

CHILD: You're listening to *Brains On*, where we're serious about being curious.

CHILD: *Brains On* is supported in part by a grant from the National Science Foundation.

[DRAWER OPENS]

MOLLY BLOOM: Hey, Marc, making a little pre-show sandwich, I see. What'll it be today? Triple pickle?

MARC No, not today. I'm going for something much more down to Earth literally.

SANCHEZ:

MOLLY BLOOM: What?

MARC I'm making an Earth sandwich.

SANCHEZ:

MOLLY BLOOM: Earth sandwich? I've never heard of that.

MARC It's only two ingredients. First, you take a slice of bread.

SANCHEZ:

MOLLY BLOOM: OK, pretty standard.

MARC OK, now take your bread and put it face down on the floor.

SANCHEZ:

MOLLY BLOOM: And you lost me. Why on Earth would you put your bread on the floor?

MARC Why on Earth? Well, because it's an Earth sandwich, of course.

SANCHEZ:

BOB: (OVER THE RADIO) Marc, are you there?

MARC Oh, hey, Bob. Yeah, I'm still at headquarters. Did you make it to the other side of the planet?

SANCHEZ:

BOB: (OVER THE RADIO) Yup, elevator took me straight here. I even double checked my compass.

MOLLY BLOOM: Where is Bob?

MARC OK, Bob went to the other side of the Earth for the sandwich. If he and I stand at opposite ends of the Earth and

SANCHEZ: put two slices of bread on the ground at the same time, we'll sandwich the planet. Boom, Earth sandwich.

MOLLY BLOOM: So Bob's somewhere in the ocean? Are you sure?

MARC All right, Bob, is your slice of bread ready?

SANCHEZ:

BOB: (OVER THE RADIO) Yep.

[WAVES LAPPING]

Oh, oh. Hold on. I have to add some mustard. I mean, it's hardly a sandwich without that. OK, ready.

MARC OK. On the count of 3, put your bread on the ground. Ready? 1, 2, 3!

SANCHEZ:

MARC AND Earth sandwich!

BOB:

[WAVES CRASH]

BOB: (OVER THE RADIO) Uh, Mark? Yeah. Since I'm out here in the ocean, my side of the sandwich, it's a little soggy.

MARC Well, (CHEWING) mm, the soggi-ness is only one of so many complex layers and textures. Mm, I'm really getting a
SANCHEZ: strong earthy flavor. Here, try some, Molly.

MOLLY BLOOM: Hmm, salt water flavor, a little much for me. I think I'll stick to peanut butter and jelly next time.

BOB: (OVER THE RADIO) Mm, watch out, Marc. I have a feeling it's still very hot in the middle.

[THEME MUSIC]

MOLLY BLOOM: You're listening to *Brains On* from American Public Media. I'm Molly Bloom, and my co-host today is Elijah from Atlanta. Hi, Elijah.

ELIJAH: Hey, Molly.

MOLLY BLOOM: So this episode, we're going deep. We're thinking about our Earth's insides and the different layers of the planet beneath our feet. And you, Elijah, sent us a great question about this.

ELIJAH: I wanted to know what would happen if you dug a hole into the Earth and jumped right in it.

MOLLY BLOOM: It is a really interesting question. So Elijah, what got you thinking about digging a hole through the Earth.

ELIJAH: I don't really. I just hear a lot of things, say, that if you dig a hole into the Earth, you're going to end up in China. And I do not think that's true.

MOLLY BLOOM: Well, we're going to learn about that in just a little bit. So what do you think would happen if there was a hole that went all the way through the Earth and you jumped into it?

ELIJAH: I actually think gravity would be really weird because I've been having dreams about it. If you jump through it, you're going to keep on falling until you go to the other side and then that's a whole another side of gravity pushing in this way. So then it's going to put you up here again. It's just going to keep on going continuously.

MOLLY BLOOM: Wow. That is really cool. I love how you thought about that. That's really awesome. So if you could go inside the center of the Earth, what would you want to see?

