



CICADAS BELOW THE SCOPE

JOSH SINGLETON: I'm Josh Singleton, and this is Below the Scope!

[Cicada calls fade in]

JOSH SINGLETON: You burst alive! And suddenly you're falling... In your first waking moments of life your entire body has compelled you to leap from the sky down to the cold, hard ground. You slam into the dirt with a soft thud, and then your body compels you again. Dig!

[Cicada calls continue]

You begin to claw into the Earth and into darkness. Away from the world that you have only known for a matter of seconds..And now you'll spend the next 17 years beneath the surface waiting—with millions of other cicadas just like you.

Above you, many cower in fear of your invasion, and others wait in awe. But what really goes on in the darkness beneath the surface, and what happens when you reemerge?

It's an answer for those ready to bury themselves Below the Scope....

[Music starts]

DR. GENE KRITSKY: They don't crawl down the tree; they do a kamikaze drop to the ground, and as soon as they hit the ground, they've got very little time to get below the surface.

SINGLETON: This is Dr. Gene Kritsky.

DR. KRITSKY: But I've watched this. I've taken these nymphs that I've harvested that were an hour old.

SINGLETON: He's an emeritus, or a distinguished but retired professor of biology at Mount St. Joseph University and the Chief Science Officer for the Center for IT Engagement.

DR. KRITSKY: And I've dumped it at the base of a maple tree to see how fast they know what what happens. Within 30 seconds, most of them, at least 50%, are gone. And what they've done is they found that connection where a blade of grass is connected with the soil. They've—that little space there is enough for them to get actually down underground. And within a minute they were all gone.

SINGLETON: The surface is a minefield of dangers.

[Crawling and digging SFX]



SINGLETON: Birds can swoop in and carry you off. Beneath a fallen leaf could be a wolf spider a hundred times your size.

You—the cicada— quickly need to descend down a blade of grass into the soil using big powerful legs. The late summer sun fades behind you as you crawl deeper. But you don't go too deep. Your first year—you only go about one to two inches below the surface.

And now you have to find food, praying is something that can be eaten with your proboscis. It's essentially your mouth, but it works more like a straw.

DR. KRITSKY: They can actually puncture through the plant tissue and and get—get moisture that way. And so they're feeding on the xylem, which is a nutrient pore.

SINGLETON: And seventeen-year cicadas, and the other periodical cicadas, rarely leave the trees they were hatched from. Unless you're in a forest or somewhere with extensive interlocking root systems—you are trapped for nearly two decades, as you roll the dice on where you'll get your meals, unsure whether or not this tree will be a sustainable food source. Nevertheless, it'd be better than becoming lunch.

PJ LIESCH: And it—it makes sense when you think of it.

LIESCH: My name is PJ Leisch.

SINGLETON: He's an entomologist at the University of Wisconsin-Madison and runs the UW Insect Diagnostic Lab.

LEISCH: If you're talking about periodical Cicadas, they need a food source that is going to be there for the long haul, 13 or 17 years. And so if you just decide one day, hey, I'm gonna wander off and tunnel in this direction, you might not hit a tree. You could be in an open park or cemetery or something like that, and it could be a long ways to the next tree, and—and that would basically do you.

SINGLETON: About 99% of your life is this, tunneling and feeding on roots. And this has its own dangers, as soils are full of life from animals to insects or even tiny organisms that will gladly eat you without blinking an eye. But without food and a little bit of luck, you won't develop properly. You continue to struggle for nourishment in the name of instinct.

DR. CHRIS SIMON: But the first stage only lasts anywhere from like two months up to—say, nine to eleven months.

SINGLETON: This is Dr. Chris Simon.



DR. SIMON: I'm a research, a senior research scientist at the University of Connecticut in the Department of Ecology and Evolutionary Biology.

DR. SIMON: The—the, 17-year cicadas have the first instar is one year, and you can think of it as one year, although it's variable. And then the second, third, and fourth and fifth instars, they all are have an average length of four years. But some are healthier than others, some have better genotypes than others, some have better feeding.

SINGLETON: When cicada nymphs switch to the next stage, it means they've outgrown their previous exoskeletons, and they begin to molt. The outermost tissue of their exoskeletons pulls apart from the rest of their bodies.

[Cracking SFX]

Then, they crack open the exoskeleton to begin their next stage of development.

SIMON: So once they get to the last stage or instar, the fifth one, then they're getting ready to turn into adults. But it takes a while. They have to develop their ovaries and their wings and wing buds and all that kind of stuff.

