- You're listening to *Brains On!*

- Where we're serious about being curious.

- *Brains On!* Is supported in part by a grant from the National Science Foundation.

- Hello, everybody. We released this episode about flu vaccines last year. But we wanted to share it with you again today. It's flu vaccine season. I just got mine last week. Didn't hurt a bit. And vaccines are also in the news a lot lately. Scientists are testing a bunch of vaccines for the new coronavirus right now.

This episode gets into the details of how vaccines work and how they're made. Here's the episode.

MOLLY BLOOM: Hey, Aviva and Sage. So glad you can make it in today.

- It's cool to finally see the headquarters.

- Looks pretty busy around here.

MOLLY BLOOM: Oh, yeah. We happened to schedule our taping on flu shot day here at *Brains On!* headquarters.

GUNGADOR: Gungador going to smash flu.

AVIVA: Oh, hi, Gungador.

GUNGADOR: Oh, hey.

MOLLY BLOOM: It's great because this is the one day that everybody's in the office.

SANDEN TOTTEN: Hey, Molly.

MOLLY BLOOM: Hi, Sanden. Why are you sweating?

- Are you feeling OK?

SANDEN TOTTEN: What? I love shots. Definitely not having a panic attack right now.

MOLLY BLOOM: It's OK to be a little scared, Sanden. Just remember that little pinprick in your arm only lasts a second.

- Yeah, and for that second of inconvenience, you get protection from this season's flu virus.

SANDEN TOTTEN: I guess you're right. But hey, Bob, you want to get ahead of me in line? You look like you're in a hurry pal.

BOB: Are you kidding me? I don't want to skip ahead. I love waiting in lines. I'm actually going to step out and head to the back. Oh, this is so exciting.

- 18th floor, flu shots.

- I guess Elevator doesn't need a shot.

HARVEY: Not a physical one, but those of us who occupy the digital world need protection from viruses, too.

MOLLY BLOOM: Good point, Harvey.

HARVEY: Elevator and I both received system updates this morning. I now have the ability to calculate pi to the 100,000,000,000th decimal. 3.1415--

- I am virus free, and can now beatbox. Ah-pu-pu-chee, ah-pu-pu-chee, ah-pu-pu-chee, going down, wickey, wickey, wickey. Ah-pu-pu-chee.

- Cool.

CATHY: Sanden, I might take you up on that offer to step ahead. I should be getting back to my studio audience. We're baking up a batch of sugarless microbiome brownies.

SANDEN TOTTEN: No sugar? I mean, you could still cut ahead of me in line. But Cathy, how could you?

MARK: Not everything needs sugar. A little pickle juice or taco seasoning will usually do the trick.

SANDEN TOTTEN: Oh, hey, Mark, please cut ahead of me in line, please.

CATHY: Pickles and tacos, not in my brownies sir.

- Mark, not all foods are pickle or taco related.

- Oh, good one. That's hilarious.

MOLLY BLOOM: Meneka, that is an amazing outfit.

MENEKA WILHELM: Thanks, Molly. I call this my yoga toga. And I actually wore it today because I have just the bandage to match it for after I get my shot.

- You brought your own bandage?

MENEKA WILHELM: Yeah, I'm a huge fan of bandages. I'm kind of a connoisseur. Even though I don't love getting shots that much, I do love putting on a fresh badge of courage. That's what I call a bandage. And this one it's white with the gold trim. Oh, it matches my yoga toga perfectly. If you all want bandages that match your outfits, just let me after you get your shot. I'd love to look in my collection for you.

MOLLY BLOOM: Well, it looks like this line ends right at the studio door.

BOB: Yeah, isn't the view of all those wonderful waiting people sensational?

- Sure, Bob. Looks great.

[MUSIC PLAYING]

MOLLY BLOOM: You're listening to *Brains On!* from American Public Media. I'm Molly Bloom, and my co-host for this episode are siblings Aviva and Sage from Greensboro, North Carolina. Hi, you two.