ELIJAH: Diamonds maybe.

MOLLY BLOOM: Mm.

ELIJAH: Or emeralds. Diamonds and emeralds are my two favorite minerals.

MOLLY BLOOM: So we're going to come back to that whole through the Earth thought experiment later on in the show. Before we tunnel through the planet, let's talk about the layers of the Earth.

ELIJAH: We actually heard from a new band about these layers.

MOLLY BLOOM: They're called Mantle and Sons.

ELIJAH: You've probably never heard of them. They're still underground.

[CHUCKLES]

MOLLY BLOOM: Here's their debut track.

[MUSIC - MANTLE AND SONS]

MANTLE AND SONS: (SINGING) It starts down deep where you can't ignore inner and outer are the Earth's two cores. Next, the mantle, thickest layer of all, dancing, rocking. Now, we're having a ball. To top it off, we have the Earth's crust, where all creatures live, including us.

Two-part core, mantle, and crust, temperatures range from hottest to dust. Two-part core, mantle, and crust, those are the layers of Earth we can trust. Those are the layers of Earth we can trust. Those are the layers of Earth we can trust.

MOLLY BLOOM: I love it. So to recap, the Earth has four layers. In the middle is the inner core, then the outer core, then the mantle, and finally, the crust, which is the part we live on.

CHILDREN: Brains On!

MOLLY BLOOM: So before we get into your very interesting thought experiment, Elijah--

[MUSIC PLAYING]

--it's time to answer these listener questions.

LISA: Hi, my name's Lisa, and I'm from Denmark. But I live in Cambodia.

MALACHI: My name is Malachi, and I'm from Moorhead, Minnesota.

LISA: My question is, how do scientists know the thickness of each layer of the Earth and how do they know the different layers in the Earth?

MALACHI: I read that no one's ever been able to dig deeper than the Earth's crust. So my question is, how do we know what is below the Earth's crust?

LISA: Thanks, bye.

[MUSIC PLAYING]

MOLLY BLOOM: These are great questions.

ELIJAH: Right. No one's ever traveled to the core of the Earth or even gotten through the crust.

MOLLY BLOOM: So how do we know that there's a mantle and an inner and outer core? That's thanks to a tool called a seismometer and some very smart scientists.

ELIJAH: One of these scientists is Inge Lehmann. She discovered that the Earth had a solid inner core.

RACHEL She called herself the only Danish seismologist.

SWABY:

MOLLY BLOOM: That's Rachel Swaby. She's a journalist, and she wrote a book called *Headstrong* that profiles 52 amazing scientists who are women. And one of the women she researched for her book was Inge.

RACHEL I stumbled upon this academic paper and found not only that Inge Lehmann was an amazing scientist, but that
SWABY: she discovered the inner core of the Earth, this huge, huge thing that we learn about when we're kids. And I had never known that she was the one who discovered it.

ELIJAH: In the 1920s, Inge was a seismologist working pretty much by herself in Denmark.

MOLLY BLOOM: Seismologists are people who study earthquakes and movement of the big plates that make up the Earth's crust.

ELIJAH: This is called seismic activity. So they're called seismologists.

[MUSIC PLAYING]

MOLLY BLOOM: Now, Denmark is a funny place to study earthquakes. It's not like California or Japan where there are a lot of earthquakes, but Inge was very excited about seismometers, cool machines that have the ability to detect seismic waves. These are waves of shaking energy in the Earth, like ripples in a pond but through the ground.

ELIJAH: Seismic waves are epic.

MOLLY BLOOM: To learn more, Inge set up seismometers all over Denmark and Greenland to take measurements of earthquakes.

ELIJAH: Those measurements are also called data.

MOLLY BLOOM: So when an earthquake happens on one side of the world, it sends waves through the Earth.

ELIJAH: And when scientists look at how fast or wiggly these seismic waves are, they can get an idea of what the wave traveled through to get there.

