

Brains On (APM) | Brains On! Bones from the inside out 01ENNHCQ0Q1CM2J7MF94HMZ6B4

CHARLOTTE: You're listening to *BrainsOn*, where we're serious about being curious.

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

MENAKA Hey, Sanden. Do you have the tibia?

WILHELM:

SANDEN No. Sorry, Menaka. I'm working on hanging the scapula right now. Marc, do you have it?

TOTTEN:

MARC Oh, yeah, yeah. I have it. I was going to start hanging it just after I get through these distal phalanges.

SANCHEZ:

MENAKA Oh, cool. I'll start on the patella.

WILHELM:

MOLLY BLOOM: Hey, Marc, Menaka, and Sanden. These skeletal decorations are looking amazing.

CHARLOTTE: That papier-mache skull is incredible.

MARC Thanks. It took forever.

SANCHEZ:

MOLLY BLOOM: Oh, and I love the crocheted vertebrae. Super crafty.

SANDEN Thanks. Crochet all day, I say.

TOTTEN:

CHARLOTTE: Oh, wow. And that origami trapezoid bone is adorable. You all have really outdone yourselves with these Halloween decorations.

MENAKA Halloween? Oh, these aren't for Halloween.

WILHELM:

MOLLY BLOOM: Oh, yeah. We just wanted to pay tribute to our favorite bones with this fabulous hallway display.

CHARLOTTE: Oh, got you.

SANDEN Yeah. If you want to see our Halloween decorations, those are just around the corner.

TOTTEN:

MARC Yeah. Just look for that giant plate of bagels-- with no cream cheese.

SANCHEZ:

[GASPS]

MOLLY BLOOM: It's truly terrifying.

[SCREAMING]

[THEME MUSIC]

This is *Brains On* from American Public Media. I'm Molly Bloom. And my co-host today is Charlotte from Saint Paul. Hi, Charlotte.

CHARLOTTE: Hello.

MOLLY BLOOM: Today, we're going to be answering listener questions about bones. So Charlotte, would you say that you think about your bones regularly?

CHARLOTTE: Well, I mean, I definitely think about them when I break them.

MOLLY BLOOM: Have you broken a bone before?

CHARLOTTE: Yes. Twice, actually.

MOLLY BLOOM: Which bone did you break?

CHARLOTTE: My wrist and the bone protecting it and the, like, bone right above my elbow bone.

MOLLY BLOOM: And what were you doing when you broke your bones?

CHARLOTTE: The first time, I was three and I was swinging and I fell off.

MOLLY BLOOM: And what about your wrist? What happened there?

CHARLOTTE: I was swinging on the monkey bars. I was in kindergarten. And I fell. And-- yeah.

MOLLY BLOOM: And did you have to wear a cast after?

CHARLOTTE: Yeah, both times, I had to wear a cast. Actually, this. It was not comfortable. Like, you could not move your arm.

MOLLY BLOOM: Was it itchy?

CHARLOTTE: Yes. Very itchy.

MOLLY BLOOM: Did you decorate it or did people decorate it?

CHARLOTTE: Lots of people signed the cast both times. And a bunch of them were kindergartners from my class. And actually, that's the year that I got, like, all my school friends.

MOLLY BLOOM: So it was a good way to meet people. Everyone got to sign your cast.

CHARLOTTE: Yeah.

MOLLY BLOOM: Bones are crucial to us being able to do many, many things. We don't really see them, so it's easy to take them for granted. So let's start with the bare bone basics and answer these listener questions.

OLIVER: Hi. My name's Oliver from West Hills, California. And my question is what are bones made of?

KATIE: I'm Katie. I'm from Concord, North Carolina. And my question is, what makes bones hard?

CORBIN: Hi. My name's Corbin. I'm from Apple, Idaho. And my question is, what's in your bones.

CHARLOTTE: First, let's think of what bones do. They support your body, giving you a shape and strength.

MOLLY BLOOM: They protect parts of your body, like your skull protects your brain and your ribs protect your lungs.

CHARLOTTE: And they're designed to move. Where two bones come together is called a joint.

