Liquid Bread and Invisible Worlds—Beer, Fungi, and the Origins of Microbial Control

[Announcer] This program is presented by the Centers for Disease Control and Prevention.

[Matt Kuehnert] Hello, I'm Dr. Matt Kuehnert, Editor in Chief of the journal *Emerging Infectious Diseases*. EID is an open access, high impact, peer reviewed scientific journal published by CDC. EID publishes articles on new and re-emerging infectious diseases that occur around the world, with the mission of improving the understanding of pathogen emergence, control, and prevention. We are pleased to present selected EID articles to you, brought to life in new and interesting ways through this podcast series.

[Candice Hoffmann] Welcome the *Emerging Infectious Diseases* podcast. Today we're going to be talking about the September 2026 cover essay on "Liquid Bread and Invisible Worlds—Beer, Fungi, and the Origins of Microbial Control".

I'm joined today by Dr. Nic Hoffmann, a medical historian and author of this article, and Dr. Shawn Lockhart, a senior advisor for mycology with the Mycotic Diseases Branch at CDC.

So first I'll have each of you introduce yourselves and then we'll get into the discussion. So, Dr. Hoffmann, can you introduce yourself? Tell me who you are, what you do, and how you got interested in medical history and the topic of this essay.

[Nic Hoffmann] I'm Dr. Nic Hoffmann. I have a PhD in 19th century American history with a focus on science and technology, and I actually got involved in the subject through my studies of Civil War battlefields and food safety therein. I'm a competition homebrewer and started looking into the history of food. Throughout European history, the water was terrible, and so people used to drink beer all the time, so much so that alcohol was a condition of work in almost every major civilization. And why are there so many different styles? Why are there so many different genres? Well, because beer is flavored by essentially the grain, the hops, but most importantly the yeast. And local yeasts provide local flavors. And the idea that you'd pay extra to have yeast from Belgium trucked over to make your beer taste more like a Trappist Quad, fascinated me. That the first food laws were about beer in Germany. And it kind of all went from there. And so that's kind of how I got into the subject.

[Candice Hoffmann] And Dr. Lockhart, can you introduce yourself? Tell me who you are, what you do at CDC, and how you got interested in fungal diseases.

[Shawn Lockhart] Yeah, so I am a clinical microbiologist who studies mycology, which is fungi and molds, molds and yeasts. I've been working here at the CDC in the Mycotic Diseases Branch for eighteen years. I first got interested in infectious fungi in graduate school. I was getting a degree in genetics, working on yeast genetics, brewer's yeast, *Saccharomyces cerevisiae* we'll be talking about today. And right before I was graduating with my PhD and looking for somewhere to go, my mother-in-law got very sick, went into the hospital, got systemic candidiasis, a yeast infection, and passed away. And I decided at

that point I didn't want to be a geneticist. I wanted to spend the rest of my career figuring out how to kill fungi. So that's how I got into it. And I've been doing infectious fungi now for 33 years.

[Candice Hoffmann] So for each of you I'm going to ask, what's one thing about fungi or fermentation that you want people to know? So, Nic, I'll have you go first.

[Nic Hoffmann] Well, I think the neat thing about it is it kind of just happens on its own. The bacteria and the yeast in the air are what allows so many of the foods we take for granted to be created. Yogurts and cheeses from dairy, but also beer and wine. I know we might talk later about the concept of liquid bread or whatever, but even in Scandinavia and Russia, there's a kind of beer made from the crusts of black bread that are just tossed into a pot with water and allowed to naturally ferment because sourdough yeast can do that. Just as you said earlier, *Saccharomyces cerevisiae* has evolved to have a higher alcohol content than the kind of yeast that you use to make bread, for example, though that didn't stop during prohibition, them arresting a bunch of Atlanta bakers for having too much yeast, a suspicious amount of yeast. And so again, like what's neat is that this is like a natural repeating system that has existed for thousands of years that humans have lived among. We've just now become connoisseurs of it, which is kind of funny that there might be a medieval brewer that's somehow better than we are still, because they just understood that the magic stick made the fermentation happen.

