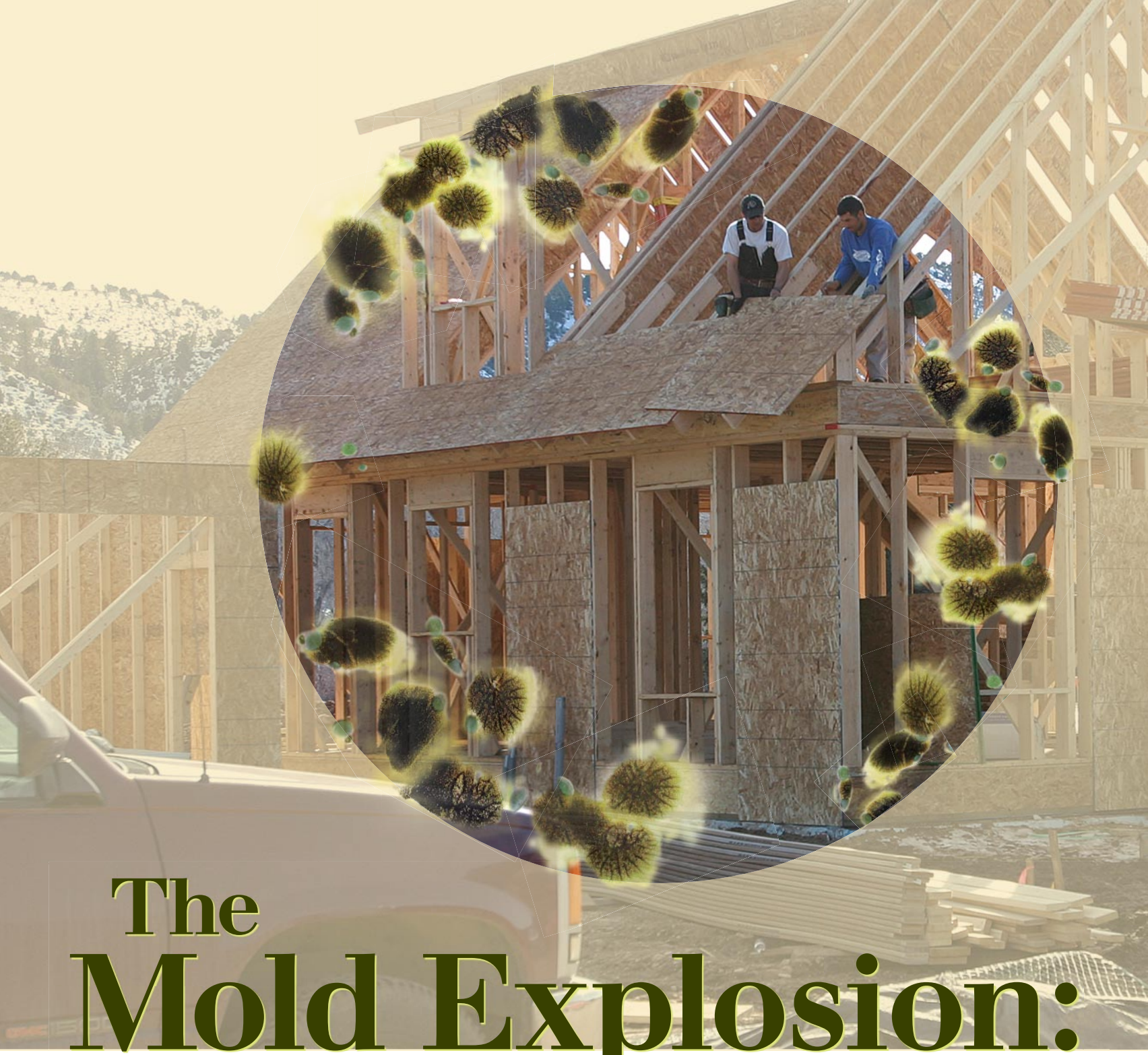


The Mold Explosion:

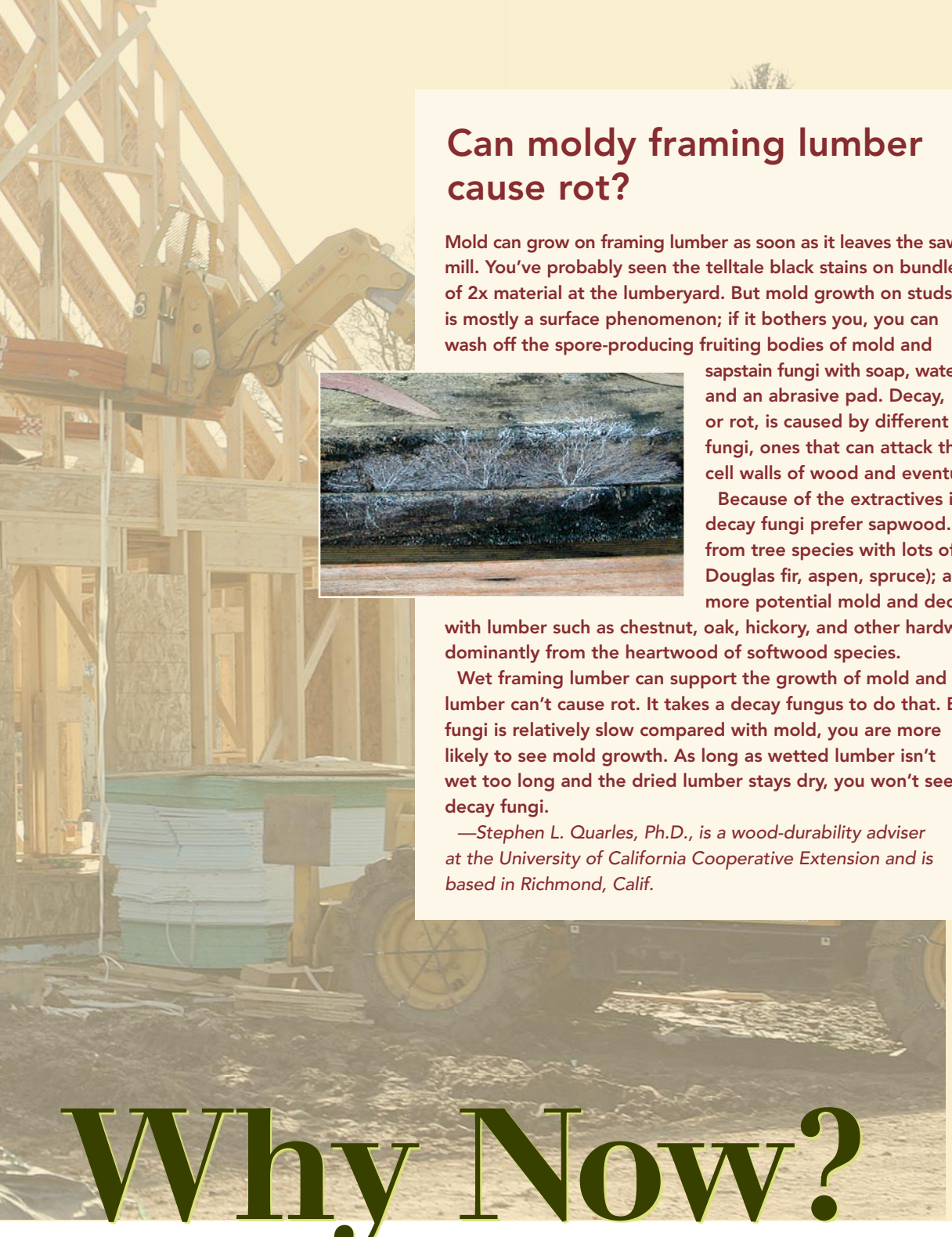
Today's houses make it easier for mold to find the food and water it needs to thrive. The cure is a quick cleanup and smarter choices in materials.