SINGLETON: But unlike the other stages, they don't molt underground in the last stage. This is when they prepare to return to the surface.

SIMON: So in the fifth instar, they're developing and at a certain point they're ready to come out. But it might not be the thirteenth year or the seventeenth year, so they just wait.

So, the really interesting thing is they have these four-year windows. Once they get to the fifth instar, there's these four-year windows. So if—if they're ready in the year 13 and they're 17 years cadet, they'll—they'll come out in year 13. If they're not ready, they'll stay in the fifth instar and they'll come out in year 17. And if it's been really cold and they're not ready, you know, the whole time it's been really cold, like during the ice ages, they're not ready.

Then they'll come out in the 21st year. So there's like these four year windows. And when you go down and look at the 13 year cicadas, we've gone down and my postdoc and my technician went down, looked specifically for them coming out four years early, and they do that as well. So they come out in nine years if they're ready.

SINGLETON: Soon you will emerge with your brethren. This complicated behavior seems to be a way for these nymphs to develop and avoid most predators.

LEISCH: What's interesting to me, though is some of the strategies that have been discussed and and kind of put out there as possible explanations for like periodical cicada behavior. And really two things stand out to me. These irregular time intervals, 13 or or 17 years, and these



are relatively large numbers as far as insects go. I mean, a lot of insects have a pretty short lifespan. Think of a fruit fly, that could be a matter of a week or two. So insects that are living that long-, that's really, pretty unique. But also these large prime numbers. That's that's hard for potential predators to catch on to.

SINGLETON: Prime numbers are those that can't be multiplied besides by one and itself.

LEISCH: What I'm getting at there is let's say you are periodical cicadas or or cicadas in general and you came out in huge numbers every single year or maybe every other year. You know, we've got some vertebrate predators that can live for a couple years and eventually those predators may catch on to this and realize there's a big resource, food for us. Every year, every other year, their populations would probably increase accordingly.

SINGLETON: It may not be clear how cicada is known to come out at the same time, but it seems to be related to ground temperature.

LEISCH: They'll actually make these tunnels that go up to the surface of the soil.

SIMON: In a lot of places they'll make their holes to the surface before they come out. And you can you can see them sitting down in the holes there if, there, if the holes are out in the open. So they'll just be waiting for the right temperature.

SINGLETON: On the right night, at the right temperature, after more than seventeen years, the brood returns...

SINGLETON: One night—when the ground temperature is just right—after the sun sets behind a silhouette of trees, you and millions of other cicadas erupt from the soil. Breaking into the surface world. Your tiny, but powerful legs pumping as you climb. Your seeming desperation to live the rest of your life to the fullest is commendable.

SINGLETON: There are about 3,000 species of cicadas around the world. Most of them are annual cicadas. They live on two to five-year life cycles, but you can find members of the same species every year. But in the United States, periodical cicadas are unique. You can find them from as far north as Massachusetts to the plains of Texas, Oklahoma, and Nebraska. There are seven species with different broods or populations, and they come out on 13- or 17-year cycles.

SINGLETON: But even you, a seventeen year cicada, and the millions in your brood don't come out in the same year as another million seventeen year cicada brood. Your brood has its own timeline, and another brood has its own. Right now is your time, and you are one of the many carpeting the forest floor.

[Scurrying sounds]



Millions of six-legged nymphs scurrying around. And you're not done developing yet. To finish and finally become the cicada you were always meant to be, you have to climb. And hope that your genetics ensure your success and survival on the surface world.

LEISCH: They're going on to tree trunks, sides of houses, fence posts, other vertical surfaces.

SINGLETON: Once situated, you lock your claws into the surface. Then you begin to molt and shed your exoskeleton for the final time. You wriggle back and forward, splitting out your old husk of a body. Wings like stained glass emerge. Those big large legs you used to dig into the soil are now much smaller. You don't fly away immediately though...

DR. KRITSKY: So but once the that they can they then start pumping fluid through the wings that expands the wings so they took look very tent-like over the abdomen, typical cicada wings. And that process takes about 90 minutes. Once crawling out of the ground, flying, and then getting the wet the animal out—that's 90 minutes. But they're still all white. They still can't fly. So that takes another 90 minutes, depending on air temperature, could be a little bit longer, to harden their exoskeleton, scleritize it as well as tan it.

SINGLETON: Pale white cicada slowly turns black in the darkness.