MOLLY BLOOM: That's like your elbow or your knee. Almost any part of your body you can move, there's a joint there.

CHARLOTTE: So bones have to be super-strong, but also light and flexible.

MOLLY BLOOM: They're made mostly of collagen, which is a strong and flexible protein, and calcium phosphate, which is a strong mineral that gives bones more strength and hardness.

CHARLOTTE: Let's look at bones from the outside in.

VOICE ON Bone layer one.

LOUDSPEAKER:

CHARLOTTE: The outer layer of a bone is called compact bone.

MOLLY BLOOM: If you looked at this layer under a microscope, it would look like a bunch of thick tubes packed closely together. Each tube has a small opening in the middle where blood vessels and nerves go through.

VOICE ON Bone layer two.

LOUDSPEAKER:

CHARLOTTE: The next layer is called spongy bone.

MOLLY BLOOM: And even though this layer may look like a sponge under a microscope, it's not squishy like one. The bigger openings in this layer are called pores, and they give room for nerves and blood vessels and marrow.

VOICE ON Bone layer 3.

LOUDSPEAKER:

CHARLOTTE: The innermost layer of your bone is called marrow. This layer is soft, but it's hard at work all the time.

MOLLY BLOOM: Your marrow makes some super-important stuff-- blood.

[ECHOING]

But actually not in the spooky. Way more like the super-important for your survival way, so like blood. Your bone marrow makes all of your red blood cells, white blood cells, and platelets. That's the stuff that keeps you alive by delivering oxygen around your body--

CHARLOTTE: --fighting off germs--

MOLLY BLOOM: And helping you stop bleeding if you get a cut.

CHARLOTTE: These are very important cells.

MOLLY BLOOM: And they're made right there in your bone marrow. Thanks, bones.

ANNOUNCER: Brains!

[SPOOKY SOUNDS]

[CLEARS THROAT]

CHARLOTTE: Next, let's answer this important question.

ALEXANDRA: My name is Alexandra from Tuscaloosa. My question is, how do bones grow?

MOLLY BLOOM: That's a great question. Let's start by explaining what our bones are like when we're young, before they are fully bones.

CHARLOTTE: Wait. Our bones aren't always bones?

MOLLY BLOOM: Not exactly. When we're babies, some of our bones are actually made of this stuff called cartilage. It's a flexible and rubber-like material.

You can feel what cartilage is like if you touch your ear or the tip of your nose. So Charlotte, try touching the tip of your nose. What does it feel like?

CHARLOTTE: Rubber.

MOLLY BLOOM: Yeah, it's kind of squishy and rubbery. When we're born, some of our bones are all cartilage, and some are partially cartilage. And get this. Babies have around 300 bones. But grownups only have around 200.

CHARLOTTE: That's freaky. So where do our bones go? Do they just magically disappear? Do they fall out like our teeth? Do they pack up and move out to find a new body?

MOLLY BLOOM: Thankfully, no. What happens is something called ossification. It's how your baby bones go from soft and rubbery to strong and hard.

And it's also how some bones fuse together. So two bones can become one. Ossification is kind of a big deal.

CHARLOTTE: Hold up. Am I saying this right? Ossification. Almost like "awesome vacation."

MOLLY BLOOM: Yes, like "awesome vacation." That is right. Growing bones are having the vacation of their lifetime. The oss part comes from the root osteo, which means bone, and fication means to make or create. Together, it becomes the creation of bones.

[ECHOING]

I just love doing that. Let me introduce you to my friend Baby Femur. Baby Femur is going to ossify or transform from cartilage to hard bone pretty soon. Baby Femur, are you here?

BABY FEMUR: Hi.

CHARLOTTE: Aw, so adorable. Can I pet you?

BABY FEMUR: Sure. Go ahead. I'm not tough like a bone yet. So be careful not to pet too hard.

CHARLOTTE: Whoa! So rubbery.

MOLLY BLOOM: Yeah. Weird, right? The femur is your thigh bone. Baby femur will start ossifying pretty soon. And it will continue for 16 to 19 years, until baby femur becomes a fully hardened bone.

BABY FEMUR: That's a long "awesome vacation."