[Candice Hoffmann] So, Shawn, what's one thing you want people to know about fungi and fermentation?

[Shawn Lockhart] Well, I'm going to go at it from the opposite end in the clinical microbiology end. And I'll say the vast majority of fungi, and we think there's somewhere around five million species of fungi in the world, the vast majority do nothing to humans. We only know of about 600 species that are actually infectious to humans. And most of those are not infectious to everyday, healthy humans. We breathe in up to a thousand fungal spores every day, and the macrophages in our lungs just eat them up and spit them out and do nothing. But we've become really, really good at keeping really, really sick people alive over the past hundred years or more. And in doing so, we've allowed these bugs that aren't very good pathogens to switch over from being just innocuous bugs that are all around us every day into bugs that can harm us. As soon as we become sick, we create an environment where a fungus that was doing nothing before all of a sudden can become pathogenic and make us sicker. So, most of the time, fungi do nothing. Most healthy people encounter fungi all day, every day, and it does nothing to them. But as people start to get sick, as they start to age, as they have encounters with a healthcare environment, all of a sudden, those fungi that were doing nothing, that were just living with us happily, can turn into pathogens and make us very sick or sicker.

[Candice Hoffmann] And I think it's very interesting to see the parallels between most fungi. We're not aware of it within our bodies and most of the time it's not going to do anything, but then sometimes it'll harm us and then looking back to, back throughout history before people knew what yeast was and just knowing that there's something happening there. And so, I think, moving back to the history side of things, Nic, I would like to talk to you about the

image, and can you just tell me about like the image of our cover story? Like who is this person, what's he doing, and what does the scene tell us about how people were managing brewing safety before the discovery of germ theory?

[Nic Hoffmann] So what we actually have is a book whose title is so German, I'm not going to try to pronounce it because I'm going to get it wrong, but effectively these brothers in Nuremberg were illustrating their town and the jobs and the people and everything in it. And what we have here is kind of an iconic image of the practicality of what this man is doing. Back then you had this idea that you would start out as an apprentice and become a journeyman and then a master. And so, this is a master brewer. And his job is to keep the city fed with beer. Now, the town of Nuremberg itself was fairly advanced as a Middle Ages city, and you can tell by the fact that there's art and there's specialized fields, right? A few centuries earlier they were hand-to-mouth avoiding the bubonic plague. So, this is kind of almost a peaceful scene of a man at work. What is impressive about this is how unremarkable everything about this is. He's not bejeweled, he's not making it for the king, he's not a monk. He is wearing the uniform of a brewmaster and he is making beer.

Now, the process has evolved over time, but effectively what you would do is you would take your grain, this part of the world it's mostly barley, and you would get it a little bit damp so it would start to sprout. This releases the sugar, the maltose. And then you would roast it to stop that process, and then you would, what he's doing here, which is steeping the grain. Nowadays in modern technology, there is numbers that we throw at this thing. The cookedness of grain is measured in something called Lovibond, and that's how dark the roast is. The darker the roast, the more flavor is left behind. And then you measure the temperature, you're steeping it like tea, so you're aiming for about 150 to 125 degrees Fahrenheit. But the thing about a brewmaster is they know this by sight and by smell. And they get respect for it. And just like almost anything else, there's an artisanal quality to it. Now, what makes this specifically the beer that we are talking about is the natural environment. What they don't know is why beer is healthier than the water around them. The water is filled with runoff, human waste, etcetera. But beer has to be boiled. Once you get the grain out, and what he has next to them there is the grain, right? In the little barrels that he is scooping out so that you have what is called the wort, which will be fermented. But the grain is boiled, or at least the sugars from it is boiled. That kills all the little beasties that are in the air, the bacterias, the mold spores, the yeast. And then it is sealed up into wooden casks. But before it gets sealed up, it has to cool down. Getting into what medical, I guess, food safety experts would call the danger zone. But luckily, it's been imbued by that point by the natural yeasts of the environment. And so, the beer there will taste uniquely like the beer there.

