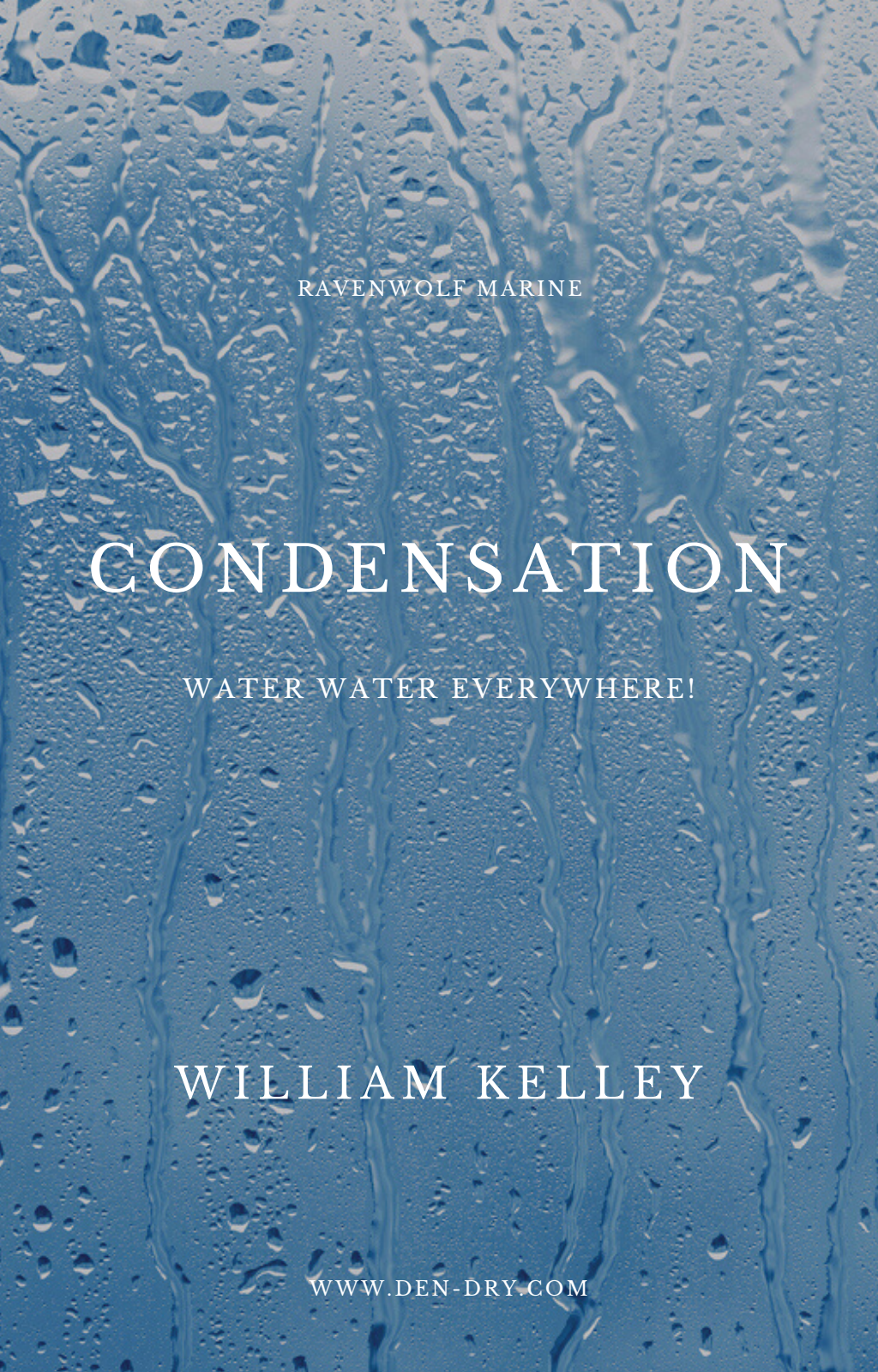


RAVENWOLF MARINE

CONDENSATION

WATER WATER EVERYWHERE!

WILLIAM KELLEY

WWW.DEN-DRY.COM

CONDENSATION

Water is the secret ingredient to life. Without it, Earth would just be a pile of dusty, baking rocks. The forests, the rivers, the wildlife, the human species—none of them would exist.

