Wood Fungi
Causes & Cures

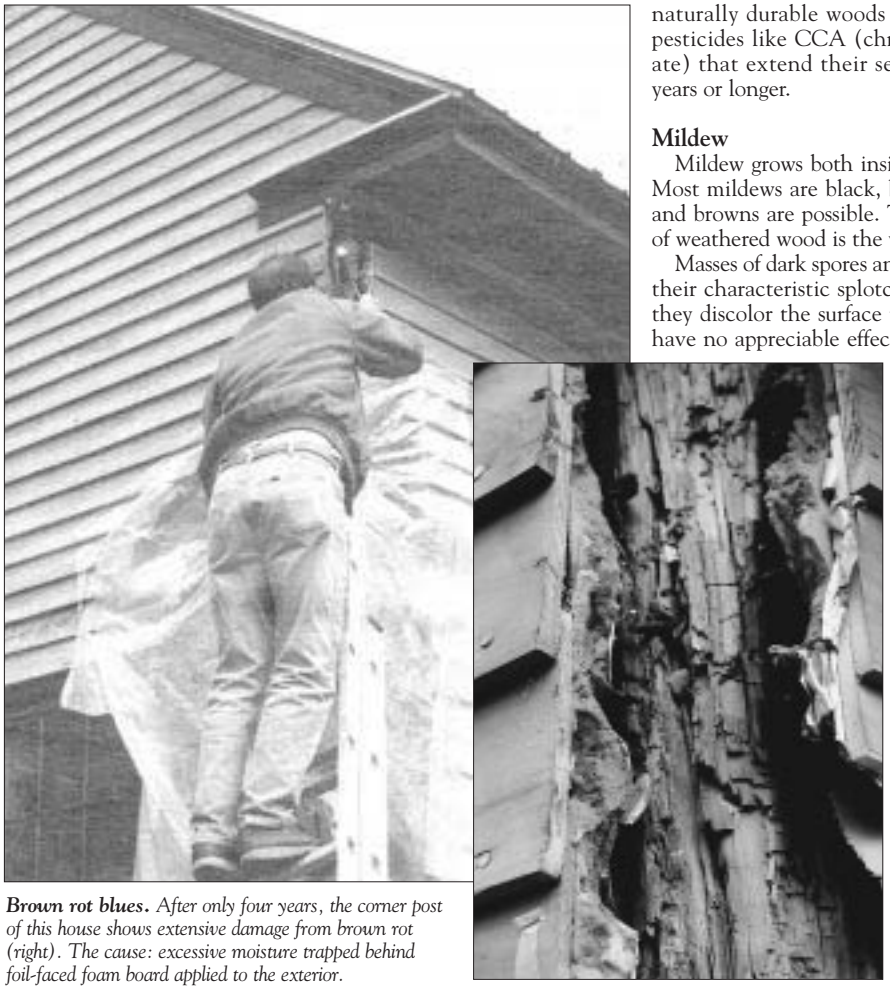
BY STEPHEN SMULSKI

More than 5% of all construction lumber manufactured in the U.S. each year is used to replace wood that has decayed in existing structures. This need not be the case. Damage to wood-frame buildings by mildew, mold, staining, and decay is entirely preventable. Their presence points to design flaws, poor workmanship, and neglected maintenance.

The Culprits: Microorganisms

The microscopic organisms that cause mildew, mold, staining, and decay in wood belong to a huge group of primitive plants known as fungi. Unable to produce their own food, fungi feed instead on natural substances that make up organic materials like leather, cloth, rattan, paper, and wood.

Mushrooms that spring from lawns and tree trunks are fungal "fruits." They release millions of dust-size "seeds" called *spores* that are scattered helter-skelter by wind. When conditions are right on the surfaces where they eventually settle, the spores germinate, sending out thread-like filaments called *hyphae*. Enzymes secreted by hyphae break down organic matter so fungi can use it for food.



Brown rot blues. *After only four years, the corner post of this house shows extensive damage from brown rot (right). The cause: excessive moisture trapped behind foil-faced foam board applied to the exterior.*

Before fungi can colonize wood, four requirements must be met: an oxygen supply, temperature in the 40°F to 100°F range, sufficient moisture, and a food source (wood). Infection can be prevented by eliminating any one of the requirements. Obviously, it's hard to limit oxygen. Temperature control is tough too, since most living things thrive in this range. And even at subfreezing temperatures, many fungi don't die; they just go dormant.