MOLLY BLOOM: It's like imagine a wiggling bowl of jello. Its surface would move a lot, so you'd know the jello is kind of flexible.

ELIJAH: But if you wiggle a bowl of solid concrete, you see a much less motion in the surface telling you that concrete is much more stiff.

MOLLY BLOOM: If the Earth were uniform on these inside, all made up of the same material, the waves would travel out in a consistent way and at a consistent speed like the waves in jello.

ELIJAH: A scientist noticed that the waves sometimes came from unusual angles or at different speeds.

MOLLY BLOOM: In 1916, scientist Beno Gutenberg figured out through this data that the center of the Earth was more like a liquid.

ELIJAH: Now, lucky for Inge, her seismic detection network was picking up waves from the other side of the world in South Asia, where there was a lot of seismic action.

MOLLY BLOOM: And since Inge was working on her own, she could take the huge amount of data coming in and go analyze it at home.

[NATURE SOUNDS]

RACHEL And she was working really, really hard like a lot of the scientists do. But she was sitting in her backyard,
SWABY: surrounded by flowers and whatever else she was growing in the summer. And she had these oatmeal boxes shoved full with index cards, and she'd sit out there in her backyard and go through her data.

MOLLY BLOOM: And as she sat among the birds and the flowers, going through her note cards, she noticed that some of the data didn't mesh with this idea of the Earth having an entirely liquid core.

RACHEL She was able to see that like, hey, this doesn't look quite right. The wave should be arriving at this velocity and
SWABY: at this location. But every once in a while, they're coming in in a different place. And so she was a stickler for data, and she realized that there were some irregularities. And then because of these irregularities, she was able to run the numbers and realize, hey, there's something else in the middle of the Earth, too. There's an inner core as well as an outer core. So the outer core is the liquid magma, and the inner core is solid metal.

MOLLY BLOOM: A solid metal core. It was a huge discovery, and it totally changed our idea of Earth.

ELIJAH: Way to go, Inge! We science salute you, a scisalute!

[HORNS PLAYING]

MOLLY BLOOM: Right on. Scientists today are still using seismic waves to get a more complete and detailed picture of the Earth.

ELIJAH: They're finding that the mantle--

MOLLY BLOOM: Which is the layer of Earth just under the crust part that we live on--

ELIJAH: That mantle is probably more layered and varied than we used to think with hidden onion-like layers.

MOLLY BLOOM: Oh, Earth, you are full of surprises.

[MUSIC PLAYING]

ANNOUNCER: And now, Sanden and Marc tell you rad facts about the center of the Earth, accompanied by--

[RECORD SCRATCHES]

--heavy metal music.

[MUSIC PLAYING]

SANDEN The Earth's core is made up of two parts, a liquid outer core and a denser inner core. That inner core is literally
TOTTEN: heavy metal. It's a solid ball of mostly iron, which is awesome.

MARC And that inner core spins around inside the Earth, but it spins totally independent of how the rest of the planet is
SANCHEZ: spinning. So weird.

SANDEN And that outer core, the liquid one, is so hot, parts of it are about as toasty as the surface of the sun, which is an
TOTTEN: epic fact!

MARC And it's that swirly liquid outer core that creates the Earth's totally rad magnetic field!
SANCHEZ:

SANDEN And without that magnetic field, we'd probably lose our atmosphere! And life as we know it would cease to exist.
TOTTEN: So if you like being alive, thank the Earth's core. (ECHOING) Gnarly!

ANNOUNCER: That was Sanden and Marc, telling you cool facts about the Earth's core accompanied by heavy metal music.
Now, on with the show!

MOLLY BLOOM: Elijah, we've got something else to check out. It's the--

[MUSIC PLAYING]

GIRL: (WHISPERING) Mystery sound.

MOLLY BLOOM: Are you ready to hear it?

ELIJAH: Yes, I am.

MOLLY BLOOM: OK. Here it is.

[MYSTERY SOUND]

Elijah, what is your guess?