The immense power of water is at once creative and destructive. A trickle over millions of years can carve the Grand Canyon, but a single crashing tidal wave can wipe out an entire coastline in minutes. A human being will die after a few days without drinking water, but total immersion in it might have the same effect in seconds!

Then there's condensation, which is responsible for the clouds that bring life-giving rain. Indoors, however, these insidious little droplets collect in all sorts of inopportune places, posing threats to health and safety.

Condensation can damage property, compromise structures, and even make you sick when it encourages the growth of mold.

The first step toward preventing these issues is to understand the forces at work. So let's dive into the science of water—we promise not to get you in over your head.

ONE

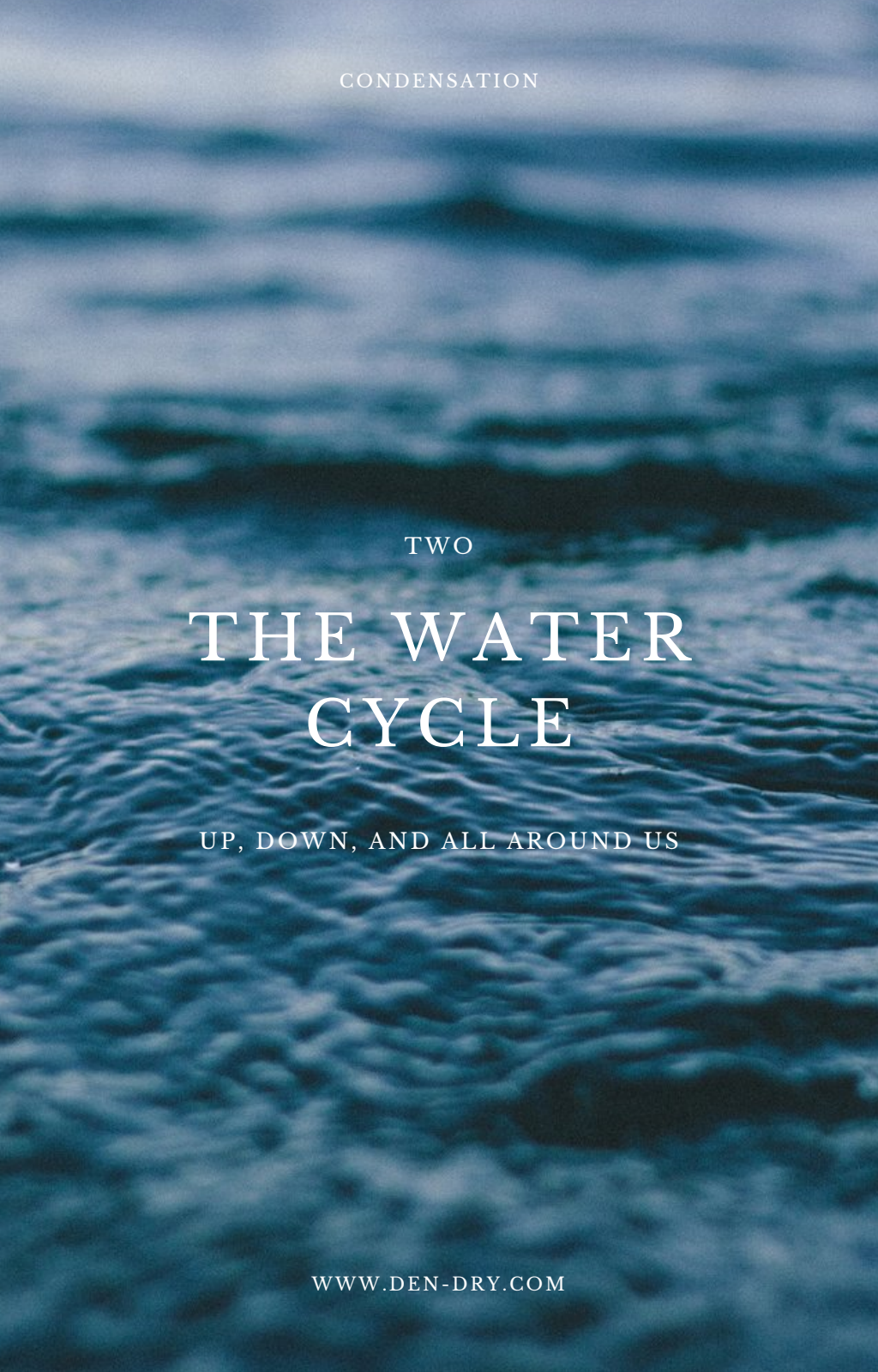
WHAT IS CONDENSATION?