Since you can usually control moisture to some extent, the most effective way to prevent fungal deterioration of wood is to keep it dry. Most fungi need a wood moisture content of at least 20% to grow. Since the moisture content of interior wood throughout most of the U.S. fluctuates between 6% and 16%, it's usually too dry for most microorganisms to get started.

In exterior or other situations where wood can't be kept dry, you can use naturally rot-resistant woods like western red cedar and redwood. Nature has partially protected these woods from fungi by depositing toxic extractives in their heartwood. But the supplies of naturally durable woods are shrinking, so to meet the demand, less naturally durable woods are impregnated with pesticides like CCA (chromated copper arsenate) that extend their service life by 30 to 50 years or longer.

Mildew

Mildew grows both inside and outside houses. Most mildews are black, but reds, greens, blues, and browns are possible. The familiar gray color of weathered wood is the work of mildew.

Masses of dark spores and hyphae give mildews their characteristic splotchy look. But although they discolor the surface they grow on, mildews have no appreciable effect on wood itself. Some mildews that feed on airborne organic matter can even grow on inorganic vinyl and aluminum sidings. Dew and rain supply the needed moisture.

Exterior mildew. Outside, mildews appear most often on unheated, projecting parts of buildings that cool quickly after sunset, like eaves, decks, and porch ceilings. North-facing walls and walls shaded by trees and other obstructions that restrict sunlight and airflow are also candidates. You often find mildew in the same places where dew forms. While mildew won't grow where siding crosses studs and other thermal bridges, mildew may thrive over the cooler, insulated bays between studs, where the dew persists to provide the needed moisture.

Interior mildew. Mildew occurs indoors most frequently in baths, basements, and other areas prone to high relative humidity. It also shows up in places with poor air circulation, such as behind furniture against exterior walls, and in closets and closed-off rooms. Mildew can form whenever the relative humidity of air near a surface exceeds 70%. This can happen when warm air near the

MOLD, MILDEW, STAINING, AND DECAY ALL DAMAGE WOOD IN VARYING DEGREES, AND ALL CAN BE PREVENTED BY CONTROLLING ONE CONDITION: EXCESSIVE MOISTURE

ceiling cools as it flows down colder wall surfaces. The relative humidity of 70°F air, for example, rises from 40% to 70% when it's cooled to about 52°F.

Thermal bridges that lead to "hot spots" outside create "cold spots" inside where mildew can form. Exterior corners are notoriously mildew-prone because of poor air circulation inside and heat-robbing wind outside. In summer, water vapor from warm, humid air entering crawlspaces and basements below air-conditioned rooms may condense on cooler joists and subflooring, creating good conditions for mildew, as well as mold, stain, and decay. Moisture condensed as ice from heated air leaking into attics in winter likewise wets rafters and sheathing when it melts.

Stopping mildew. Not only is mildew unsightly, its spores and odors indoors can trigger allergic reactions. Fortunately, ridding wood of mildew is easy. But first, do a simple test to see if the splotches are mildew or just plain dirt. Place a drop of fresh household bleach containing sodium hypochlorite on the suspected area. The dark color of mildew will fade in a minute or two, while dirt is unchanged.

Once you've determined the stain is mildew, clean it by brushing or sponging the surface with a solution of one-third cup household detergent, one to two quarts household bleach, and two to three quarts of warm water. Or use commercial cleaners. Wear eye protection and gloves, and rinse surfaces with water.

Virtually all exterior finishes — paints, solid color and semitransparent stains, and water repellents alike — are susceptible to mildew. Oil-base formulations, especially those with linseed oil, are particularly vulnerable. Among water-base coatings, acrylic latexes have proven the most mildew-resistant. Defend against mildew on siding and trim by using only primers and topcoats that contain mildewcide, or by mixing in the add-it-yourself types that paint shops sell. Finishes with zinc oxide pigments also deter mildew. But beware: Finishes applied over mildewed surfaces that are recoated without first killing the fungus will soon discolor.

The amount of moisture generated inside a home may be beyond your control, but you can encourage use of the bath exhaust fan, for example, by wiring it to the room light switch or to a timer. Install louvered doors to ensure airflow in closets. Use a soil cover and vent and/or insulate crawlspaces as site and climatic conditions dictate. Always install a vapor retarder and use plenty of insulation in walls and attics, and provide adequate roof ventilation.

Molds

Molds need a wood surface moisture content of about 20% to get started. To provide that, simply surround wood with air at 90% relative humidity at any temperature from 40°F to 100°F, and presto! That's why mold and mildew sometimes suddenly appear on furniture during the dog days of summer.