ELIJAH: Feel like it sounds like something is scraping on concrete.

MOLLY BLOOM: Hmm, very good guess. Well, we're going to give you another chance later in the show to hear it and guess again.

[MUSIC PLAYING]

We're working on an episode all about color, and we want to hear from you. We want you to invent a superhero based on a color. Captain Fuchsia, Super Turquoise, Purple Woman, what is your color superhero, and what are their superpowers?

ELIJAH: Send it our way at BrainsOn.org/contact.

MOLLY BLOOM: You can also send us questions, drawings, and mystery sounds.

ELIJAH: That's where this question came from.

GRETA: My name is Greta, and I'm from Seattle. And my question is, do fishes have tongues?

ELIJAH: We'll get to the answer in the Moment of Um at the end of the show.

MOLLY BLOOM: And we'll read the most recent list of names to be added to the Brains Honor Roll.

ELIJAH: So keep listening. Welcome back to *Brains On*. I'm Elijah.

MOLLY BLOOM: I'm Molly.

[KNOCKING]

Come in.

[DOOR OPENS]

[DOOR CLOSSES]

RUBY GUTHRIE: Hey, Molly. Hi, Elijah.

MOLLY BLOOM: Hey, it's our pal Ruby Guthrie. But Ruby, we're in the middle of an episode?

RUBY GUTHRIE: I know, but I just had an epiphany.

MOLLY BLOOM: Ruby, the last time you told me you had an epiphany, you told me you finally realized cilantro isn't just bitter parsley, that they're just two different herbs.

RUBY GUTHRIE: Look, I can't help it if I have spontaneous insights about the world. But to your point, this isn't just any random realization. It's an Earth-piphany. It ties in nicely with everything you've been talking about. I promise.

MOLLY BLOOM: OK, if you say so.

RUBY GUTHRIE: Thanks. I'll make it quick.

MOLLY BLOOM: So it all started yesterday.

[CHIMES PLAYING]

I was in my sandbox, and I started digging. And let me tell you, I was really getting into it. I was just going in with the shovel, and then my mom came out and said--

RUBY'S MOM: Hey, if you dig a hole deep enough, you'll end up in China.

RUBY GUTHRIE: And that made me think, why do people say that? Have either of you ever heard of this phrase before?

MOLLY BLOOM: Yeah, I've heard that phrase. And like Elijah and I were talking about earlier, he told me he's a little skeptical of this phrase. So Elijah what do you think of that phrase, "if you dig a hole deep enough, you'll end up in China."

ELIJAH: I don't think it's true. I just don't think it's true.

RUBY GUTHRIE: Well, I did some digging of my own, the research kind not the shovel kind. And guess what? China isn't actually the opposite of the United States.

MOLLY BLOOM: But isn't China on the other side of the planet?

RUBY GUTHRIE: Yes, that's true. China is on the other side of the world, compared to the US. But it's not the antipode of the United States.

MOLLY BLOOM: An antipode? What's that?

RUBY GUTHRIE: An antipode is the spot on the other side of the planet that's the exact opposite of you. So if you were to dig straight down through the Earth, you would end up at the antipode.

MOLLY BLOOM: Antipode is pretty fun to say. Antipode.

ELIJAH: Antipode.

MOLLY BLOOM: Antipode!

ELIJAH: Antipode.

MOLLY BLOOM: OK, so you're saying, if you dug straight down from the US, you wouldn't end up in China?

RUBY GUTHRIE: Exactly. If you literally dug through the center of the Earth from nearly any state in the continental United States, you'd actually end up in the middle of the Indian Ocean.

[WAVES CRASHING]

MOLLY BLOOM: Better wear your wetsuit.

RUBY GUTHRIE: Maybe bring some flippers, too. So the whole digging to China phrase isn't geographically accurate, at least for us Americans. It makes sense when you stop and think about it actually.

[MUSIC PLAYING]

Even though China and the United States are far away from each other, they're both in the northern hemisphere, which means we're both on the top half of the globe. So naturally, we can't be true opposites. Our opposite would have to be on the bottom half of the globe.