- Hello.

MOLLY BLOOM: So we asked you two to co-host because you were curious about flu vaccines. So I am curious to know what got you thinking about them?

SAGE: Well, when my sister was having her flu vaccine, we just had this pop into our heads. We thought it was really cool.

MOLLY BLOOM: And so how are you when you get shots? How do you deal with that?

AVIVA: I do pretty badly, but I have a technique. I have either my mom or my dad hold me down.

SAGE: I don't like it. But it works better than just squirming about.

MOLLY BLOOM: It's helpful.

AVIVA: Yeah, it's helpful. I hate it, but it's helpful. I just get very nervous around the shots, because I feel like it's going to hurt like a million pounds falling on your head, and then it hurts like a needle.

MOLLY BLOOM: Yeah, it's not so bad. It hurts a little.

AVIVA: Yeah.

MOLLY BLOOM: So have you gotten the flu or do you know anyone who's gotten the flu?

AVIVA: My mom has gotten the flu.

MOLLY BLOOM: And how sick did she get when she got the flu?

AVIVA: She was really tired, and she needed a lot of tissues. And she just wanted to lay down the whole time.

MOLLY BLOOM: Yeah. Sage, do you get the flu vaccine every year?

SAGE: Yeah, me and my sister both get the flu vaccine every fall.

MOLLY BLOOM: Me, too.

HARVEY: Brains. Brains. *Brains On.*

MOLLY BLOOM: Well, let's see what we can learn about this seasonal safeguard.

AVIVA: But before we get to the flu vaccine, let's start with the basics.

SAGE: What is a vaccine anyway, and how do they work.

MOLLY BLOOM: That's something other listeners were curious about too.

MATTHIAS: This is Matthias.

ISAIAH: Isaiah.

JOSIAH: I'm Josiah.

ISAIAH: We live in Beaumont.

CHILDREN: We were wondering, how do vaccines work?

MOLLY BLOOM: You might think of vaccines just as these annoying shots you have to get sometimes. But in reality, they're nothing short of modern miracles.

AVIVA: Vaccines protect us against lots of very scary and sometimes deadly diseases.

SAGE: Diseases like polio, measles, and whooping cough.

MOLLY BLOOM: The basic idea of how they work is pretty simple. It all starts with your immune system.

[MUSIC PLAYING]

Your immune system includes all these different things in your body that help keep you safe from infections and disease. We're talking threats like bad bacteria, harmful fungi, and nasty viruses.

SAGE: The part we're interested in today are the immune cells, called white blood cells.

AVIVA: Think of them as the tidying experts of your body.

LEELA LYMPHOCYTE: Hi, I'm Leela Lymphocyte. My mission is to help spark joy in your body by keeping things neat and tidy.

MOLLY BLOOM: You have thousands of immune cells in your body, and one of their jobs is to sort through all the stuff inside you and tag the bad things for disposal.

LEELA LYMPHOCYTE: First--

[BELL DINGS]

--I like to center myself with some mindful meditation. Then I wander through your body and decide what to keep and what our cleanup crews need to get rid of, like this red blood cell. Does it spark joy?

RED BLOOD CELL: I hope so I'm kind of important for the body.

LEELA LYMPHOCYTE: Yes, you are. We'll keep you.

RED BLOOD CELL: Uh, thanks.

LEELA LYMPHOCYTE: Moving on-- liver cell?

[BELL DINGS]

Yes, sparks joy. Keep. Intestinal cell?

[BELL DINGS]

Keep. Plasma?

[BELL DINGS]

Keep. Platelets? Keep.

[BELL DINGS]

AVIVA: But when these immune cells encounter a foreign object, like a virus, they jump into action.

[BOING]

LEELA LYMPHOCYTE: Oh, and what are you? I've never seen you in here before.

VINNY THE VIRUS: Name's Vinny. I'm a virus. Nice to meet you.