While most molds are green, black and orange molds are not uncommon. The color comes from spores strewn across the surface. Though hyphae reach deeper into wood, discoloration in softwoods tends to be limited to the surface of the sapwood. It can usually be planed, sanded, or even brushed off. Brown, gray, or black patches penetrate more deeply into hardwoods and can't be machined away. Discoloration aside, molds generally have little effect on wood's integrity.

Some molds are surprisingly tolerant of wood preservatives. This explains the fuzzy growths occasionally found between boards in banded shipments of CCA-treated southern yellow pine. Molds die once lumber dries, but can be washed off beforehand with the same solution used for mildew.

Preventing mold. Flourishing in damp crawlspaces and basements and in poorly vented attics, molds form a living veneer on framing and sheathing. Prevention lies wholly in controlling air moisture levels and condensation potential through proper site drainage and dampproofing, and again, the proper use of soil covers, vapor retarders, insulation, and ventilation as required in your area.

Staining Fungi

Discoloration of wood by staining fungi happens almost exclusively in logs and freshly sawn lumber. As a precaution, rough lumber is often dipped in a fungicidal bath immediately after sawing.

Also called sap stains, these fungi are most troublesome in softwoods, where they cause a steel-gray to blue-black color commonly called blue stain. In hardwoods, staining fungi may create blue or brown hues. The stains result from dark hyphae that permeate sapwood in search of stored starches and sugars. You can often spot inactive blue stain in doors, millwork, and other pine products. Active staining fungi sometimes discolor the bottom rails and corners of pine windows that are kept wet by condensation. These stains are indelible and will not wash off.

In their search for food, staining fungi destroy certain wood cells. As a result, the wood becomes more permeable, and more susceptible to decay. Its strength and toughness are slightly reduced as well.

Decay Fungi

While discoloration by mildew, mold, and staining fungi is only an appearance problem, decay fungi threaten the structural integrity of wood. Aptly termed the "slow fire," these fungi eat the very cellulose and lignin of which wood cells are made.

Moisture content is the critical factor that makes wood susceptible to decay. It must exceed 28%, and liquid water must be present in cell cavities before decay fungi can gain a toehold. Once established, some fungi can carry on their destruction at a moisture content as low as 20%. When moisture content falls below this level, all fungal activity ceases. That's one reason why framing lumber is dried to 19% moisture content or less.

In its early, or *incipient*, stages, decay can be difficult to detect, even with a microscope, yet strength loss can still be appreciable. As the slow fire advances, wood's luster fades. Surfaces become dull and discolored, and a musty odor is often present. The rate at which decay progresses depends on moisture content, temperature, and the specific fungus.

It doesn't take a trained eye to recognize decay in its advanced stages. Wood is visibly discolored, spongy, and musty. Surfaces may be stringy, shrunken, or split across the grain. Cottony masses of hyphae called *mycelia*, as well as fruiting bodies, may be present. Decay extends deep into wood; strength loss is significant.

Brown rots and white rots. Decay fungi fall into three major groups: brown rots, white rots, and soft rots. Soft rots are rarely found inside homes, though they occasionally degrade wood shakes and shingles on heavily shaded roofs in wet climates.

Detecting Decay

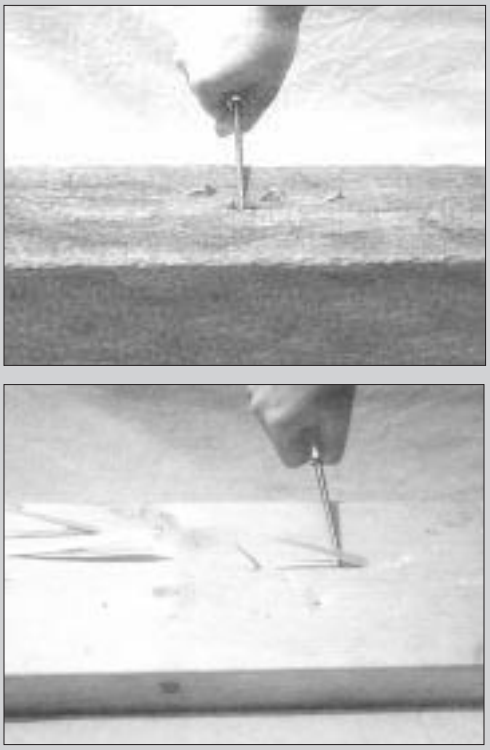
I use several methods when looking for decay in wood. When wood is suspiciously wet or discolored, but otherwise looks okay, I first determine its subsurface moisture content with a moisture meter. If it's 20% or below, I know that there's no active decay present. If it's between 20% and 28%, existing decay can continue merrily on its way. If it's over 28%, conditions are ripe for fungi to get started.