MOLLY BLOOM: During ossification, minerals fill in areas around the cartilage cells of a bone. When those cartilage cells die, minerals also fill in the spaces they leave behind. Cells that collect calcium begin to make the bone strong and hard. That's why people always talk about getting enough calcium for strong bones. While that's happening, other cells come and fill our young bones with that marrow stuff we talked about earlier.

BABY FEMUR: So long, cartilage cells. Next up-- strong bones.

MOLLY BLOOM: That's only part of growing. Our bones also need to get longer and bigger. To explain how that happens, we talked to Myeashea Alexander, a biological anthropology grad student in New York City. She started the Rockstar Anthro Mobile Bone Lab to bring hands-on learning experiences to urban schools. She said, with a bone like the femur, growth happens in more than one place.

MYEASHEA ALEXANDER: That thigh bone or that femur bone is actually several different pieces. And the several different pieces are connected by that cartilage that we talked about. And as we grow, those spaces begin to fill in due to that ossification process that we talked about. That is essentially us growing more and more bone.

And eventually, those bones harden. We grow taller. Our bones become stronger.

MOLLY BLOOM: Those spaces of cartilage that Myeashea mentioned are called growth plates. Most growth plates are near the ends of your long bones, like the femur, for example. New cartilage is made there and adds to the bone, making it longer.

It happens very slowly over years and years, which is why we grow slowly. Once those plates are completely hardened, that bone has finished growing. So let's fast forward about 16 to 19 years and see how baby femur is doing.

BABY FEMUR: Time flies. I feel so old now. I have to do my own laundry, and maybe even get started on this year's taxes. Now I'm the strongest, best version of me.

MOLLY BLOOM: This process happens with bones throughout our body. All told, this will take years. Human bones typically grow until we're in our mid twenties. So those are the bone-growing basics.

CHILDREN: *Brains On!*

Did you know some of the smallest bones in your body are actually in your ear? Yeah. They're called auditory ossicles. They help you pick up sounds. And they better be ready because here comes the--

CHARLOTTE: Mystery sound.

MOLLY BLOOM: Here it is.

[BUZZING SOUND]

Let's hear it one more time.

[BUZZING SOUND]

OK. Charlotte, what is your guess?

CHARLOTTE: It kind of sounds like a car kind of-- or like one of those toy lawnmowers, where you pull the thing and bubbles come out and it makes the sound like that.

MOLLY BLOOM: Yes. That is a very, very good guess. We're going to hear it again, and give you another chance to guess later in the show.

[SPOOKY MUSIC]

CHARLOTTE: Molly. Did you hear that?

MOLLY BLOOM: Yeah. That's odd. What is that?

ANNOUNCER: And now a word from the scariest skeleton in town-- Mr Bone jangles.

MR. BONE Woo! "Bone-jour," *Brains On*. Tis I, Mr Bone Jangles, a bona fide skeleton, here to drop some hair-raising skeleton
JANGLES: facts. I don't have any hair. But if I did, they would be standing straight up at the very thought of this parade of petrifying truths.

MOLLY BLOOM: How unexpected. Welcome to the show, Mr Jangles.

MR. BONE Oh, enchanté. Oh, I hope I'm not interrupting anything.

JANGLES:

MOLLY BLOOM: Actually, we're kind of in the middle of the show. But--

MR. BONE Oh, so I'm just in time. Perfect. The last thing I'd want to do is-- get under your skin.

JANGLES:

[LAUGHS]

CHARLOTTE: Wow. I've never met a skeleton in the flesh-- or bone, actually. How fun.

MR. BONE Fun, my dear Charlotte? Fun? I can guarantee you these are not fun facts. These facts are spooky!

JANGLES:

[SPOOKY MUSIC]

Did you know that most of the species on Earth are invertebrates, meaning they have no backbone? Bone chilling, am I right?

CHARLOTTE: Uh, actually, didn't find that scary. Like at all.

MR. BONE Oh, well, I find spineless jellyfish quite spine-chilling. But I guess that's me.