HIDDEN WATER REVEALED

When water vapor in the air turns to liquid, that's called *condensation*. It's the reason your iced tea starts sweating when you take it out on the front porch. It's what makes your car windshield fog up on a cold morning or in muggy weather when you turn on the AC. It's why you can clean your glasses by breathing on them, then wiping off all the steam. In each of these cases, condensation occurs because warm, wet air comes in contact with a cold surface, causing water vapor in the atmosphere to change into its liquid phase.

The density of water molecules accounts for its state changes. In the case of ice, water's solid state, the molecules are closely packed and organized, while in liquid they are further apart. In water's gaseous state, the fast-moving particles contain a lot of molecular energy and are more spread out. When this vapor meets cooler temperatures, the molecules slow down and release their energy as heat, causing condensation as the vapor changes to liquid.

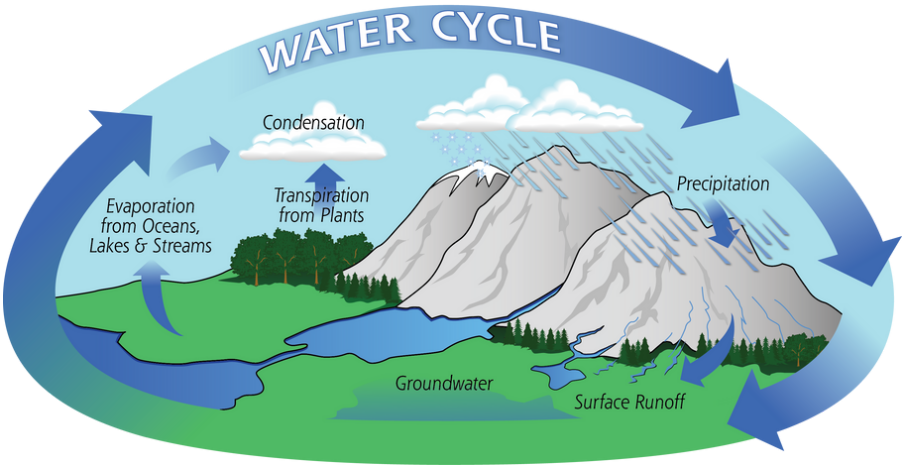
All that to say, temperature is the magic wand that makes this process happen. Whether it's hot steam from the shower hitting the cold bathroom mirror, or beads forming on a can of soda after it's taken out of the fridge, the meeting of warm and cool air is what causes condensation.



TWO

THE WATER CYCLE

UP, DOWN, AND ALL AROUND US



About 71% of Earth's surface is covered by water, mostly in the oceans[1]. Along with evaporation and precipitation, condensation is an essential component of our water cycle. This self-perpetuating process sustains life without the precious resource of H2O ever leaving the confines of our planet and its atmosphere. When the sun's heat warms the ground surface, liquid contained in bodies of water is evaporated to collect in the air as water vapor. We call this *humidity*, and if you're lucky enough to live in a humid climate, you don't need to be told how it makes you take three showers a day and still feel like a bowl of sticky rice.

As warm air rises and comes in contact with cooler air high up in the atmosphere, it can condense into clouds. Little droplets combine to form bigger droplets, and when they become too large to stay suspended in the air they fall down as precipitation. Of course, not all clouds are up high—ground level fog is another product of condensation.

If you enjoy the outdoors, you live very close to the water cycle. Imagine how the sun evaporates your sweat, mingling it with water vapor in the atmosphere. Eventually this moisture rains down to fill the lakes and rivers where you swim, boat and camp, or falls to Earth as snow on which you ski.

When you see your breath, this is actually a cloud of water vapor being exhaled from the warm interior of your body—as it hits the frigid air, it condenses into a billion tiny drops that suddenly become visible. There are so many ways to witness the process of condensation in daily life.