BY JOSEPH LSTIBUREK

Mold isn't a bad thing. Without it, we wouldn't have beer, blue cheese, or penicillin. When mold starts attacking the inside of your house, however, it is a bad thing. Even before the memorable onslaught of hurricanes in 2004 and 2005, we'd seen a lot more moldy buildings. Mold claims in Texas alone increased by five times a few years ago and cost homeowners' insurers more than $1 billion in 2001. Why?

Mold is a water problem. Excluding the flooding in the Gulf states, though, there suddenly isn't more water, so why is there more mold? The problem is that the water we've always had is hanging around in a

Photo: Daniel S. Morrison. Mold photo: Dan Sahli.



Why Now?

Can moldy framing lumber cause rot?

Mold can grow on framing lumber as soon as it leaves the sawmill. You've probably seen the telltale black stains on bundles of 2x material at the lumberyard. But mold growth on studs is mostly a surface phenomenon; if it bothers you, you can wash off the spore-producing fruiting bodies of mold and sapstain fungi with soap, water, and an abrasive pad. Decay, or rot, is caused by different fungi, ones that can attack the cell walls of wood and eventually cause structural failure.

Because of the extractives in heartwood, both mold and decay fungi prefer sapwood. Framing and sheathing are made from tree species with lots of sapwood (southern yellow pine, Douglas fir, aspen, spruce); as a result, today's houses have more potential mold and decay food than earlier houses built with lumber such as chestnut, oak, hickory, and other hardwoods as well as lumber cut predominantly from the heartwood of softwood species.

Wet framing lumber can support the growth of mold and decay fungi, but by itself, moldy lumber can't cause rot. It takes a decay fungus to do that. Because the growth rate of decay fungi is relatively slow compared with mold, you are more likely to see mold growth. As long as wetted lumber isn't wet too long and the dried lumber stays dry, you won't see decay fungi.

—Stephen L. Quarles, Ph.D., is a wood-durability adviser at the University of California Cooperative Extension and is based in Richmond, Calif.

Like mold, this blue-stain fungus can't penetrate heartwood. *As a tree ages, sapwood is converted to heartwood and often gains decay resistance.*

new generation of building materials that can't tolerate water as well as yesterday's building materials could. Today's building materials are also more palatable to mold because they're more refined.

Many of the wood products that make our lives convenient during the construction process can make our lives inconvenient later on. These deficiencies don't show up, though, until something bad happens. It can be a single event like a hurricane, or an ongoing event like a roof valley that lets water into the house every time it rains.

While "toxic mold" makes headlines, news stories tend to offer more hype than hope. It's really not difficult to avoid mold problems if you understand how mold works. Getting rid of mold isn't so difficult, either.

Mold likes sugar, and trees are made with sugar

To engineers like me, trees are just big batteries. Let me explain: A tree stores the energy it converts from the sun (through photosynthesis) in the form of glucose, which is a hunk of sugar. When we burn the tree, we convert the energy in glucose into heat.

Mold prefers the sugar found in dead plants, which is in the form of cellulose. Unfortunately, we build houses out of dead plants and

Photos right: Stephen L. Quarles

TODAY'S WOOD PRODUCTS ARE EASY FOR MOLD TO EAT

Refining wood makes the mold nutrients more accessible to mold. As we go through this refining process, we also switch to tree species that are high in sapwood content and make them more susceptible to mold.

Solid lumber

Even young, violent mold with a bad attitude can't get the sugar from old-growth timber-frame structures. That's because most of the lumber is heartwood cut from species like Douglas fir, white pine, and white oak. Mold can live on a sapwood surface, but it doesn't like the heartwood that's common in old buildings.

Sheathing

Rather than cutting the tree into ¾-in.-thick boards for sheathing, we now peel the tree and smash the layers together under heat and pressure. This heat and pressure caramelizes the wood sugars into mold candy, or plywood. We also flake the mold candy and put the flakes in a vat to make oriented strand board. OSB is the Spam of mold food. Because we peel and flake the tree, we can use smaller trees that are faster-growing and contain mostly sapwood. If you're mold with the choice between 2x4s and OSB, which are you going to choose? OSB, every time.