Now, depending on the year, they may or may not have hops. Hops were developed by the Dutch, and they had become common use by the fifteenth, sixteenth, and seventeenth century, and the Germans encouraged the use of hops by the 1560s. But for the most part, what makes it distinct here is the fact that it will be fermented by the yeast of Nuremberg. And he sanitizes in the way he sanitizes, which is not with soap or water, but generally with fire, and then leaving the top of the fermenter open for a specific amount of time before sealing it up and creating the beer that will let people survive for another cold season.

[Candice Hoffmann] And Nic, can you talk briefly through the history of brewing as explained in your essay just from the early days through the German laws that limited ingredients, to pasteurization?

[Nic Hoffmann] We don't know what comes first, bread or beer. And in fact, the Egyptian hieroglyphs sometimes even fudge that word, and it's sometimes hard to tell the difference what they're referring to. Which seems odd. Why would one of humanity's oldest advanced civilization confuse these two terms? Well, because they essentially provided the same service. When we think of beer, we think of something crystalline, often clear, if not fairly clear, fizzy, and bittered to hide the bitterness of the alcohol and the leftover sugars from fermentation. Don't think of that when you're thinking Egyptian beer. Essentially, what they would do is take grain, leave it in a jar with water and seal it up. What this is, is kind of like an alcoholic version of, like, oatmeal. It would be fizzy because it traps the carbon dioxide when you seal it. But it's important enough that it's listed on ledgers next to the laborers who were building the pyramids and the temples. And I say laborers here because there's a debate whether they were enslaved, whether they were carpenters, whether they were paid workers. But regardless, they were given a beer ration a day. And the better the work, the more beer they get, as to feed it to their families. The process of making alcohol around the Mediterranean is universal. Every society has something like it, and it just depends on where they grow. The Greeks and the Romans generally preferred their wines, but around the Mediterranean and elsewhere, it's beer. And beer as a concept can be made by pretty much anything. Throughout medieval Europe, as we see, the brewmaster is one of the most important things. The act of collecting grain and using it for both bread and beer is a matter of food safety, it's a matter of feeding the people, right? It’s a matter of pretty much every aspect of daily life. These are people who work in the field and they work hard. And so, to keep fed and hydrated is important. And these, kind of whole grain beers, these heavy beers, are important as well.

The biggest change to this are twofold. First, we have the introduction of hops, which allows for lower alcohol beer, which I didn't really talk about in the piece, but it's worth mentioning because the British didn't have it, and the English ales averaged about 8% alcohol, and I can't imagine working a day drinking only 8% alcohol beer. But apparently King Henry VIII tried to grow hops, his goats ate them and died. So, he called it a vile and wicked weed and banned it. But the other is the German Reinheitsgebot, which are some of the oldest food laws in the world. I mean, let's talk about beer just for a second and what it is. Beer is essentially watered down alcohol, and in it is the alcohol part, but also a bunch of unfermented sugars. That's what gives beer its general flavor, right? You don't want to taste something that just tastes like bitter grass. So, you want that flavor left behind. The problem is, that's a really good vector for bacterial infection and makes the beer go bad. So, the Germans though noticed a problem. People were adding all sorts of stuff to their beer. And this includes different grains, wheat, bulgur. They would also add what they call adjuncts, things like sugars, things like mint, or instead of hops, spruce or pine needles. And they saw people getting sick from this. And part of it is a big problem with the grain rye. If rye is not properly kept, it can grow another fungus, leading to ergot poisoning, which is a hallucinogen and can cause people to get very sick. And you're not using your best grain for

this stuff. So, they would see, oh we're going to miss our quota, they find some left behind rye and they would chuck it into the beer and then poison an entire town. So, the Germans passed a law requiring that the only things in beer could be water, grain, and hops. And they would even have people check the purity of the grain. And so, the German food purity laws, literally the first section of note is the German beer section. And the Germans literally get to the point where their grains and their hops are so specified that they become the gold standards. And so, in brewing circles, we still call them the noble hops, the ur-hops that everything comes from.