KRITSKY: After three hours or so after they start coming out of the ground that you now have this the typical periodical skate of the red eyes, the black body, the wings of the orange colored veins and what have you. But they're still even though they now an adult, they can't mate yet. Once that happens, they start crawling up the tree and they get up in the canopy where they sit and continue to harden their exoskeleton, get their reproductive structures matured. That's when they start singing and flying.

SINGLETON: Over the next four to five days, cicadas fully develop their sexual reproductive parts. Female cicadas develop ovaries, but male cicadas develop something else.

LEISCH: The males they've essentially evolved to be living musical instruments. Their abdomen for the most part is hollow. You got these membranes, there's muscles attached to it, so when you pull those it causes vibration and—and that produces the sound and and they're doing this, they're basically yelling, screaming to attract the females.

SINGLETON: The songs of cicadas are so iconic that many of us associate them with the sounds of spring and hot summers. And for the next four to six weeks, cicada males and females will be trying to find mating partners. But now that your brood of your brothers and sisters has emerged, and with the males not being able to be quiet, the dinner bell has rung.

Cicadas don't have stingers, toxins, or strong jaws, so you are essentially defenseless to your surroundings. Everything from fish, insects, reptiles, and mammals eat cicadas, including humans.



LEISCH: And actually if you go back into some of the oldest written documents related to periodical cicadas in North America, this is we're talking about first half of of the ~ like sixteen hundreds. You know, settlers came from Europe. What are these? Because they only occur in in eastern parts of North America. So Europeans had never seen or experienced these before. And yet they saw Native Americans were collecting these, used as a a food source because again it's a very abundant protein source at the time.

SINGLETON: If you're curious, you can find cicada recipes online. Periodical cicadas also don't have natural predators. You may have heard of the cicada killer. They're large wasps, one of the largest in the United States. They focus on annual cicadas, attacking them and bringing them back to their nest for their young. They only attack periodical cicadas if they happen to luck out.

Since periodical cicadas emerge with no natural predators, brood populations can grow exponentially.

Rarely, different broods of periodical cicadas—one 13 and the other 17— can emerge at the same time and have partially overlapping geographical areas. This nearly happened in 2024 when two separate broods emerged in Northern Illinois. However, despite the hype, the two broods were miles apart. Because there are only three 13-year broods, a joint emergence won't happen again until 2037 and these two broods will be even farther apart.

But even during a normal periodical cicada emergence, there are so many cicadas. That scientists can see the evidence of the buffet.

DR. KRITSKY: In some urban areas where cicadas emerge, they often see a spike in the number of mice and rats in the cities because there's more food. It's prevalent. There was a study done a few ~ a couple of years ago that found that there was a a caterpillar that was a pest on oak trees. But during the cic-the brood ten emergence, those birds— the birds that kept the oak tree caterpillars in check, stopped feeding on the caterpillars and they started feeding on the cicadas. And so the caterpillars did a lot more damage that year.

SINGLETON: In the long run, researchers aren't sure how much damage the caterpillars actually did to these trees, but other research has shown that when a periodical cicada brood emerges, local trees grow slower as predators feed on them instead of other pests, which can set the development of a forest back. So, the emergence of a brood can be beneficial for all.

LEISCH: And in local areas you can get tens of thousands, hundreds of thousands just in small areas like an acre or so. And the idea is, and this is part of an evolutionary strategy, there are so many that emerge that yes, plenty of them will be eaten by birds or fish or raccoons or skunks or whatnot, but there's gonna be so many overwhelming numbers that many more survive and successfully mate and and reproduce.



So that is really an important part of their biology. If they emerged at these long time intervals, but you only got twenty or forty that popped out and a lot of those get eaten because you're you're a male, you're screaming, you're making noise, you're conspicuous to predators. you're probably gonna fizzle out in that.

SINGLETON: While hundreds of thousands of your brethren become dinner. Enough survive during each emergence to sing and mate, if they can avoid the danger among them.

[Music...]

SINGLETON: Periodical cicadas don't have a natural predator. However, they do have a natural parasite. It's a fungus called *Masopora cicadina*, and it only affects 13 or 17-year cicadas. It changes how they look and behave.

One of the earliest descriptions of the fungus actually comes from a freeborn black man named Benjamin Banneker, who helped survey what is now Washington, D.C. He wrote in the year 1800.

"The hindermost part rots off, and it does not appear to be in any pain to them, for they still continue on singing till they die".

He is referring to the spores of the fungus, which causes the abdomen of the cicadas to fall off. It then forms a plug of white chalky spores where the abdomen was.