THREE

RELATIVE HUMIDITY AND DEWPOINT

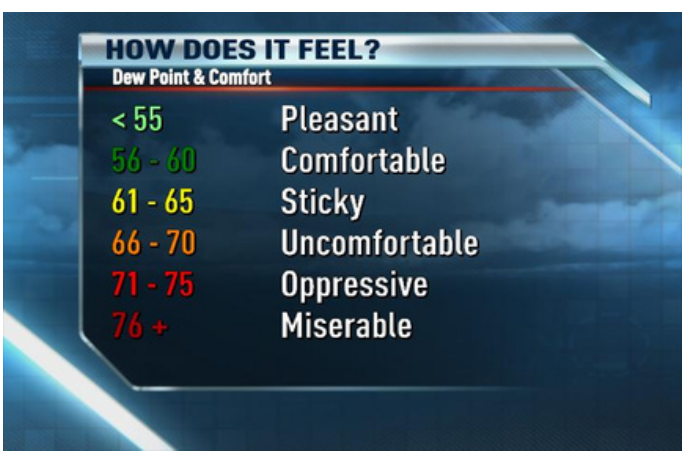
TEMPERATURE IS A BIG DEAL

When the air becomes so saturated that it can no longer hold any more water vapor, it must release excess moisture as condensation. This is the process responsible for dew. Overnight as temperatures fall, little sparkling droplets string along spiderwebs and collect over blades of grass, only to evaporate the next day as sunlight warms the Earth's surface. This is because at higher temperatures water molecules move more energetically and are therefore more likely to go into the vapor phase, making it seem as though warm air can "hold" more moisture. If the temperature drops below freezing, water vapor sublimates, meaning it changes directly from gas to its solid state of ice. We see this as frost.

Actually, the processes of evaporation, condensation and sublimation are happening continuously as individual water molecules move back and forth from solid to liquid to gas. But it's only when the rate of condensation exceeds the rate of evaporation, as it does in cooler temps, that more molecules remain in the liquid state.

There is a specific temperature at which the air becomes saturated with water vapor, and below which the vapor condenses into liquid. This is called *dewpoint*. But unlike the boiling point of water (212°F/100°C) or its freezing-melting point (32°F/0°C), there is no single number for the dewpoint. Instead, it depends on relative humidity.

The percentage of moisture in the air in relation to the amount it can hold at that temperature is relative humidity. So, if the relative humidity is 50%, that means the air contains half of the water vapor it could potentially hold. This is related to dewpoint because the higher the relative humidity, the closer the dewpoint will be to the current air temperature. At 100% relative humidity, the dewpoint is the same temperature as the air. But as the relative humidity goes down, a formula or calculator is required to determine the dewpoint[2]. For example, on an 80˚F/˚27C day with a relative humidity of 50%, the dewpoint is 60˚F/˚16C—which explains why dew forms overnight as warm air drops below that threshold and the moisture in it condenses. High amounts of water vapor in the air prevent our sweat from evaporating, thus rendering the body's natural cooling system ineffective. But while we tend to think of relative humidity as the best indicator of how unbearably sticky we feel outside on a summer day, the dewpoint is actually a more reliable way of calculating the heat index. Any time the dewpoint is over 60˚F/˚16C, most people start complaining!



FOUR

WATER IN THE HUMAN BODY

IT MOVES MORE THAN YOU THINK

The adult human body is composed of about 60% water[3]. Certain vital organs, such as the brain, heart and lungs, contain an even higher percentage. But all this water doesn't just stay neatly inside our bodies. Even when we don't see it coming out (by processes we won't mention in this sophisticated publication), it still exits as invisible water vapor through our breath and skin.