JANGLES:

[CHUCKLES]

Let's see. Well, how about this? Humans and giraffes have the same number of bones in their neck. Got seven bones. Ooh!

[CRICKETS CHIRPING]

Because, you know, their necks are so much longer than ours. But the number of bones, still the same. The horror!

MOLLY BLOOM: I'm with Charlotte. These facts are fascinating, not frightening.

MR. BONE Still not spooked, huh? Well, I saved the creepiest for last. Over half of a human's bones are found either in their
JANGLES: feet or their hands. That's 26 bones in each foot and 52 in each hand. Woo!

[LAUGHS]

Still nothing?

MOLLY BLOOM: No. Not really. But look. I appreciate you stopping by, but we really should be getting back to the show.

MR. BONE I completely understand. I'll return after my lunch break.

JANGLES:

MOLLY BLOOM: It wasn't exactly an open invitation, but--

MR. BONE You don't have to tell me twice, Molly. Just riddle me this. Where could a numbskull get some spare ribs around
JANGLES: here?

MOLLY BLOOM: The *Brains On* cafeteria is down the hall.

MR. BONE Say less. I'm gonna get my "Bone-BQ" on. "Tibia" continued?

JANGLES:

CHARLOTTE: "Bone" appetite.

[SPOOKY MUSIC]

[UPBEAT RHYTHMIC MUSIC]

We have a cool opportunity coming up for *Brains On* fan club members.

MOLLY BLOOM: We're going to be doing a live virtual hang in November where you can ask me, Marc, Sanden, and Menaka all your questions. Anything you want to ask, we'll answer. If you want to join us, the first step is to sign up for our totally free fan club at brainson.org/fans. In November, we'll send an email out to the fan club with more details about this free virtual hangout. So keep an eye out for that.

CHARLOTTE: These guys also wrote a book.

MOLLY BLOOM: We did. It's called *It's Alive: From Neurons and Narwhal to the Fungus among Us*. We're really proud of how it turned out. But you don't have to take our word for it.

SARAH: Hi. My name is Sarah, and I'm from Santa Fe, New Mexico. I love the new book from *Brains On* called *It's Alive*. I really love the illustrations, and that Molly, Marc, and Sanden pop up throughout the book to share their thoughts.

The comics and literally everything else in the book do a great job of mixing humor and facts, which makes it extra easy to learn all about the sciencey topics in the book. Unfortunately, this also makes it super-hard to put the book down. If you haven't read this book already, you definitely should.

MOLLY BLOOM: We love hearing from all of you that have read the book. If you've read it, we'd love to hear your review, too. You can send it to us at brainson.org/contact.

CHARLOTTE: While you're there, you can also send us questions, ideas, mystery sounds, and drawings.

MOLLY BLOOM: That's how we got this amazing question.

HANNAH: Hi. My name is Hannah, and I'm from Phoenix, Arizona. And my question is, why does time fly when you're having fun?

MOLLY BLOOM: We'll be back with an answer during our Moment of Um at the end of the show. And we'll also read the latest group to be added to the Brains Honor Roll.

CHARLOTTE: So keep listening. You're listening to *Brains On* from American Public Media. I'm Charlotte.

MOLLY BLOOM: And I'm Molly. And it's time to answer this question.

ANDREW: Hello. My name is Andrew and I'm from Toronto. And my question is, what happens inside your leg while it is healing when you have a broken leg?

MOLLY BLOOM: Producer Menaka Wilhelm's joining us to talk about how bones heal. She's been reading up on it since she broke her wrist two weeks ago.

CHARLOTTE: Hi, Menaka. What happened?

MENAKA WILHELM: Well, I fell, and it put more force on my wrist than it could really handle with no cushioning. So one of my bones in there, my scaphoid bone, it cracked like a dropped plate.

CHARLOTTE: But how did you fall?

MENAKA WILHELM: Oh, right. Yeah, I was scootering like I usually do. But I was also wearing my yoga toga. And that led to a tumble.

MOLLY BLOOM: Bummer.

MENAKA WILHELM: Yeah. I think I'll be keeping my long flowing robes separate from my wheeled accessories from now on.

CHARLOTTE: Probably wise.