Particleboard and MDF

We take those candy fibers, and we grind them down to make sawdust. Then we add nitrogen to make particleboard (the nitrogen is like Cajun seasoning for fungi). We make furniture, cabinets, flooring, and underlayment from this. If you're mold with the choice between OSB and MDF, which are you going to choose? MDF, every time.

Paper-faced drywall

Finally, we grind the sawdust and reconstitute it to make nature's most perfect mold food: paper. Old mold with no teeth can eat paper. We glue the paper on both sides of drywall and wrap the insides of buildings with it. On commercial buildings, we wrap the outside, too. Even the dumbest of the three little pigs didn't build his house with paper. Sometimes we color it green to fool the mold and put it in the shower. We glue tile to the paper, and we hose it down with hot water twice a day. Unless you're mold, repeat after me: paper, water, bad.

dead-plant by-products. That's OK as long as we don't make it easy for mold to get to the cellulose. Unfortunately, as wood is refined from a log to the paper facing on drywall, the cellulose is chopped, baked, ground, and seasoned to become easier for mold to eat.

Mold likes water, and houses leak

Living inside of mold food isn't too much of a problem as long as we make it hard for mold to eat the food. We do this by avoiding moisture problems. When houses get wet at a rate that exceeds their ability to dry out, moisture accumulates. When the rate of accumulation exceeds the storage capacity, we have a moisture problem. The house can't dry out. The amount of water coming in isn't the problem; it's the balance of how much water is coming in compared with how much is going out.

Unfortunately, both the storage capacity and the drying potential of houses have decreased over the past 100 years. You can store a lot of water in lath and plaster, but you can't store much in drywall. The drying potential has shrunk because of thermal insulation and the lower permeability of roof and wall materials (plastic vapor barriers).

Ductwork: the mold superhighway

We've made building materials into better mold food as we move down the processing stream from tree to paper, we've reduced the drying capacity of houses by adding insulation and vapor barriers, and we've reduced the storage capacity of houses by using newer materials that can't store much water (if any at all).

The last big change in our buildings is that they now are hollow. Walls, floors, and ceilings are hollow cavities. These hollow cavities with insulation in them can't control airflow or moisture. We're inadvertently building complex three-dimensional airflow networks.

The classic example is a commercial building where the dropped ceiling acts as the return plenum. The dropped-ceiling return plenum is connected to the exterior walls, and the interior walls are connected, too. We've got a three-dimensional airflow network where every interior partition wall is connected to the exterior walls by the floor and the ceiling assembly, so everything is connected to everything else. That network is the contaminant interstate. It transports mold from wet walls to the breathing zone of the space via the building's mechanical system.

Residentially, we do the same thing with forced-air heating and cooling when HVAC contractors bang a few pieces of sheet metal on the underside of a floor joist or a stud cavity and call it an air return. Basically, they're drawing air through wall and floor cavities. And the floor and the partition walls are connected to the cavities of the exterior envelope with holes cut for plumbing and electrical. We're connecting the envelope to the breathing zone via the mechanical

Living inside of mold food isn't too much of a problem as long as we make it hard for mold to eat the food.

We do this by avoiding moisture problems.