MOLLY BLOOM: Right, like if I had a globe, and I took two slices of bread and put one on the US and one on China, it wouldn't make an even Earth sandwich.

RUBY GUTHRIE: Mm, love me an Earth sandwich. Yeah, that's true. To make an Earth sandwich with China, your other slice of bread would actually need to be in Argentina because Argentina is the antipode of China.

MOLLY BLOOM: So if this phrase is not geographically correct, where did it come from?

RUBY GUTHRIE: It's hard to say exactly where and when this thing started, but one theory is that it originated back in the 1800s when this dude Henry Thoreau wrote a book called *Walden*. In the book, he described a man who dug a hole so deep that he could hear pots and pans rattling from China.

[POTS AND PANS RATTLING]

That was an exaggeration of course, but the idea stuck. There are even two towns in Illinois, Canton and Pekin, that were named after Chinese cities because people believe they were the geographic parallels. This phrase is still repeated today in different stories, cartoons, TV shows, and movies. So that's my Earth-piphany.

[MUSIC PLAYING]

Digging to China is just one big old geographical misunderstanding. So if you're planning to dig to the other side of the Earth from the US, just remember to bring your swim goggles.

ELIJAH: Thanks, Ruby.

RUBY GUTHRIE: Happy to be here. I think I'll go fix myself an Earth sandwich now. I hear Bob has a good recipe. See ya.

ELIJAH: Since when did Earth sandwiches become the new it food?

MOLLY BLOOM: Good question.

[MUSIC PLAYING]

Elijah, are you ready to hear that mystery sound one more time?

ELIJAH: Yes, I am.

MOLLY BLOOM: All right. Here it is.

[MYSTERY SOUND]

OK, so last time you heard it, you thought maybe something scraping on concrete. Do you have any other thoughts?

ELIJAH: No, not really.

MOLLY BLOOM: OK, are you ready to hear the answer?

ELIJAH: Yes please.

MOLLY BLOOM: Here it is.

LILY: Hello, my name is Lily, and I'm from Idaho, Coeur d'Alene. And this is a book, and I'm flipping through the pages like this.

[RAPID FLIPPING]

MOLLY BLOOM: So it was flipping through the pages of a book. Have you ever done that before?

ELIJAH: Yes, I read a lot of books actually.

MOLLY BLOOM: Yeah, and it does kind of sound like dragging something on concrete when you do it that fast. It's a cool sound.

MEN: (SINGING) Ba ba ba ba ba ba ba ba ba Brains on.

MOLLY BLOOM: Elijah, let's get back to your question that started this whole episode, the one about digging a hole through the Earth and jumping in it. We asked producer Menaka Wilhelm to look into this.

ELIJAH: Hi, Menaka.

**MENAKA
WILHEM:** Hey, Elijah.

ELIJAH: What did you find out?

**MENAKA
WILHEM:** Well, no one has ever really gotten to try this out, but I did find a scientist who has dug pretty deep into the Earth.

**DONNA
BLACKMAN:** We got as far as 800 meters into the crust, so not quite 1 kilometer.

**MENAKA
WILHEM:** Donna Blackman is a geologist, and she's into rocks below the Earth's surface. That digging that you mentioned, she worked with a team of scientists out on a big boat in the Indian Ocean to do that. They wanted to drill as deep as they could and take samples along the way to see what rocks in the crust were made of. They basically got half a mile into the Earth's crust, right under the ocean. And technically, they drilled that hole rather than digging it.

ELIJAH: But that's just the crust, the thinnest part of the Earth's insides.

**MENAKA
WILHEM:** Right, and scientists have drilled holes deeper than the one that Donna mentioned, but they've never made it more than about a third of the way through the crust. Drilling into the Earth takes a bunch of time, energy, and tools. And most expeditions eventually run out of at least one of those things. It turns out, it's really hard to drill through rocks. And it gets even harder the deeper that you go.