MENAKA WILHELM: Thanks, Charlotte. Well, healing broken bones is a mega talent. Especially since bones are such complicated special structures, the first thing on your body's to-do list if you fall and break a bone is damage control. Bones have blood vessels running through them. So those break if your bone breaks, too.

VOICE ON WALKIE-TALKIE: Hi. I'm here at the southwest corner of the wrist. We've got some broken blood vessels here. We're gonna need a blood clot to stop that flow.

MENAKA WILHELM: Your immune system also helps out. You might notice swelling at a broken bone, and that's partly because the immune system is sending white blood cells to the clot. They help clean up dead bone cells, and also get rid of any germs that might have come in through a scrape.

VOICE ON WALKIE-TALKIE: Great work, white blood cells. Love what you've done here.

MENAKA WILHELM: Once the initial damage is taken care of, your body needs to hold the broken bones in place in order to mend them. And this is where cartilage comes in. Remember, cartilage is that rubbery material in your nose and ears that we talked about earlier? It's also part of healing.

VOICE ON WALKIE-TALKIE: Bring that cartilage a little to the right.

[HEAVY EQUIPMENT BEATING]

Back just the smidge. And perfect. Right across that crack in the bone, nice and easy. Perfect.

MENAKA WILHELM: So you often get a plaster cast on the outside of a broken arm or leg. But you also have almost like a little cartilage cast inside your body around the bone itself. How neat is that? That holds the bone in place, and also starts healing the break inside and out.

VOICE ON WALKIE-TALKIE: OK, people, look alive. We're doing more than just holding things together.

MENAKA WILHELM: Blood vessels start to heal inside this cartilage structure. And then eventually, some of the cells in this cartilage start converting themselves into bone. They bring in calcium, which hardens bone.

VOICE ON WALKIE-TALKIE: Cartilage. You, you, you, and you, go ahead and start hardening into bone.

MENAKA WILHELM: Meanwhile, other cells also make new bone. You can think of that a little bit like a bunch of bone cells repaving a road. Lots of different cells are in this road crew, and two important ones are osteoblast cells and osteoclast cells. They're both bone cells, but that do different jobs.

OSTEOBLAST: I'm a kind of cell called in osteoblast. I lay down bone cells and pull minerals in to make them harden.

MENAKA When your body heals a bone at first, the area right around the break will actually be a little bit bigger of a bump
WILHELM: than the rest of the bone. So there's also a kind of cell that breaks things down, so that the repaved road is the right shape.

OSTEOCLAST: And I am an osteoclast. My job is breaking down bone where it isn't needed.

MENAKA In your body, osteoclasts use acid to get rid of little bits of bone-- not tiny jackhammers, as cool as that would be.
WILHELM: Over time, osteoclasts and osteoblasts will end up creating a repaired bone that's normal-shaped and good as new.

CHARLOTTE: Cool. Thanks, Menaka.

MENAKA Any time. Now I got to run. That long flowing robe collection of mine is not gonna organize itself. Bye.
WILHELM:

[UPBEAT MUSIC]

[SPOOKY MUSIC]

ANNOUNCER: And now, once again, Mr Bone Jangles.

MR. BONE I'm back!

JANGLES:

[APPLAUSE]

MOLLY BLOOM: Welcome back, Mr Jangles. Did you bring some fearsome facts this time?

MR. BONE Thanks, Molly. The pleasure is all spine-- er, mine.

JANGLES:

[CHUCKLES]

And yes. I'm much more prepared. In fact, dim the lights.

[THUNDER]

Birds have hollow bones that are filled with air sacs. These extensions of the bird's lungs allow them to take in oxygen while they Inhale and exhale.

CHARLOTTE: You know you had me with the music for a second. But that's not really scary. Cool, not scary.

MR. BONE Hush, hush, Sweet Charlotte. I'm just getting started. Did you know that gummy bears contain bones? Woo!

JANGLES: Gummies typically use gelatin, which is made by extracting collagen from boiled animal bones. It gives them that soft jelly-like texture.

MOLLY BLOOM: Hmm. I'd rate that maybe a tiny bit gross, but zero bit spooky.