[Candice Hoffmann] So you told us about the laws and how they limited the ingredients, and they found that this made beer safer, even though at the time they didn't know why, like what was happening at the microscopic level. And so, nowadays we know a lot about what's going on with fungi and the things that we can't see. And so, I think this is a really good segue into asking Shawn to tell us if you can tell us a little bit about fungi, because I think most people, they hear that word and they might think mushrooms, but there's much more to it than that. So, can you just kind of give us an overview of what it is?

[Shawn Lockhart] Yeah, so fungi are eukaryotes like us. So that means they have a nucleus and a DNA. And most of the machinery in a fungus is very similar to the machinery in a human cell. In fact, when I was in graduate school, one of the experiments we did was to take a human gene and put it in a yeast that had lost that gene, and we showed that the human gene functions just fine because they are so similar to us that we can use the same molecular machinery. So, fungi are everywhere. They're all around us at all times. Mostly they're invisible, but we tend to run into them when we see them growing up in our yard or in a field or in the forest or on our pizza, or maybe the three-week old Chinese food in the back of the refrigerator that has this nice fuzzy coating on it. That tends to be when we encounter fungi. But actually, they're all around us, as I was saying. They're everywhere. So, our bodies are actually covered in beneficial fungi. Our skin has beneficial fungi, our gut has beneficial fungi, that just live with us symbiotically as long as we're healthy and play a role in how we function. It's also in every bit of soil that we see. When you see a compost pile in the fall and it seems to be steaming, that's the fungus doing its job. A lot of the role is to break down organic matter. And so, when you see that steamy pile, it's all the fungus heating up and eating all the leaves and sticks and things that are in there. That is a major role of fungus.

Another really interesting role, they play a major role in plant health, in bringing nutrients to the roots of plants and in allowing plants to talk to each other. So fungi, especially mushroom type fungi, grow underground in these long, long threads that can go, for them, inches, sometimes longer, but what seems like, when you're talking at the microscopic level, these huge, huge, long cells. And they allow trees in a forest to talk to each other by sending signals and relaying signals back and forth. In fact, the largest fungus in the world is a mushroom that lives in Oregon. It's the species *Armillaria*. It stretches over 3.5 square miles, and it's estimated to weigh up to about 34,000, not pounds, tons. 34,000 tons of microscopic threads. Imagine that. So, we don't encounter fungi to our knowledge every day, but actually we do encounter fungi every day. And as I said, for the most part, they're innocuous until we start to get sick, and then they can become deadly.

[Candice Hoffmann] So what makes some of them harmful versus beneficial?

[Shawn Lockhart] So there are actually only a few of them that are harmful. One of the big reasons that there aren't a whole lot of harmful fungi is that, well, there's two reasons. One, they can't break down what we're providing. So they, you know, they're used to breaking down organic matter, but it is usually plant organic matter and they're not so good at using human-type matter. But the other is that the vast majority out of that five million, only a few thousand actually can grow above 37 degrees Celsius. That's body temperature. So if they can't grow at body temperature, they can't cause infection. And so that's the real actual basic reason why most fungi aren't infectious. There are only a few actual fungi that are pathogenic to otherwise healthy people. The ones in the United States are histomycosis, *Histoplasma capsulatum*, *Blastomyces dermatitidis*, and then the one that causes Valley Fever, *Coccidioides*. That's a really interesting one. You hear about it all the time in construction projects, they've had outbreaks in festivals, people up dancing all night, sucking in fungal spores as they stomp on the soil and release them into the air. And actually, this issue has a really interesting paper about a *Coccidioides* case in Taiwan. You don't find *Coccidioides* in Taiwan, but there was a worker who was on a dock cleaning out a shipping container that had come from California, and he's sweeping out the dust, and as he's sweeping out the dust, he's causing those fungal spores to go airborne, he breathes them in, and he gets Valley Fever (coccidioidomycosis) thousands of miles away from where you can find it naturally.