ELIJAH: Wow.

**MENAKA
WILHEM:** But Donna was game for our thought experiment because it's such a good question. So let's imagine that it is possible to dig a hole all the way through our planet.

[MUSIC PLAYING]

So Elijah, it's up to you. Where should we dig through the Earth?

ELIJAH: In the Mariana Trench.

**MENAKA
WILHEM:** The Mariana Trench is a great choice.

[SPLASHES]

So first, we'll have to travel through quite a bit of ocean because the Mariana Trench is the deepest trench on the Earth, and it's out in the Pacific Ocean. But then eventually, we'll get to the Earth's crust that's underneath the ocean. And overall, the crust that's underneath the ocean is a little different than the crust that's on land.

So the crust on land formed when Earth's tectonic plates crashed into each other. But the crust underneath the ocean formed when magma oozed out of cracks in Earth's surface. And then as that magma cooled, it became the crust. So crust underneath the ocean is only 3 to 6 miles deep, whereas crust on land can be more like 30 to 40 miles deep. So we'll start out in a really deep part of the Pacific Ocean.

Oh, and Donna has one more suggestion before we jump in. The center of the Earth has really high pressure, and she says, that means our hole might collapse. So we should use a casing, which is basically a vertical tunnel to hold our hole open as we go.

DONNA
BLACKMAN: We're going to have to think about what we want to make that casing with because otherwise, we're not going to be able to see the rocks on the way down, which if you're a geologist like me, that's one of the main things you want to do.

MENAKA
WILHEM: I definitely want to see the rocks. So let's make that a see through, super strong vertical tunnel.

[TAPPING]

ELIJAH: How's our signal? You can still hear us?

MOLLY BLOOM: Yep, strong, imaginary signal coming through.

MENAKA
WILHEM: All right, you ready?

[MUSIC PLAYING]

Here we go!

DONNA
BLACKMAN: So as you go down, you're going to get to see the different layers of sediments. The sediments are going to go by pretty quickly because they're just a really, really thin skin on the surface.

MENAKA
WILHEM: Sediments are a kind of rock, so they're part of the crust. Oh, and actually, you mentioned earlier wanting to see gems deep in the Earth. And the crust is where emeralds form. They don't form everywhere in the world, just in some parts of the Earth because it takes a mixture of hot water and just the right chemicals to make them. Sometimes, emeralds also form in magma, which is liquid rock. All right, so we're moving along in the crust.

ELIJAH: And when the crust ends?

DONNA
BLACKMAN: Then we're going to get to a really cool interface, which is the bottom of the crust and the top of the mantle. And so this is a place where there's going to be more olivine and so a little bit of a greenish color to the crystals.

MENAKA
WILHEM: Olivine is a mineral that's green, kind of like emeralds, but it's lighter. To me, it looks more like if grass became a mineral. So now, we're headed through the mantle. And this is farther than anyone's ever dug. And you mentioned also wanting to see diamonds if you got to travel into the Earth. So this is where diamonds form, about a hundred miles beneath Earth's surface in the upper mantle area.

[CHIMES]

But since this is farther than anyone's ever been, you might wonder how we get any diamonds up to us. And the answer is that the diamonds that we can mine, so the diamonds that we can dig for, they got pushed closer to Earth's surface by underground eruptions a long, long time ago.

ELIJAH: Cool, is it just me or is it pretty toasty down here?

MENAKA
WILHEM: It definitely is not just you. We're hitting higher temperatures and pressures by the minute. The temperature changes a lot around here, but we can expect it to be somewhere between 2,000 and 7,000 degrees Fahrenheit. So pretty toasty. Hang tight. We're headed to another important spot about 1800 miles below Earth's surface.

DONNA
BLACKMAN: And that's where we're going to hit a more metallic core material, and the outer core, in fact, is going to be molten. So as we look through our clear, really strong, really temperature-proof casing, we're going to be able to, if we take our time and look, we're going to be able to see that outer core metallic material actually flowing around us.