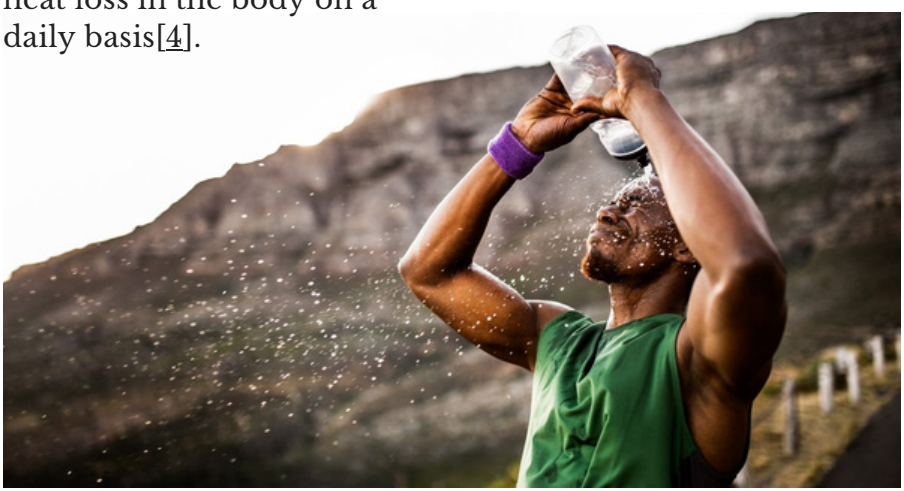
Skin transpiration, better known as perspiration or sweating, doesn't only happen on hot days or when we work out. It is a fairly continuous process—we just don't always notice it. It's only when the amount of water vapor exiting through our pores is more than the surrounding air can absorb that it appears as beads of sweat. This is most obvious in hot, humid conditions when the body needs to cool off yet the air is already so saturated that there's nowhere for the moisture to go. Or let's say it's 90° out and you're eating spicy food at a sidewalk café on a first date that's making you nervous—skin transpiration overload!

But back to the vapors you don't notice. Think about what happens when you wear rubber gloves. The inside quickly becomes all slimy and disgusting as moisture from your skin gets trapped by the impermeable barrier

around it. Who knew fingers could sweat that much?!

This phenomenon actually has a name: *insensible perspiration*, which refers both to vapors exhaled by the lungs and those evaporated off the skin. The latter is different from sensible perspiration (a.k.a. sweat) because it is just pure water without any solutes (traces of your body's natural chemicals, salts etc.) that are normally lost through sweat. Insensible perspiration is unavoidable; the minimal amount is about 27 ounces over a 24-hour period, and it constitutes the main form of heat loss in the body on a daily basis[4].

Even the slightest activity level will increase the amount of insensible perspiration. A person sleeping loses 1.4 ounces per hour through exhalation and skin transpiration, but that number goes up to 2.5 if they are seated, and 3.2 when standing or doing light housework[5]. Obviously, exercise or exposure to extreme heat can cause a person to lose even more water—as much as 47 ounces per hour![6]




CONDENSATION
FIVE
MOISTURE INDOORS
AND NOW, WATER BECOMES A PROBLEM
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All this liquid coming out of you, along with water vapor that's naturally present in the atmosphere, can create some sticky conditions in your living space. And that's before you start air-drying your laundry or reducing a pot of stock on the stove. Just taking a hot shower puts up to 50 ounces of moisture into the air![7]

In the great outdoors, water moves dynamically and accounts for all the spectacular diversity of our planet, from steaming rainforests to polar caps. When trapped indoors, however, it can cause a lot of problems.

High humidity makes you feel uncomfortable—hot and lethargic in warmer temperatures, cold and clammy in cooler ones—and it wreaks havoc on your property. Wood can warp and swell, or even begin to rot and attract insects. Paint can peel and items can acquire a musty smell. Worst of all, mold and mildew may start to grow in places where condensation forms. (More about that in a minute.)

Ideally, indoor relative humidity should be maintained between 30%-65% [8]. But that may not always be possible, especially in boats, RVs and tents. There are a number of factors conspiring to make our favorite recreational—or even full-time—dwelling places prone to moisture problems. The most obvious is that they are small and enclosed. What happens when you sit in a parked car with the windows up? They fog due to condensation.

Warm, moist air inside the car comes in contact with the cooler surface of the windows, causing tiny droplets to collect all over the glass. Remember, you are about 60% water, so just being a warm body living, breathing and perspiring (insensibly or otherwise) is enough to affect the humidity inside your car, camper or boat cabin.