LEELA LYMPHOCYTE: Hm. I'm not sure about you.

VINNY THE VIRUS: Trust me. I am the best. You see, I go around taking over cells in the body and reprogramming them so they make more of me. Who wouldn't like that? Then that cell gets so full of new me's, it explodes--

[EXPLOSION]

--just like a pinata. I am everywhere, baby.

VIRUS: Yo, what up, Vinny?

VINNY THE VIRUS: Hey, more me's.

VIRUS: Vinny!

VINNY THE VIRUS: Hi, guys. Let's get this place thumping.

VIRUSES: (SINGING) Go virus. It's your birthday. Go virus. It's your birthday. Go virus.

SAGE: Viruses like this can do serious damage to the body, as they multiply and destroy cells.

MOLLY BLOOM: So once the white blood cells recognize them as a threat, that white blood cell replicates, creating an army of cells to start the cleanup process.

LEELA LYMPHOCYTE: Does not spark joy. Time to multiply. Hello. Let's clean. Tidying sparks joy. This place is so cluttered with viruses.

Did someone bring a broom? I love organizing things.

AVIVA: Then the white blood cells use special proteins called antibodies to tag those viruses for disposal.

MOLLY BLOOM: Antibodies can also stop viruses from going about their business.

LEELA LYMPHOCYTE: I will tag you all for tossing out. Tag. Tag. Tag. You are junk, and you are junk, and you are junk. All of you are headed to the dump. A tag for you. A tag for you. There you go you. Must get rid of this. Not a keeper, not a keeper at all.

MOLLY BLOOM: Then special cells come to destroy and clean up these tagged intruders.

VINNY THE VIRUS: Oh, party's over Vinnys. [COUGHS] I'm dead now. Goodbye.

AVIVA: Now that your body knows this virus is an enemy, it will create more cells that will remember this non-joy-sparking invader.

SAGE: So next time that virus shows up, your tagging and cleanup crew can wipe it out before it spreads.

MOLLY BLOOM: The problem is, during that first encounter it can take days for your immune system to mount its defense. During that time, you'll get pretty sick. That can be dangerous and even deadly, depending on the virus.

AVIVA: Yeah. It would be much better if your white blood cells knew what to tag for disposal before it even got inside your body.

SAGE: That way, as soon as it gets in there they can tag it right away before it multiplies and spreads.

MOLLY BLOOM: Exactly. That's where vaccines come in.

[MUSIC PLAYING]

Vaccines are full of weakened or dead viruses, stuff that can't really make you sick but can activate your white blood cells.

LEELA LYMPHOCYTE: Oh, what do we have here, some dusty old virus? Not useful. I shall tag it for cleanup right away.

AVIVA: Then, your immune cells will remember that virus and will tag it immediately if a real one shows up.

VINNY THE VIRUS: Hey, nice digs you got here. I'll be making myself right at home.

LEELA LYMPHOCYTE: Oh, no you won't. I remember you.

VINNY THE VIRUS: No. I'm pretty sure you don't. This is my first time in this body.

LEELA LYMPHOCYTE: You are just like that dusty old virus I found a few years ago. Here you go.

VINNY THE VIRUS: What's this, a tag?

LEELA LYMPHOCYTE: Yep. These other cells will show you out. And by show you out, I mean totally destroy you. Bye forever.

MOLLY BLOOM: So each vaccine you get is loaded with these weakened or dead versions of a specific virus or disease, like mumps or rotavirus or measles or polio. Your body learns to destroy that virus on site by practicing on these vaccine versions.

LEELA LYMPHOCYTE: Aha, neat and tidy once again, just how I like it.

[BELL DINGS]

[WHISTLING]

MOLLY BLOOM: I hope your ear canals are nice and tidy because you'll need your full range of hearing for the--

[MUSIC PLAYS]

AVIVA: (WHISPERING) Mystery sound.

MOLLY BLOOM: Are you ready?

SAGE: Yes.