MR. BONE Tough crowd. I do have one more fact. "Bone-us" if you please. Music.

JANGLES:

[SPOOKY MUSIC]

Would you believe there are places around the world that are made up of bones? One of the most popular is called the Catacombs of Paris in-- you guessed it, Paris, France. At the end of the 18th century, the city's cemeteries were overflowing.

The solution? They decided to move the remains to tunnels running underneath the city. Over six million skeletons are buried in the catacombs with stacks of skulls lining the walls. It's the perfect place to take a selfie.

[LAUGHS]

Too much?

MOLLY BLOOM: Whoa. Mr Jangles. That was legit creepy.

MR. BONE Oh, I did warn you.

JANGLES:

MOLLY BLOOM: Wow. Thanks, Mr Jangles.

CHARLOTTE: Yeah, Mr Jangles. You're bad to the bone.

MR. BONE Oh, you flatter me. Thank you, and farewell *Brains On*. "Bone" voyage.

JANGLES:

[CLANKING]

(SINGING) Ba ba ba ba ba ba ba ba ba ba-- brains.

[SCREAMING]

MOLLY BLOOM: OK, Charlotte. Are you ready to go back to the mystery sound again?

CHARLOTTE: Yes.

MOLLY BLOOM: OK. Here it is.

[BUZZING SOUND]

Last time you were hearing toy car, toy lawnmower. Do you have any new thoughts.

CHARLOTTE: OK. I forget the name of this, but screwdriver? Like a motorized one? Like a motor?

MOLLY BLOOM: Yes. Excellent. Excellent guess. Let's hear the answer.

JADEN: Hi. My name is Jaden. And I'm from western Nebraska. That sound was me screwing a screw in and out with a drill.

MOLLY BLOOM: Charlotte, you were 100% correct. Yes, so that motorized screwdriver is called a drill. So really, really good ears

CHARLOTTE: Woo hoo!

MOLLY BLOOM: Yes. Yeah, that was a really, really good guess. So you know, we are playing this for a reason in this episode. Because sometimes when you break a bone, doctors will use screws or nails or plates to hold your bone together in place while it's healing. So did you have any screws or pins or anything put in when your bones were healing?

CHARLOTTE: I had three pins. I still have the mark, actually.

MOLLY BLOOM: Oh, really? That's really cool. Sometimes, doctors take them out after the bone is done healing. But sometimes, people have screws or plates in their legs or arms forever.

ROBOT VOICE: *Brains-- Brains-- Brains On.*

MOLLY BLOOM: So far, we've learned how bones are super-strong and super-resilient.

CHARLOTTE: And now our pal Ruby Guthrie is here to tell us why bones last so long.

RUBY GUTHRIE: Hi, Charlotte. Hey, Molly. Thanks for having me. I was at the museum the other day, and I noticed it was filled with bones-- dinosaur bones, bird bones, whale bones, even human bones.

And it made me think, how can bones last so long? To find out, I asked the dinosaur bones. And they didn't answer because they're dead. So then I asked Professor Sean Tallman, who isn't dead.

DR. SEAN TALLMAN: Hello. My name is Sean Tallman. And I am an assistant professor in anatomy and neurobiology at Boston University.

RUBY GUTHRIE: Sean is a biological anthropologist, which means he studies old skeletons to learn more about our past.

DR. SEAN TALLMAN: I think bones are really fun to work with. So putting together bones, whether it be from an animal or a human, is really satisfying because it is like a big puzzle.

RUBY GUTHRIE: Sean says one of the reasons bones last so long is thanks to their super-strong calcium phosphate structure.

DR. SEAN TALLMAN: And so it's really resistant to a lot of the natural effects of being outside maybe, or being in the water or underground, and exposed to dirt or maybe animals picking at it or moving around.

RUBY GUTHRIE: But they're not invincible. Over time, bones, like anything else, start to degrade and decompose. Bones are best preserved when they become fossils.

Fossils aren't actually bones, but rather an imprint of a bone. Fossilization happens when remains like bones are quickly covered by sediment. The sediment could be anything from piping hot lava to sand from the bottom of the ocean.