Another reason condensation can become a big problem in these spaces is that they are poorly insulated. This is especially true of tents, pop-up trailers, truck campers and boats, which aren't insulated at all. Again, it creates the situation of warm, moist air inside hitting the cold, exterior-exposed walls so that water vapor changes into its liquid state and gathers over surfaces. Unfortunately, that is why it rains *inside* your tent when you have the rainfly up. Just try not to roll over against those side walls in your sleep!

SIX

MOLD AND MILDEW

THIS IS WHERE IT GETS ICKY

There are a lot of things in nature that have their useful function—as long as they stay *outside*. Mold is one of those things. (Sand is another one, and bugs, and muddy children...but we'll stop there.) A member of the fungi kingdom along with yeast and mushrooms, mold is naturally present in the environment and serves to break down organic materials that have begun to decompose. That's a good thing, because if everything that ever fell down to the forest floor remained there, we wouldn't be able to see the forest for the leaves.

Mold grows from spores, minute reproductive units that disperse easily through air and water, or by clinging to other objects as they travel around. (An animal's fur, for instance, or your car that you keep meaning to wash.) These invisible spores are everywhere, floating through the air both indoors and out. They can survive in a dormant state while the environment is not suited to their growth, then suddenly burst to life as soon as the right conditions are met. That's when the nasty fuzz begins to form, or the blue powder on a bad orange, or the tiny forest growing over old food, or the scary-looking black splotches between your shower tiles that you suspect of being deadly. (Not all black molds are toxic, by the way. And the spots in the shower are probably just mildew, a type of mold that only grows topically on flat surfaces and isn't as dangerous. But you should still clean it up.)

Four things are needed for mold to grow: food, water, oxygen, and a congenial temperature. Out of the four, only one is practical to control in our living environments. Can you guess which?

Let's break these factors down. Mold needs oxygen, and so do humans; in fact, mold can survive with less. So getting rid of oxygen in our homes won't work. The optimal growing temperature for mold is 77° - 86°, but it can survive down to 40°, which is why food is refrigerated at 39°. That's too chilly for most of us. And what about food? Well, mold can "eat" just about anything. Unlike plants, which photosynthesize from sunlight, fungi derive energy from organic matter that they digest. This means that whatever mold is growing on, it's eating, breaking it down and destroying it over time. Mold can be found growing on wood, paper, cloth, plants, carpet, insulation, paint, mattresses —basically anything that contains organic matter. Clearly, starving mold out is not an option.

We're down to one last factor, which you probably already guessed: water. Mold needs moisture to thrive, so dealing with an excess of it in your space is critical to preventing this unsightly and potentially dangerous problem.

SEVEN

CONTROLLING HUMIDITY AND CONDENSATION

SHOW ALL THIS WATER WHO'S BOSS!

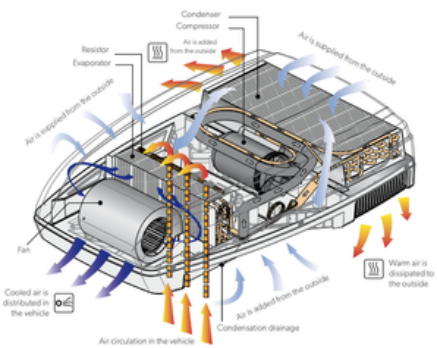
You've probably heard that mold can make you sick. But it's not like food poisoning or catching a cold from your kid who picked it up at daycare. In those cases you know exactly how and when you got it, but with mold exposure it could be harder to make the connection. Maybe the culprit is growing somewhere you can't see—mold likes to do that—or it's just been going on for so long that you thought the symptoms were allergies. Even if you're not sick, your safest bet is to do everything possible to eliminate this risk in your home, which not only means cleaning up visible mold but preventing it in the first place by controlling moisture.

Leaks should be dealt with as soon as they are discovered and the area around them thoroughly dried out. Other types of water problems may not be so obvious. By now you should have a pretty firm grasp on how condensation works and why occupying small indoor spaces like RVs and boat cabins can cause issues. We won't keep reminding you how much moisture you're putting in the air with your warm, watery self. Nor will we paint ghastly pictures of everything that could be growing under your plastic-backed couch cushions or in the dim recesses of your closet. Instead, we'll offer some tips to help you mitigate the moisture problem.