The pick test is also useful (see photos). I judge the soundness of the wood from the way a large splinter breaks when I pry it with an awl or ice pick. Sound wood emits a sharp crack as the splinter is pried up. The splinter is typically long, with one end still attached to the wood. Sometimes it breaks in the middle over the tool, but the fracture will still be splintery.

A splinter pried from wood with incipient decay lifts quietly from the surface and almost always fails directly over the tool, with both ends still anchored to the wood.

The pick test is highly subjective; natural characteristics of sound wood can produce misleading results. Accurate interpretation comes only with experience and consideration of other clues.

To find decay hidden inside timbers, I take a small-diameter boring and examine the shavings. Discolored, wet, and musty shavings signal decay. I always plug the hole with a preservative-treated dowel. — S.S.



Pick test. *A short splinter pried from decayed wood (left) typically breaks quietly over the tool with both ends still anchored. When pried from sound wood (bottom), the splinter cracks sharply, is longer, and remains attached at one end only.*

Fungi Field Guide

A guide to fungus identification and habitat.

(All case studies photographed in southern New England.)

Mildew

Dark stains, usually black, on surface of wood. Needs 70% relative humidity at surface to grow. Primarily a visual problem. Will lighten from bleaching.

Location: Cedar siding on shady side of house.
Cause: Persistent wetting from dew.

Location: Bottom side of roof sheathing, new home.
Cause: Dryer vented into attic.

Mold

Green, black, or orange discoloration on surface of wood. Can penetrate below the surface of hardwoods and cause permanent stain. Needs a surface moisture content of 20% to get started.

Location: Douglas-fir floor joists in basement.
Cause: High humidity in basement.

Brown Rot

The most common decay fungi in softwoods. Requires 28% moisture content to start, but once established, needs only 20%. Turns wood brown and crumbly, with cross-grain and cubical checking. May sprout cottony mycelia and mushroomlike fruiting bodies.

Location: Behind shower stall in 22-year-old home.
Cause: No vapor retarder, no bath exhaust, cold outside wall corner.

Location: Crawlspace of 20-year-old apartment building.
Cause: Standing water and poor ventilation. Note mycelia (left) and fruiting bodies (right).

Location: Sill in direct contact with concrete in five-year-old home.
Cause: Untreated wood on concrete slab-on-grade.

Location: Trim at entrance to three-year-old home.
Cause: Splashing water from unguttered eaves two stories above. Exposed endgrain sitting on metal flashing.

Staining Fungi

Discoloration of wood in logs or freshly sawn lumber, primarily softwood. Can also occur on pine windows wet from condensation. Steel-gray to blue-black color, commonly called blue stain. Stain is indelible.

RICHARD B. NEWTON

Photo: Eastern white pine lumber, sawn green during humid summer months, discolored by blue stain.

White Rot

Most common in hardwoods, giving them a whitish, gray, or yellow bleached appearance. Turns wood spongy and stringy.

RICHARD B. NEWTON

Photo: Partially decayed, or "spalted," rock maple. Spalted maple is prized by woodworkers for its figure.

Brown rots are so-named because infected wood turns dark brown. They usually colonize softwoods, consuming cellulose but hardly touching the darker lignin, which is the natural glue that holds wood cells together. Mycelia appear as white growths, either sheetlike or fluffy, on the wood's surface. Brown-rotted wood shrinks excessively and splits across the grain as it dries. The surface becomes friable and crumbly, and shows cubical checking.

Water-conducting fungi are a special type of brown rot that show up infrequently in the Southeast, Northeast, and Pacific Northwest. These fungi are unique in their ability to pipe moisture from the soil over long distances. They do this through rootlike fusions of hyphae called *rhizomorphs*, wetting otherwise dry wood in advance of their attack. Water-conducting fungi are sometimes called dry rot fungi. Unfortunately, this name suggests that dry wood can decay. Dry wood can't decay, period! What builders, inspectors, and homeowners alike routinely mislabel as dry rot is almost always, in reality, wood that got wet, rotted, and dried out before discovery.

Water-conducting fungi infect both softwoods and hardwoods. Their light-colored mycelia look like large, papery, fan-shaped sheets. Damp crawlspaces and wood in contact with the ground are avenues for entry.

White rots give wood a white, gray-white, yellow-white, or otherwise bleached appearance. They most often infect hardwoods, feeding on both cellulose and lignin. In advanced stages of decay, white-rotted wood is spongy, has a stringy texture, and lacks the cubical checking of brown-rotted wood. A thin black line often marks the advancing edge of incipient white rot in hardwoods. Ironically, this partially decayed, or *spalted*, wood is coveted by woodworkers for its unique figure.