ELIJAH: Whoa, liquid metal.

DONNA
BLACKMAN: Then the pressure is just going to get too high, and that material becomes solid. It just can no longer maintain its liquid form. And so that's the last layer that we're going to go through to get to the center.

MENAKA
WILHEM: Whoa, we made it all the way to the center.

DONNA
BLACKMAN: And then we're going to sit in the center and see what it feels like. All of a sudden, there's no gravity.

[MUSIC PLAYING]

ELIJAH: I feel floaty.

MENAKA
WILHEM: Yeah, so the no more gravity thing, that's because gravity is basically when a big heavy thing pulls on you. So if you're standing on Earth's surface, but you jump off the ground, gravity is what pulls you back down. And that's because Earth's mass, which is really, really big, it kind of wins a tug of war against your mass, which is much smaller. So even though you resisted gravity to jump up, you land back on the ground afterward instead of floating into space.

ELIJAH: Oh, OK.

MENAKA
WILHEM: But here, in the middle of the Earth, we're surrounded on all sides by the Earth. So there's half the Earth on our left, Half the Earth on our right, half the Earth above us, half the Earth below us. And the Earth on one side pulls on us but so does the Earth on the other side. And those two poles actually cancel out. So that leaves us weightless.

ELIJAH: Wow. It's cool to be here, but isn't it time for us to head to the other side?

MENAKA
WILHEM: OK, that's where I'll admit this plan has a bit of a hitch. I've been imagining like normal laws of physics so far. And gravity helped pull us down here, but like we said, there's no gravity at the center of the Earth.

DONNA There's no way you're going to be pulled out of the center on your own. You need some help.

BLACKMAN:

ELIJAH: Oh, tricky. But we can still imagine a way out of here, right?

MENAKA Oh, of course, that's a great idea. And overall, continuing through our hole would just be a backwards version of
WILHEM: the journey we already took. So we go back through the solid core, then the molten bits, and then the mantle, and last, the crust.

MOLLY BLOOM: Welcome back to Earth's surface.

ELIJAH: Great to be here.

MOLLY BLOOM: Well, thanks for taking us on this journey, Menaka.

MENAKA No problem. Now, I'm going to go eat an Earth sandwich with pickles.

WILHEM:

MACHINE: Brains, brains, brains on.

OLIVER I remember trying to dig a hole when I was maybe 10 years old, just to see how far I could get and where I would
JEFFERS: pop up. Only got about, I think, 4 feet before I hit a layer of something very solid. And I think that was my first introduction to the layers of the Earth.

MOLLY BLOOM: That's Author and Illustrator Oliver Jeffers. He's written a lot of incredible books, and one of my favorites is here we are, which was actually just turned into a movie. And even though Oliver didn't get too far with his hole, he never stopped wondering about the world around us.

OLIVER I'm in Belfast right now where I grew up. I normally live in Brooklyn, and I was halfway through a year of
JEFFERS: traveling around the world with my wife and two young children whenever this pandemic struck. And so we came back here to be with family, but it was really quite striking having traveled around so much in the last 6 months that just all of the different types of landscape that there were.

And any time we've been somewhere where there has been a crack in the Earth or been a cliff face or even on a highway, driving through where they've clearly blasted rock, and you can see to these sides just these patterns of the layers and just how striking how thin they can be and just how much history is gathered up into those different levels of dust that are just falling on top of each other over the years.

[MUSIC PLAYING]

MOLLY BLOOM: The vastness of the Earth, both what's beneath the surface and on it, has always amazed and inspired him.

OLIVER A book that I just finished reading was called *The Body, A Guide For Inhabitants* by Bill Bryson. And in it, there
JEFFERS: was a fact that really struck me as shocking. Our planet is quite large, but there is only a certain amount of places on the planet that can harbor human life. Obviously, we can't live at sea. We can't live on the sea, so I think 70% of the surface of the Earth is water.