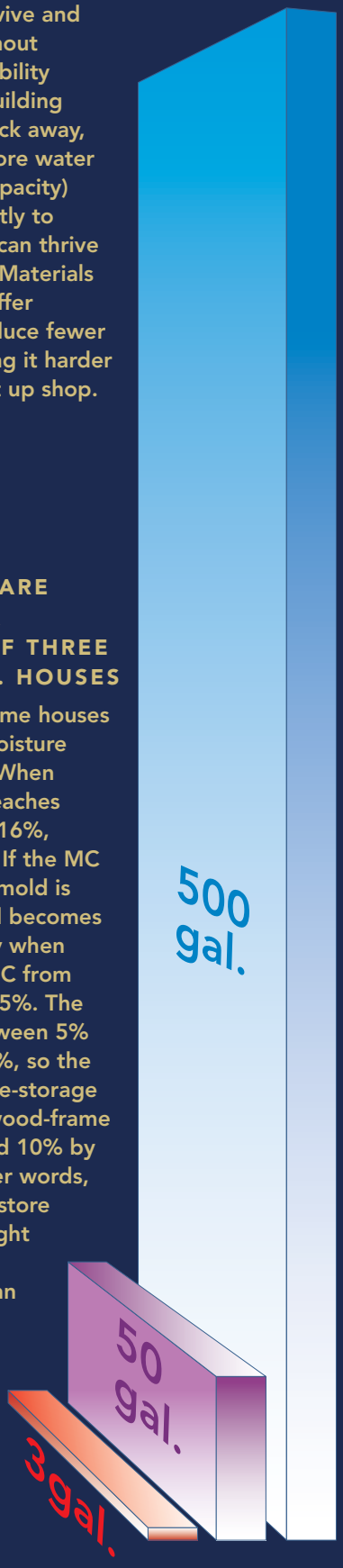
Photos this page: Krysta S. Doerfler

MOLD THRIVES ON THE MOISTURE IN TODAY'S HOUSES

Mold can't survive and reproduce without water, so the ability of particular building materials to wick away, absorb, and store water (their buffer capacity) is related directly to whether mold can thrive in your house. Materials with higher buffer capacities produce fewer puddles, making it harder for mold to set up shop.

LET'S COMPARE THE BUFFER CAPACITY OF THREE 2000-SQ.-FT. HOUSES

Most wood-frame houses average 5% moisture content (MC). When solid lumber reaches MC of around 16%, mold is active. If the MC is under 15%, mold is dormant. Mold becomes a problem only when we push the MC from 5% to above 15%. The difference between 5% and 15% is 10%, so the typical moisture-storage capacity of a wood-frame house is around 10% by weight. In other words, the house can store 10% of its weight in moisture before mold can break out of dormancy and reproduce.



In a typical 2000-sq.-ft. house, the wood weighs 5000 lb. The buffer capacity is 10% of that, or 500 lb. So the house can hold 500 lb. of water before mold can cause a problem. A gallon of water weighs 8 lb. (which is a lousy number to divide by, so for simplicity, let's call it 10 lb.); 500 lb. divided by 10 lb. equals 50 gallons. This house can have **50 gallons** of leaky plumbing, bad flashing, and poor drainage, and mold won't be a problem.

Swap steel studs and gypsum sheathing for plywood and 2x4s. Steel studs can hold 0% of their weight in moisture. Gypsum sheathing can hold about 0.7% of its weight in moisture (0.7 is a lousy number to divide by, so for simplicity, let's call it 1%). The gypsum sheathing in the house weighs 3000 lb. The buffer capacity (1% of 3000) is 30 lb., or about **3 gallons** of water.

In a 100-year-old masonry house with plaster walls and a rock foundation, the buffer capacity works out to be about **500 gallons.**

Can mold make me sick?

Most molds reproduce by making spores, which are small enough to mix and move freely with air. When spores become airborne, you can be exposed three ways: You can inhale spores into your lungs, you can absorb them through your skin, or you can ingest them.

Mold's musty odor is caused by volatile organic compounds (VOCs) that can create reactions including eye irritation, runny nose, cough, wheezing, laryngitis, headaches, and nausea. Some types of molds also produce mycotoxins that can be irritating to breathe, touch, and ingest. Remediation workers handling mold-contaminated materials without skin protection have developed skin lesions, skin dryness, and rashes. Similarly, ingesting food contaminated with mycotoxins can cause digestive problems such as diarrhea.

In most cases, the symptoms disappear when exposure to mold is curtailed or eliminated. That's why it's important to dispose of moldy materials, stop mold growth, and wear protective gear when doing mold cleanup. (See "How do I clean up mold?" on p. 75.)

After a flood or sewer backup, more than mold can make you sick. You also could be exposed to bacteria and human pathogens, which can cause sickness or death if you're not properly prepared to handle them.

—Laura Oatman is a research scientist with the Minnesota Department of Health.

