time. *It is extremely dangerous to sleep in a room in which an unvented heater or stove is burning.*

Burning Wood. Carbon monoxide poisoning can be caused by wood fires too. Wood-burning stoves and fireplaces, like kerosene heaters, produce carbon monoxide, carbon dioxide, and nitrogen oxides, in addition to benzopyrene, a carcinogen, and respirable suspended particulates. Because wood stoves and fireplaces are vented, their combustion by-products enter the home only when the venting system malfunctions through improper installation, downdrafts in the chimney, cracks in the stovepipe, or other problems. Nonetheless, studies have shown that such by-products almost always do enter to some degree, producing elevated levels of breathable particles and benzopyrene. Your total exposure from wood burned in the fireplace for pleasure will likely be too low to cause harm. But some studies raise questions about the health effects of fireplaces and wood-burning stoves used as major sources of heat, or for cooking. Several studies suggest that children in households that use wood-burning stoves for indoor heat have significantly higher rates of respiratory illness.

Wood stoves should be checked for proper installation, inspected frequently for leaks in stovepipes, and adjusted at regular intervals. Fireplace users should employ proper techniques for causing the chimney to draw, and for reducing smoke. Do not use green wood, chemically treated wood, or damp wood in stoves or fireplaces. Open the flue before lighting the fire and do not close it until the ashes are cold. Tight-fitting fireplace doors are also recommended. Good ventilation is necessary in rooms with wood stoves or fireplaces so that the fire can draw enough oxygen. See chapter 48, "Fireplaces."

Gas Stoves. Gas stoves are used in 60 percent of the homes in the United States. They do not really boil water faster than electric stoves do, as is commonly believed, but they permit you to change cooking temperatures far more rapidly. Unfortunately, when gas cooking stoves are not vented to the outside, they cause elevated levels of carbon monoxide, nitrogen oxides, formaldehyde, and respirable particulates in the home. According to one study, the levels of carbon monoxide produced after two burners and the oven are lit for two hours are more than two and a half times greater than the EPA's maximum allowable eight-hour average concentration for outdoor air. (There are no comparable standards for indoor air.) People who unwisely use their cooking stoves for heating purposes create increased levels of indoor air pollution. Pilot lights also cause pollution. Use a range or dryer with an electric spark-lighting system. Make sure any area in which a pilot light is burning is well ventilated.

There is controversy about the health effects of cooking on gas stoves. Several studies have found increases in respiratory illnesses in children, and decreased lung functions in children and adults, in homes with gas cooking stoves, but other studies do not agree. The weight of the evidence at present seems to lean toward the existence of at least some negative health effects.

Until more is known, the commonsense response to these worries is simply to install a range exhaust to the outdoors over your gas stove (if you do not already have one). This is an easy way to prevent most of the combustion by-products of your stove from building up indoors. A second response is to improve the overall ventilation in your kitchen and the rest of your home. Opening the window always helps, but an exhaust fan over the stove or range hood that simply recirculates the air in the room does not help. It can even make things worse; unless it is cleaned and its filter replaced frequently, it can support the growth of molds and microorganisms and cause offensive odors. Finally, some cooks settle for a gas stove cooktop (with an exhaust to the outdoors) and an electric oven, a readily available combination that can significantly reduce the level of air pollution from combustion in your home air. You should have your gas range and all other gas appliances (dryer, furnace) inspected and, if necessary, adjusted at regular intervals. If the flame on your gas range or any pilot light burns yellow or orange (instead of blue), you need to call for service. Finally, never use a gas range for heat. (See also chapter 60, "Fire.")

Tobacco Smoke

Smoke from cigarettes, cigars, and pipes is probably the most serious of all indoor air problems. Publicity about the lethal effects of smoking and of breathing secondhand

tobacco smoke is so widespread that there is little point in repeating the sad statistics here. Secondhand smoke is particularly dangerous for children and for those with heart or lung disease. Tobacco smoking adds to indoor air not only the usual products of combustion, but other carcinogens, including nicotine, that are drawn from the tobacco itself—about forty carcinogens in all. The more smoke, the greater the levels of these substances. Smoking sometimes aggravates the effects on health of other air pollutants, such as asbestos and radon. The best solution is for the smokers to stop. Smoking outdoors helps, as does smoking next to a window. No one should ever smoke indoors when children are present. Increasing ventilation in the home is essential; good air-cleaning machines also help quite a lot.

Air-Cleaning Devices

Air Filters and Cleaners. Heating and air-conditioning systems help clean the air in your home by filtering it as it passes through. Filters should be cleaned regularly at intervals recommended by the manufacturer to ensure that you reap their benefits. They can block only large particles, however.

Air-cleaning machines are also available, and a good one is highly desirable in homes with smokers or other air problems. Some are more effective than others. Technology in this area changes, so check consumer product research publications before buying. Choosing a machine of the right size and maintaining it carefully are essential if you are not to waste your money. Those with HEPA filters are most effective. These are said to remove just about everything that gets into the air: mold spores, pollen, animal dander, dust, tobacco smoke, and some bacteria. A HEPA filter cannot trap gases. Most air cleaners are not designed to remove gases, but some have absorbent materials that can trap some gases. Air cleaners are also said to be fairly ineffective with dust-mite allergens because these remain in the air for only a short time before they resettle on surfaces. At present the EPA does not recommend using air cleaners to remove radon. In general, according to the EPA, source control is the most effective solution to indoor air pollutants. Air cleaners should be used only as a backup measure.

Houseplants. You have probably read that plants clean the air. Plants really can remove gases and vapors such as carbon monoxide, formaldehyde, benzene, and trichloroethylene from the air of your home. But, says the EPA, a reasonable number of houseplants cannot remove enough pollutants to make a difference. It is pleasant to think that a philodendron might make my air clean, but I believe the EPA. Those who believe in the plants recommend that you set out two to three plants in eight- or ten-inch pots for every one hundred square feet of floor space. The larger and more numerous the plants, they say, the cleaner your air, and the longer you keep them, the more effectively they clean. Note that the EPA, however, also cautions that watering too many plants in your home can increase humidity and lead to mold and other problems. It is probably best to choose the variety and number of your houseplants according to your tastes and what will thrive in your home without creating an over-humid indoor environment.