MOLLY BLOOM: Here it is.

[SCRAPING AND SQUEAKING]

I will start with a hint, and I will say that sometimes our mystery sounds are directly related to the episode and sometimes they are ones sent to us by listeners. And this is a sound that was sent to us by a listener. So with that in mind, I would like to hear, Sage, your guess first.

SAGE: It sounds like something scraping, like maybe like, you know those, like, doormats that have these really bristly things and you scrape it, and it makes kind of a rough sound. And then maybe there was a bird in the background. I don't know.

MOLLY BLOOM: That's a really good guess. Aviva, what is your guess?

AVIVA: It sounds like someone pushing a comb along something, like, a pod.

MOLLY BLOOM: Ooh, got it. Great guesses. Well, we're going to be back with the answer in just a bit.

[ELECTRONIC TONE]

CHILDREN: Brains On!

MOLLY BLOOM: Vaccines are relatively new inventions, historically speaking. But the idea of inoculating yourself, meaning using a germ or pathogen to help your body learn to protect itself from a disease, that idea has been around for hundreds of years.

SAGE: In fact, humans were developing early versions of vaccines even before we knew what a virus was,

MOLLY BLOOM: This earliest kind of inoculation was called variolation, where you give someone a little bit of the smallpox virus to build immunity to that disease. I'll let our friend Anna Rothschild explain.

[MUSIC PLAYING]

ANNA ROTHSCHILD: I'm Anna Rothschild. I'm the senior video producer for FiveThirtyEight. And I made a three-part video series on the science and history of vaccines for the *Washington Post.* The first inoculations were for smallpox, which was a terrible disease that could be fatal. If you survived, it left pretty intense scarring. It was really a horrible, terrifying disease. And variolation was a method to inoculate yourself against smallpox that originated both in Africa and Asia. And the methods to do it varied.

In Africa, a common method was to sort of dip a thread into a smallpox pustule and then make a small incision in somebody else's arm and run that thread through the incision. And that would confer immunity.

MOLLY BLOOM: That means it would make the person immune, or safe from that disease.

ANNA ROTHSCHILD: In Asia, there was a different technique, where actually people would grind up smallpox scabs and then blow them up a person's nose. And that would confer immunity. But the terrible thing is that there was a 1% to 2% fatality rate. So even though it provided lifelong immunity if you survived, there was a small chance you could die from this treatment. I think it just sort of goes to show how terrifying the disease was at the time, that people submitted themselves and their children to variolation.

MOLLY BLOOM: Now, fast forward several hundred years to England in the late 1700s. Scientists notice something interesting about dairy maids who milked cows.

ANNA ROTHSCHILD: There was some sort of conventional wisdom that dairy maids never got smallpox. And this guy Edward Jenner decided to look into why that was. What he found was that dairy maids often had these similar but much less dangerous pustules, sort of like scabs, on their hands that were due to a very similar disease called cowpox. And Jenner basically did something very similar to variolation. He took pus from a cowpox scab and used that to inoculate a small boy.

That, obviously, today would be like completely unethical. We would never do something like that today. But luckily, the small boy, whose name was James Phipps, he survived the process and became immune to smallpox as a result of this very similar type of process, but using a much less dangerous disease.

MOLLY BLOOM: Even though some people were nervous about the idea of vaccines, smallpox was so dangerous that many people were very eager to get the vaccine. And it soon became available all over the world.

ANNA ROTHSCHILD: "Vaccinate" comes from the word "vacca," which is Latin for cow. And when Edward Jenner was doing these early tests, he was taking cowpox pustules and giving them to people to provide immunity. So vacca-- vaccinate.

MOLLY BLOOM: Then, once people really started to understand germ theory-- that's the idea that diseases are caused by bacteria and viruses-- then they could start developing vaccines like the ones we have today.