Dealing With Decay

Like mold, mildew, and staining, existing decay can be stopped by drying up the moisture. But remember that to make the remedy permanent, you've got to cure the disease (water infiltration) not just treat the symptoms (mildew, mold, and decay).

Stopping decay. The first and most important step when you find decay is to figure out where the water is coming from. Check for the obvious — roof and plumbing leaks, and missing or punctured flashing. Look for stains and drip tracks caused by ice dams. Are the eaves wide enough to prevent water from cascading down sidewalls? Are gutters poorly maintained or missing? Do finish grades slope towards the foundation? Are foundation cracks admitting water? Is untreated wood in direct contact with concrete, masonry, or soil?

Check to see if crawlspaces have soil covers and if venting and/or insulation is adequate and properly installed. Look for adequate attic ventilation as well.

Peeling and blistering paint often signal inadequate interior ventilation or a missing vapor retarder. Water stains on framing and sheathing inside walls suggest condensation from excessive indoor humidity.

Once the source of water has been shut off, remove as much decayed wood as is practical and economical. Decayed wood absorbs and holds water more readily than sound wood, inviting further decay and insect attack. This is especially important with girders, columns, and other critical members whose load-carrying ability may have been compromised. There's no known way to accurately determine the remaining strength of decayed wood left in place. Cut back rotted members to sound wood, keeping in mind that difficult-to-detect incipient decay can extend well beyond visibly rotted areas.

When a partially decayed structural member can't be replaced, reinforce it with a sister anchored to sound wood. Let any rotted areas you don't remove dry out before making repairs. Otherwise, you're just adding fuel to the slow fire.

In damp crawlspaces or other places where water is likely to reappear, replace decayed members with preservative-treated wood. The major model building code agencies — BOCA, ICBO, and SBCCI — require that treated wood be used for sills and sleepers on concrete or masonry in contact with the ground, for joists within 18 inches of the ground, for girders within 12 inches of the ground, and for columns embedded in the ground that support permanent structures.

Borates. Dormant fungi can be reactivated when dry, infected wood is rewetted. Consider treating infected but otherwise serviceable wood left in place with a waterborne borax-based preservative that will not only kill active fungi, but guard against future infection as well (see "Sources of Supply," at end of article). Borates have low toxicity to humans and are even approved for interior use in food processing plants. They don't affect wood's strength, color, or finishability, don't corrode fasteners, and don't outgas vapors. Widely used in treating new timbers for log homes, they're the preservative of choice for remedial treatment of wood in service. Because of the decay hazard posed whenever wood bears on concrete or masonry, solid borate rods are often inserted into holes bored near contact areas. Should wood ever get wet, the rods dissolve and ward off infection.

Epoxy. Sometimes replacing rotted wood isn't an option. In conserving historic buildings, for example, the goal is to preserve as much of the original "architectural fabric" as possible. Stabilizing deteriorated wood with epoxy is often the only choice. Epoxies consist of resin and hardener that are mixed just before use. Liquids for injection and spatula-applied pastes are available. After curing, epoxy-stabilized wood can be shaped with regular woodworking tools and painted. Epoxies are useful for consolidating rotted wood, restoring lost portions of moldings and carvings, and for strengthening weakened structural members. In the last case, they're used to bond concealed metal reinforcement inside holes or channels cut into hidden timber faces. Epoxies aren't preservatives and won't stop existing decay or prevent future infection. They can also be tricky to use; follow the manufacturer's mixing, application, and safety instructions to the letter. ■

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Sources of Supply

Borax-Based Wood Preservatives

AquaBor
Bethel Products Inc.
P.O. Box 176
New Carlisle, OH 45344
513/845-2380

Bora-Care, Impel Rods
Nisus Corp.
Cherokee Place
101 Concord St. N.
Knoxville, TN 37919
800/264-0870

Impel Rods
Chemical Specialties Inc.
One Woodlawn Green
Charlotte, NC 28217
704/522-0825

Tim-Bor
U.S. Borax
3075 Wilshire Blvd.
Los Angeles, CA 90010
213/251-5400

Epoxy Resins

Colma-Dur Gel, Sikadur Hi-Mod
Sika Chemical Corp.
201 Polito Ave.
Lyndhurst, NJ 07071
800/933-7452

LiquidWood, WoodEpox
Abatron Inc.
33 Center Dr.
Gilberts, IL 60136
800/445-1754