But it also affects the behavior of the cicadas.

LEISCH: When the spores infect the periodical cicadas, it doesn't kill them, but what it does is it actually produces and releases some amphetamine-like compounds and it alters the chemistry of the brain. So these infected ~ cicadas, I mean, they're they're hopped up on drugs, so to speak.

SINGLETON: Scientists believe that these compounds make the cicada hypersexual.

DR. KRITSKY: The periodical cicada mating process is quite fascinating. It's only recently been well understood. Initially just a few were singing, but as that the over the course of the next week to week and a half, more and more males will be singing, and they gather in the trees that we call chorusing centers. Female cicadas, hearing the chorusing center, will fly into the tree. And of course wherever you have an aggregation of of males, it's called a lek, L-E-K. And so the females fly into this coring chorusing center.

And she'll there's gonna be tens of hundreds of kids possibly eating in that tree. She's gonna land and be close to one. If there's a male nearby singing, she will respond by flicking her wings



at a specific point in his call. Now that's a rather interesting time because other males are sitting around, and if they hear a female make a flick, the next time that first male sings, they will start singing as he's approaching that critical point, so that she doesn't hear the first male, she hears the second male's call and starts responding to him. And as that happens, the male and the females will walk well, they'll walk both walk closer together and eventually this the call will stop having a gap for her to flick her wings and it'll be a continuous call and that's when they get really close and then the male starts tapping her on the back with his foreleg. And as physical mating starts to occur he goes into a third call. For whichever male wasn't successful at attracting a mate he gets frustrated and flies either to another branch but oftentimes to another tree and that's when you hear these cicadas call get this really loud cacophonous chorus and I've measured as high as 102 decibels.

SINGLETON: That's as loud as an average construction site and almost as loud as a nightclub.

DR. KRITSKY: [Laughs] That's enormous! That's louder than jets flying into the Dallas airport. [Laughs] I mean it's just incredible. And so but as you listen, it's not a constant. It actually gets really loud and then it drops a little bit. And then loud again and drops and that that time when gets decreases in sound, that's when the unsuccessfully mating males fly to other branches.

SINGLETON: Male cicadas show a significant difference in behavior if they're infected before the mating process. These hypersexual cicadas can fly from tree to tree, spreading their spores as they attempt to mate. If the abdomen of a cicada is removed, male cicadas can't sing as well. Instead, they flick their wings like females, attracting other male cicadas. However, their wings can become infected from doing so. And as you fly, spores shake off the fungal plug, and if the fungus gets lucky. It can infect other cicadas, spreading disease instantly.

But this is just stage one of the infection. In stage two, a cicada dies and falls to the ground, where the spores are deposited. But if a female cicada is successfully impregnated by a male, she lays her eggs a few days later.

DR. SIMON: They'll lay eggs in pencil-sized branches on trees and they'll lay them in V-shaped nests and in each side of the V there'll be about twelve eggs and—and then those eggs will still take about six weeks before they hatch. So they'll be hatching in late summer.

SINGLETON: However, female cicadas do this several times, laying over 500 eggs in her life. Some research has suggested that cicada nymphs may become infected with fungal spores as they pass through an infected mother. These spores are possibly lying dormant in the nymphs until they reemerge. Unfortunately, the mother will never see her young. After four to six weeks, the life cycle is complete. Male cicadas die soon after mating for the final time. And females after laying their final eggs.



So, your life as a cicada and your generation's time has ended. Fish, insects, reptiles, birds, and mammals feast on all of your corpses, providing a source of protein for their entire ecosystems. For those of you who aren't eaten, your bodies will decompose in the soil, providing nutrients for plants and other life that live there. Your life has new meaning. As you provide from the grave.

And when the new generation of nymphs hatch at the end of summer, they dig tunnels, improving air circulation, making it easier for water flow to the roots of trees and plants. The thought of millions of cicadas invading our lives can inspire fear. However, these harmless insects are an important and unique part of the forest of the eastern half of the United States. Something you could only appreciate if you're willing to look...

Below the Scope!

[B-Scientists Theme Music]

CREDITS:

Thanks to our experts, Dr. Gene Kritsky, PJ Leisch, and Dr. Chris Simon.

This episode was narrated by me—Josh Singleton! It was written by Chad Singleton, myself, and Jordan Chapman. Jordan also edited and fact-checked the episode.

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Thanks for listening to this episode! Please subscribe to know when a new episode drops and like and leave a comment when you do!

And finally, B-Scientists, until next time!