And so it's only in the dry bits of this Earth that we can live. And it's only in some of the dry bits. Whenever you exclude all of the bits that are too wet, or too high, or too arid, according to this book, Bill Bryson says, that there's only 4% of the surface of our planet that is habitable to human life, which is a shocking, shocking thing to consider. And human life only exists on our Earth in the solar system. So we're crammed into a very small amount of space. It still feels big, but really, this is a small world.

Any astronaut who's ever been to outer space and looks back at our Earth, there's a phenomena called the overview effect. And it is the realization that Earth is not divided into countries or even cultures, that it is one single super system. Everything is connected to everything else. Weather affects everyone. As we're finding out, things like viruses affect everyone. It doesn't matter. We're all part of one single system, and you cannot see borders from outer space.

I made a project last year that was an accurately scaled model of the Earth and the moon. But in the sculpture, I did draw every single border known to man at that point in on my sculpture. But instead of writing the country names, I just wrote over and over and over again people live here, people live here, people live here because it's true. This is the only place in the entire universe that people can live.

[MUSIC PLAYING]

MOLLY BLOOM: You can find Oliver Jeffers' book *Here We Are* at libraries and bookstores, and the movie version is now streaming on Apple TV+.

[MUSIC PLAYING]

There are different layers inside the Earth.

ELIJAH: The crust is the part we walk on. It's the thinnest layer.

MOLLY BLOOM: The next layer is the mantle. It's the biggest layer.

ELIJAH: In the center of the Earth, there's the inner core and the outer core. Those are the hottest layers.

MOLLY BLOOM: We've never managed to dig past the Earth's crust.

ELIJAH: Seismic waves from earthquakes tell scientists what the inside of the Earth is like.

MOLLY BLOOM: But if we did dig a hole all the way through the planet, we'd see a lot of cool rocks at super high temperatures.

ELIJAH: And we end up in the place called the antipode, the spot opposite another on the globe.

MOLLY BLOOM: That's it for this episode of *Brains On*.

ELIJAH: It was produced by Menaka Wilhelm, Marc Sanchez, Sanden Totten, and Molly Bloom.

MOLLY BLOOM: We had production help from Sabby Robinson, Christina Lopez, Ruby Guthrie, Rose Dupont, and engineering help from John Miller. Special thanks to Eric Ringham, [? Katherine ?] [? Salata, ?] [? Melva ?] Glass, and Vicky Kreckler.

ELIJAH: Now, before we go, it's time for a moment of um.

[SAYING UM]

CHILD: Do fishes have tongues?

[MUSIC PLAYING]

TIERNEY THYS: Fish do not have the kind of tongue that we're used to like having the ability to move our tongue around with our musculature. They don't have that. My name is Tierney Thys, and I'm a National Geographic Explorer, Marine Biologist, and Independent Filmmaker. But they do have this sort of raised fold in the bottom of their mouth. And some of them do some pretty interesting things with that.

One of my favorite fish tongues is the osteoglossomorphs. The name of the group actually translates into bony tongues, and they are able to grab their prey, hold it in their normal jaws, and then essentially, shred the prey in their mouth because they have these teeth on their tongue and on the roof of their mouth. And they kind of chew with their mouth open and rasp. So it's not something you'd want to invite over for dinner.

One of my favorite examples of a fish that uses a tongue-like structure would have to be the Archer fish. Contracting the muscles in their gill region, they can squeeze out the stream of water that can knock prey out of the air. And that's a pretty cool trick if you ask me.

[SAYING UM]

MOLLY BLOOM: There is nothing fishy about this list. It's time for the Brains Honor Roll. These are the brilliant listeners who keep this show going by sending us their ideas, questions, mystery sounds, drawings, and high fives.

[MUSIC PLAYING]

[LISTING HONOR ROLL]

ROBOT: Brains Honor Roll.

MOLLY BLOOM: *Brains On* will be back soon with more answers to your questions.

ELIJAH: Thanks for listening.