[Candice Hoffmann] Could fungal spores like that stick around when they're introduced to a new place, like invasive plants or insects might?

[Shawn Lockhart] So something like *Coccidioides immitis*, it comes from the desert. And so, coming out of a shipping container, it is not likely to go out and there aren't any deserts in Taiwan. And it's probably not going to happen. But there's another bug called *Aspergillus fumigatus*. *Aspergillus fumigatus* is found worldwide, but there is a certain strain of *Aspergillus fumigatus* that has become drug-resistant because the fungicides that we use on our crops are very similar to the antifungal drugs that we use in our patients. And this resistant *Aspergillus fumigatus*, like those other two bugs, has started circulating the globe. *Aspergillus fumigatus* spores have been found in the jet stream. And so, imagine you get picked up behind the vacuum behind a jet and you get up to the jet stream, and you can literally be distributed anywhere in the world. And when we look at whole genome sequencing, what we see is these mutations that are associated with fungicide use probably only arose once, and then it has been spread around the world. We found it here in the soil in Georgia, in a peanut farm. And so that was about six years ago. Just two years ago, we found our first human patient that had azole-resistant *Aspergillus fumigatus* associated with agricultural use of fungicides. And there actually was a paper on the first patient in the U.S. to die of an azole-resistant *Aspergillus fumigatus* was published a few years ago in *Emerging Infectious Diseases*.

[Candice Hoffmann] Can you give us some other examples, kind of maybe more from daily life, of how we might find beneficial or harmful fungi?

[Shawn Lockhart] Yeah, so another really interesting case. So, everyone knows sake wine. It's the Japanese wine. It's made from a fungus called *Aspergillus oryzae*. And they use that to ferment the grain to get sake. The same organism, the same *Aspergillus*, it has got a slightly different name, but only because we didn't know they were the same thing, is *Aspergillus flavus*. And *Aspergillus flavus* is the *Aspergillus* that causes a toxin that can spoil our crops, spoil our grains, especially corn, get people very, very sick and also cause human infections in the lung. And the only difference between those two, between making really nice rice wine and causing horrible toxins in food production, is one little set of genes that's found in one and missing in the other. Some what we believe is that actually the Japanese when they cultivated this species of *Aspergillus* to use, they selectively got the isolates that no longer produce that toxin until they'd completely gotten rid of it. So that's one example.

Another example that we don't think about very often, some of the roles of fungi in nature, I'll give you two very specific species and I don't expect anybody to ever know how to spell these, but there's one called *Metarhizium* and its job in life is to kill insects and destroy insects. We actually spray that on our crops to get rid of locusts and things and you can spread, you know, spray *Metarhizium*. It's thought to be safe. But every once in a while, somebody will get *Metarhizium* in their eyes, they'll get keratitis, and they can actually lose their eye. There's another one called *Purpureocillium lilacinum*. Farmers spray this on their crops for nematodes. It's job in nature is to go out and kill nematodes in the soil that would eat their plant roots. And that's another one that has a very beneficial role. In most cases, it doesn't do anything, but it can also cause keratitis or eye infections in healthy patients. And we're seeing that in farmers. We don't know that they got it from the crops they were spraying it on, but we see that fungal keratitis. And we're actually seeing *Purpureocillium lilacinum* in other patients, in transplant patients and cancer patients in their lungs. So it's one that we use, and it has a beneficial purpose, but then you can turn right around and cause infections. Even *Saccharomyces cerevisiae*, baker's yeast, it's great. We make beer, we make bread. But we also sometimes find it in the gut. It is a good gut bug, but it can cause bloodstream infections in sick patients and actually go on to kill us. We even use *Saccharomyces* as a probiotic in patients who take antibiotics, and their microbiome, the organisms that live in them, have become disrupted. So we think, we'll put a good yeast back in, we'll put in a *Saccharomyces*. And sometimes that goes on to make the patient sick, even though we were using it for what we thought would be beneficial to the patient. So, there are lots of examples of these things that, all of a sudden, they're doing great things and then they're not. *Penicillium*, one of the first fungus most people have ever heard of, gave us penicillin. So, they have good roles and they have some bad roles.