WIN THE WAR ON MOLD BY CHOOSING MATERIALS WISELY

Combined with good details such as flashing and a sloping grade away from the house, materials can have a big effect on a house's mold tolerance. Smart decisions can be made everywhere between basement and roof sheathing.

Photo: Daniel S. Morrison

Driveways

Make porous driveways with pavers or bricks set in gravel. This type of driveway reduces runoff, which can cause problems for you and your neighbors.

Photo: Charles Bickford

Foam sheathing

Use foam sheathing to insulate inside basements and crawlspaces because it doesn't absorb water. Using foam outside wall sheathing eliminates the condensing surface on the plywood's inside face.

Photo: Courtesy of Frame Guard

Framing

For hurricane- and flood-prone areas, use framing lumber treated with antimicrobial coatings (BluWood, 561-416-1972, www.perfectbarrier.com; FrameGuard, 770-801-6600, www.conradfp.com).

Photo: Daniel S. Morrison

Exterior walls

AdvanTech (www.huberwood.com) and plywood are the best sheathing choices; regular OSB is second best. The worst choice is paper-faced drywall.

Photo: Scott Phillips

Housewraps

Nonperforated housewraps such as Tyvek, Typar, Weathermate Plus, WeatherSmart, asphalt-saturated kraft paper, or asphalt-impregnated felt repel water and let vapor escape.

Photo: Krysta S. Doerfler

Siding drainage

Plastic mat material or wrinkled housewrap like Tyvek's Stucco-Wrap allows water to drain out (www.benjaminobdyke.com; www.stuccoflex.com).

Photo: Roe A. Osborn

Siding

Aluminum, vinyl, and fiber-cement siding are more water-tolerant than wood. If you use wood siding, it needs a drainage plane, and all the ends must be sealed with primer.

Photo: Christopher Ermides

Spray foams

Spray-foam insulations are breathable and water-tolerant (www.sealection500.com; www.icynene.com; www.biobased.net; www.insulstar.com; www.corbond.com).

Photo: Andrew Wormer

Loose-fill insulation

Borate-treated cellulose has big buffer capacity (www.nuwool.com; www.greenfiber.com).

Photo: Roe A. Osborn

Tile backerboard

Use cementboard or a fiberglass-faced drywall like DenShield (www.gp.com) for tile backing in a shower or other wet area.

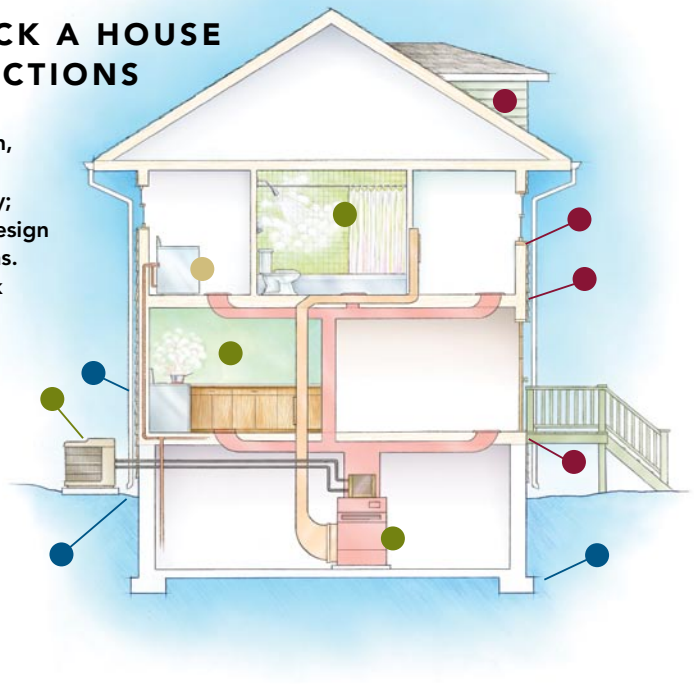
Photo: Courtesy of Huber Inc.