As time passes, moisture and minerals from the sediment start to slowly replace the bone itself. What you're left with is a rock-solid copy of the original bone. And we can learn so much from old bones. They help us construct what the past looked like, who and what was there, and how we evolved into the species we are today.

MOLLY BLOOM: Thanks for sharing, Ruby.

RUBY GUTHRIE: Any time. Say, has anyone seen Mr Bone Jangles? I have a bone to pick with that dude. He totally copped the last of the spare ribs.

MOLLY BLOOM: Oh dear.

[UPBEAT RHYTHMIC MUSIC]

Bones are mostly made of collagen and calcium phosphate. But they also have nerves and blood vessels running through them.

CHARLOTTE: The inside of bones is called marrow. And that's where the super-important cells in your blood are made.

MOLLY BLOOM: Babies have more bones than adults, and a lot of them aren't really bones just yet.

CHARLOTTE: As you grow, your bones harden and fuse together in a process called ossification.

MOLLY BLOOM: Bones are super-strong. But if they get hit into right way or are under a lot of pressure, they can break.

CHARLOTTE: Luckily, bones are great at healing thanks to some cool cells called osteoblasts and osteoclasts.

MOLLY BLOOM: A bone's lifespan completely depends on its environment. While most bones eventually decompose, others can last up to thousands of years thanks to fossilization. That's it for this episode of *Brains On*.

CHARLOTTE: *Brains On* is produced by Molly Bloom, Marc Sanchez, Sanden Totten, and Menaka Wilhelm.

MOLLY BLOOM: We had production help from Phyllis Fletcher, Ruby Guthrie, Ava Kihen, and Kristina Lopez. We had engineering help from Johnny Vince Evans. Special Thanks to Drew Stephenson, Elise Morgan, Mickey Bloom, Stuart Bloom, Jeyca Maldonado-Medina, Shiny Vargas, and Lulu.

CHARLOTTE: *Brains On* is a nonprofit Public Radio podcast.

MOLLY: You can support the show and help us keep making new episodes at brainson.org/contact. We're taking a break after this episode, and we'll be back with new episodes on January 5. Until then, go check out our sister show *Smash Boom Best*. So far, they've tackled flowers versus rainbows, drums versus guitars, and coming out October 29, werewolves versus vampires. Oh yes. It's a good one.

CHARLOTTE: And now before we go, it's our Moment of Um--

[ECHOING]

HANNAH: Why does time fly when you're having fun?

**DR. RUTH
OGDEN:** That's such a great question, and it's something that I experience all the time. Hi. So my name's Ruth Ogden. I'm a lecturer in psychology, and I am interested in how people experience the passage of time in their daily lives.

So I would say that time flies when you're having fun for a couple of different reasons. So one is that when we're having fun, we tend to get very excited. So we experience different emotions. We might breathe a little bit more quickly. We might sweat a little bit more.

And one of the things that we know about time is that how we experience it in the brain-- so how our brain processes time, is influenced by emotion. So for all our other senses-- for touch and taste and smell and hearing and vision, we've got an organ, haven't we? So you have your eyes. You know you have your ears. And for time, we don't really seem to have that.

We know there are specific bits of our brain that are involved and perceive in time. So you can think about it like a stopwatch. You've got a little stopwatch in your brain. It's ticking away normally.

And then you get excited, and this stopwatch starts going quicker and quicker and quicker and quicker, and you feel like time is passing by more quickly. When you're really sad or when you're very bored, you probably get the opposite effect and it starts going more slowly.

Another reason might be that when you're really happy, you just don't think about time. Like, you're enjoying the things that you're doing. You don't really think about time, and then you're just surprised that so much time has passed.

KID: Um--

[ECHOING]

MOLLY: Time's gonna fly as I speed through this list of names. It's the Brains Honor Roll. These are the incredible listeners who keep this show going by sending in their questions, ideas, mystery sounds, drawings, and high fives.

[LISTING HONOR ROLL]

ROBOT: Brains are on, high five!

We'll be back in January, with more answers to your questions.

CHARLOTTE: Thanks for listening.