[Candice Hoffmann] Shawn, can you tell us about some of the top fungal disease threats today and where we're seeing them? If it's more like healthcare settings or community or the environment or maybe all three?

[Shawn Lockhart] Yeah, so for the most part, it's healthcare settings. That’s where we see most fungal infections and it's not necessarily just in hospitals, it's people who have encounters with healthcare, in other words, being treated for something. And probably the most prominent fungal infection that we see is *Candida*. And *Candida* is a yeast. It's very,

very similar to *Saccharomyces cerevisiae* or baker's yeast, but it's in us and on us. We walk around with *Candida* in our gut, sometimes in our skin. But we're seeing right now the circulation globally of a brand-new species of *Candida*. Obviously, it didn't just drop off a comet, although there is a publication suggesting that that might be the case. Don't believe it. But it has only emerged from wherever it was hiding within the last about thirty years or so. And it was seen in four different places originally. And it has literally spread across the world. It's not emerging in new places. It's literally spreading as patients move from healthcare setting to healthcare setting. It's carried on their skin from one hospital to another. The first introductions in the U.S. were for patients who had sought healthcare abroad, had it colonizing on their skin, and then they came to the U.S. What makes this one so scary is that it tends to be drug-resistant. We only have very few drugs for treating fungi. And the reason is fungi are so similar to us that anything that we use to target fungi usually has side effects for us. So, we haven't been able to develop a whole lot of drugs against fungi the way we have against bacteria. Bacteria are very different from us. Fungi aren't, they're eukaryotes. They have the same machinery, as I said. And so, we've had a hard time developing new fungal drugs. We have three good classes, and we found this new bug can develop resistance to all three. It's really, really scary.

This is also the first time we've ever had a human pathogenic fungus circulate, circle the globe. We've never had spread like this. And we've seen it in plant pathogens for sure. The chestnut trees...a billion chestnut trees in the U.S. were wiped out by a fungus that came over from Asia. But we've never seen it in humans. There's another one. There's a really nice article in this edition this month about a fungus called *Trichophyton indotineae*. *Trichophyton indotineae* is a dermatophyte, and what that means is it's a ringworm. We've heard of ringworm. Everybody...very, very common, especially kids, to get ringworm, and you get a little lesion about the size of a quarter, and you put a cream on it for a couple weeks and it goes away. This one doesn't. Number one, it's drug-resistant. And number two, instead of causing athlete's foot between a couple of toes or a little dime-size lesion on the skin, it will cover your whole trunk from your knees all the way up to your waist. And besides the itchiness and things like that, the stigma of walking around with this infection is terrible. So that one, again, is circulating the globe, carried on patients from place to place to place. That one's not actually associated with healthcare. It's just associated with human-to-human contact. It's very easily spread from person to person. It started somewhere in Southeast Asia and we're now tracking it all across the whole world. We've seen outbreaks in the United States in the last five or six years. And we know that it's going to get much worse before it gets better. And it's drug-resistant, again. So scary things. All of a sudden, we have multiple human pathogens circulating the globe when we've never seen any in the past thirty years that I've done this. Nothing like this. We've got two.

[Candice Hoffmann] So, I was going to ask about like fictional scenarios, but it sounds like real life may sometimes be more scary, but I wanted to ask you about fictional scenarios where fungus causes like a zombie-like outbreak, like things like *The Last of Us*, and if you're concerned at all, if you're going to be preparing and stocking up your basement with essentials, maybe even with beer, to prepare for the next big outbreak?