Roof sheathing

Use Zip Roof panels (shown), which are AdvanTech sheathing with sprayed-on membrane and tape that actually sticks (www.huberwood.com). Or use AdvanTech or plywood covered entirely with a self-stick membrane: Tri-Flex 30 or Ice & Water Shield (www.graceathome.com), Polyglass (www.polyglass.net), or Flintflash SA (www.certainteed.com). Stickiness is key; the membrane shouldn't blow off during construction or in hurricanes.

WATER CAN ATTACK A HOUSE FROM MANY DIRECTIONS

Some common water problems are easy to fix after construction, but many are complicated and expensive to repair retroactively; they're best addressed in the design stage before construction begins. Four major water sources attack your house.



Plumbing

Supply or waste pipes in exterior walls, where they don't belong

Clothes washers or water heaters on an upstairs floor, where they don't belong

Rain

Poorly detailed valleys, chimneys, and roof-to-wall interfaces

Poorly flashed windows and doors

No drainage plane on outside of wall

Poor deck-to-wall flashing

Surface and ground water

Ground sloped toward the house

Gutter downspouts not directed away from the house

Bad footing-drain detail

Interior moisture

Vapor barrier and vinyl wall coverings

No exhaust fan in kitchen and bathrooms

Poor interior ventilation

Oversize air-conditioning unit

system. To me, that's the greatest danger and the greatest tragedy of the buildings that we're constructing today. The principle is the same for residential and commercial, whether we're in Alaska or in Florida. This inadvertent linkage of the occupants to the envelope via the mechanical system is something that nobody expected or predicted. When we add this piece to the three others that I've described, it answers the question, "Mold, why now?"

View mold as the canary for all other contaminants. If they're carried by air, decay fungi and other pollutants are likely to be transported along this three-dimensional airflow network into the breathing zone of building occupants.

The fix: smart design and remediation

We build houses of materials with little buffer capacity and with thousands of pounds of water in cast concrete. We fill them with insulation, we wrap them with vapor barriers on the inside and on the outside, we heat them and cool them without any understanding of the physics, and we look around and wonder why they're turning into mush and falling down. But there's no mystery here.

The solution starts with selecting materials systems differently. We can choose smart materials and simple systems or simple materials and elegant systems. When you have a water problem, fix the problem quickly and dry it out, or replace the damaged materials. Don't wait for the lawsuits to establish who's at fault. Fix the problem quickly, and it won't be worth quibbling over who pays for it. The cost will be minimal.

And please, don't blame mold and indoor-air quality problems on energy conservation. Yes, if houses were leaky, we wouldn't have these problems, but the answer isn't to take out the insulation and make the house leaky. The answer is to understand what went wrong, get past this issue, and build even higher-performing buildings. As a society, we can't afford to build disposable structures. People aren't disposable, and buildings shouldn't be disposable, either. □

Joseph Lstiburek, Ph.D., P.Eng., is a principal of Building Science Corp. (www.buildingscience.com) in Westford, Mass.

Drawing: Don Mannes

How do I clean up mold?

Consider the size of the mold problem when deciding who should do the cleanup. You can tackle most small jobs (less than 10 sq. ft.) yourself. Big jobs require a professional.

Small mold problems usually result from small water problems. If you don't fix the water problem, the mold will grow again. And don't put off the cleanup; do it within 48 hours. The longer you let it go, the more mold you'll have.

If the source of the water was clean, such as that from a pipe leak or from rain, mold can be cleaned by scrubbing hard surfaces with detergent and water. You don't need bleach. Then dry everything thoroughly. Throw away most soft or porous items if they get moldy because they are difficult or impossible to clean. For mold caused by contaminated water (sewage), consider using a cleaner/sanitizer, which is widely available in grocery stores and hardware stores.

It's also important to avoid exposing yourself to mold while cleaning it up because mold produces both allergens and irritants. Wear an N-95 respirator ($10 to $25), goggles (without ventilation holes, $5), and water-resistant gloves ($5). You can get this protective gear at most hardware stores.

—Laura Kolb works with the U.S. Environmental Protection Agency's Indoor Environments Division (www.epa.gov/mold).