Air Circulation

The most basic advice is to open a window! In fair weather this is a wonderful option, as fresh air is what most of us love about the lifestyle to begin with.

In summer, running the air conditioner will automatically lower humidity. You see that steady trickle draining out of the unit? That's condensation, which means just a minute ago all that liquid was water vapor in the air of your living space.



In winter you need to consider your heat source. Water is a byproduct of propane combustion, so using a non-vented catalytic heater means putting a lot of extra moisture into the air—as much as 1.64 pounds for every gallon of propane burned[9]. If you're using a heater without a blower—such as an oil-filled radiator—be sure and use a fan in conjunction, because just warming the air without circulating it is a surefire way to create condensation problems. In fact, fans are your friends all year round, from little portable ones next to your bed, to huge industrial ones on hand for drying out spills and leaks, to ceiling fans and roof vents installed in the bathroom, stove or elsewhere. Keep in mind that enclosed spaces like closets and cabinets are special breeding grounds for mold, so periodically opening the doors to air them out is a good idea.

Last but not least, that mattress. You breathe and transpire on it all night—remember the statistic of 1.4 oz per hour during sleep? All this heat and moisture gets trapped inside your blanket and sucked up by the mattress, which lies directly on a cold platform, creating the perfect recipe for condensation.

Without air flow, mold is likely to become an issue, so consider investing in a mattress underlay that allows air to pass freely between it and the platform.

Dehumidifiers

As mentioned earlier, air conditioners reduce humidity. But what about in winter? Dehumidifiers remove moisture from the air without cooling it down—in fact, they even put out a little heat. Moist air is drawn in via a fan, then run over refrigerated coils so that the air cools down and water vapor in it condenses. This liquid catches in a removable tray while the dry air is rewarmed and circulated back into the room.

Dehumidifiers range in size, capacity and price, so choosing the right unit really depends on your budget and the space you need to treat. Most require electricity and periodic emptying of the catchment tray, so if you're wanting to control moisture in a stored boat or camper, a better option is chemical moisture absorbers. These are available in disposable or refillable containers full of crystals that pull moisture out of the air, then drip liquid into a holding chamber for later removal.

Insulation

If you've gotten nothing else from reading this, you should understand that the meeting of warm air on cold surfaces causes condensation. Lack of insulation means there is very little buffer between the moist, heated air inside your living space and the cold dry air outside. That's why little drips of water form on the inside of window panes and moisture often collects along thin

exterior-exposed walls. In order to prevent this, you need to equalize the temperatures of interior air and surfaces as best you can.

There are so many DIY ways to beef up insulation in an RV that the topic is beyond the scope of this article—but hey, that's what Google is for. Just capture the idea that insulation will help prevent condensation, not to mention make your heating/cooling devices more efficient, thereby saving you money. On the other hand, boats are very difficult to insulate and tents are just plain impossible, which brings us right back to our original advice of opening a window. Sorry!

Reduce activities that put moisture in the air

As we've already established, just being alive causes you to release water vapor into the atmosphere. You can't help that, but you can hang your wet clothes on a line or rack outside.

You can take shorter, less steamy showers, maybe even install an outdoor shower or use a public facility. At the very least, squeegee and wipe down the shower when you're done and use the roof vent fan if you have one. Another great strategy is setting up an outdoor kitchen with a camp stove, grill, or propane burner for that big vat of boiled peanuts. When you do cook inside, use the stove vent or open a window, especially if you're cooking with gas. Besides letting out all the water vapor, it will keep you from getting carbon monoxide poisoning!

So there you have it, our informal treatise on condensation and how it affects your outdoor life. Stay dry y'all and we'll see you out there.

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ABOUT THE AUTHOR

FOR FURTHER READING

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About the Author

William "Bill" Kelley is a serial entrepreneur, founding and running 7 companies over 40 years, mostly in technology. He is one of the founders and is the CMO of Ravenwolf Marine, Inc. RWM specializes in condensation control in outdoor living spaces. Bill became interested in condensation dynamics while living aboard his Morgan 41' Classic sailboat "Shindyah." He is an avid sailor, private pilot, retired (recovering?) software engineer, and the luckiest man in the world, married to his wife Laura Ann "Wolfie" Kelley. You can find them both, generally up and down the east coast, living aboard Shindyah.