[Shawn Lockhart] I have answered so many questions in the past four or five years about the zombie apocalypse, and yeah. No, I love that TV series. I've never played the videogame, but the TV series is awesome. No, we're not going to see a fungal zombie apocalypse. That is a real fungus that they talk about, *Cordyceps,* and it does cause bugs to climb up to the highest point in a plant, clamp down, and let the fungus sprout out of their body. That will not be happening to us. But we do know that if we ever have a pandemic or a natural disaster, we will see fungi. They probably won't be causing the pandemic, but they definitely take advantage. As I said, they're advantageous. When people become sick, you see fungus. We saw this during COVID, COVID-19, when people's lungs were injured and they were taking steroids. On top of that, we saw all these horrible, horrible fungal infections in these same patients. Candidemia infections went through the roof. We saw something called the black fungus. It's not actually a black fungus, but they call it that because it turns the skin in the face black where it infects. The mortality was about 50%, but the morbidity was horrendous. People lost eyes, they lost their nose. The best way to fight this fungus is with a scalpel, so they'd have their cheek removed. We see it when we have floods, all of a sudden there's an increase in fungal infections. We saw it after tornadoes. So, after the tsunami. So, when there is some sort of apocalypse, but we'll just call it a pandemic, we can assume during the next pandemic, whether it's next week or it's 30 years from now, there will probably be fungal infections associated with it. Probably not going to cause the pandemic, but I guarantee any time we have sick or injured or hospitalized patients, we see a huge rise in fungal infections because they're everywhere.

[Candice Hoffmann] So, fungi have been around humanity throughout history. Even now it'll always be there with us, sometimes harming us, sometimes helping and creating foods and beer. I want to, I guess ask each of you as we wrap up, what's one thing you want us to take away from this conversation? So, I'll start with Nic.

[Nic Hoffmann] Well, honestly, it's part and parcel to the fact that food science and food health have been linked to civilization for as long as there's been civilization. Once we started settling and planting and building, we needed to take care of ourselves and we adapt very well. Unfortunately, as my colleague on the other end of the microphone has pointed out, the little beasties can evolve as well. And so, we will always be in a constant battle to keep ourselves fed and keep us nutritious and I guess intoxicated, but also they will evolve alongside it. And that's part and parcel to humanity and civilization. Even the best we can do often falls apart. We just suffered an egg shortage because of bird flu. We've run out of so many breeds of bananas because only the Cavendish was immune to, I actually believe it was a fungal infection that killed off a lot of bananas. But as I go out the door, I want to add personally that one of the reasons I became so interested in medical history was because of my microbiology teacher who was also a fungal expert. His name was J.K. Bhattacharjee at Miami of Ohio. And his expertise was synthesizing lysine in the aminoadipate pathways. And so, he had patents to treat *Candida albicans*, among other things, and developed several tests for fungal infections. One of the best educators I had, and for someone who's not a science guy at heart, he made me really interested in science. So, I'll give credit to fungal experts everywhere for that.

[Shawn Lockhart] So the third week of September is Fungal Disease Awareness Week. And we call it FDAW. And it is a time for us to talk to clinicians and talk to patients about thinking about fungi. A lot of times when a patient goes into the hospital, they will be treated for all the most common things first, and they keep getting sicker and sicker and sicker. Finally, somebody says, I wonder if it's a fungal infection. And they start treating them well into the disease. And so, we like both clinicians and patients to be thinking fungus. Patients can advocate for themselves. If they're not getting better, they can say to their doctor, hey, have you thought about a fungal disease? Is that maybe why I don't seem to be getting better on an antibiotic? Because antibiotics don't work against fungi. And so, patient advocacy and clinician knowledge is really, really important. This is our tenth year of FDAW. Tenth year of telling people, think fungus, whether you're a patient, whether you're a clinician, or whether you're just someone who's getting your Chinese food out of the back of your refrigerator three weeks too late, think fungus.

[Candice Hoffmann] Thanks for listening to our conversation with Dr. Nic Hoffmann and Dr. Shawn Lockhart about beer, bread, fungus, and fungal diseases. Want to learn more about fungal infections? Check out the September 2026 issue of EID at cdc.gov/EID.

[Outro] The conclusions, findings, and opinions expressed by authors contributing to this journal do not necessarily reflect the official position of the U.S. Department of Health and Human Services, the Public Health Service, the Centers for Disease Control and Prevention, or the authors' affiliated institutions.

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