HARVEY: Brains. Brains. *Brains On.*

MOLLY BLOOM: Did you know we have a *Brains On* fan club? It's totally free to join. And our fan club members get access to a great newsletter that has activities related to the week's episode. And we've even sent out stickers in the mail in the past. I love stickers. We have another cool opportunity coming up, Marc Sanden, Menaka, and I will be doing a virtual hang with fan club members. We'll play some mystery sounds for you to guess and answer as many questions from the chat box as possible. It will be a blast.

If you want to join us for the hang, the first step is to sign up for the fan club. You can do that at brainson.org/fans. Then in November we'll send out a link with more info about how to join the chat, and we'll record it and make it available to fan club members in case you can't make it live. And again, that's brainson.org/fans.

And while you're at our website, why not drop us a note to say hi.

AVIVA: You can also send us a mystery sound, drawing, or question for the show.

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

JULIANNE: Hi, my name is Julianne, and I'm from Ardmore, Pennsylvania. My question is, how can liquid travel through a straw, even going up?

SAGE: We'll answer that at the end of the show.

MOLLY BLOOM: Plus, we'll hear the latest group to join the exclusive super rad club known as the Brain's Honor Roll.

SAGE: So keep listening. You're listening to *Brains On.* I'm Sage.

AVIVA: And I'm Aviva.

MOLLY BLOOM: And I'm Molly. Today we're talking about vaccines and specifically vaccines for influenza.

AVIVA: Or as most people know it, the flu. The tricky thing about flus and shots is that it takes months to make enough flu shots for everybody.

MOLLY BLOOM: So researchers have to decide what goes into a flu shot long before flu season starts. In labs all over the world, scientists take samples of different flu viruses that are spreading fast, and they try to figure out which ones might be next year's catchiest flu.

AVIVA: You can think of it a little bit like a case for a detective to solve.

SAGE: So we thought we'd ride along with a few flu virus gumshoes. Check it out.

[MUSIC PLAYING]

HALE SHIELDS: Name's Hale Shields. And this is my partner, Ace Kilter.

ACE KILTER: Someone tipped us off about a flu virus nearby. So we're off to check it out.

HALE SHIELDS: Ace, left at the next light. We're headed to a used tissue in a trash bin at the corner of Woodlawn and Central.

[SIREN WAILS]

Flu virus detective force. Flu virus, you have been detected. You're coming with us.

FLU VIRUS: Hey, hey, time for a chill pill, right? My friends and I are just lounging on this totally mellow tissue, and we never going to hurt anybody.

ACE KILTER: Bring your friends. We've got some questions for all of you. But we'll start with you. Once we've got a flu sample back in our detective lab, we're looking for a couple of clues.

HALE SHIELDS: Our first clue-- where the virus is from. We want as much information as possible. So Flu--

FLU VIRUS: Detectives, please. Flu sounds so stiff. I go by Enza.

ACE KILTER: Enza then, tell us your backstory.

FLU VIRUS: Well, first thing I remember is being in a human. It was dark and kind of like mushy. I'm pretty sure I came from another virus that copied itself. But I turned out kind of different from that virus.

HALE SHIELDS: And do you remember where and when that was?

FLU VIRUS: Well, that was a few hours ago in Wichita, Kansas, I think. And then I found these rad snot waves to surf. I got totally tubular. And they say there's no surfing in the Midwest. Yeah. I've pretty much been hanging 10 in that tissue you found me and since then.

HALE SHIELDS: So we've got a Kansan flu strain on our hands, year 2019.

ACE KILTER: Our next clue is the type of flu. Flu viruses come in four types-- A, B, C, or D. So, Enza, what kind of virus are you?

FLU VIRUS: I'm a Type A flu virus, brah. Aaaay.

ACE KILTER: OK, Type A, you cause a lot of human flu.

HALE SHIELDS: Same with Type B.

ACE KILTER: But Type C and D don't affect humans so much.

HALE SHIELDS: For Type A viruses, there's one last thing we take a look at.

ACE KILTER: Something called surface proteins. These are little tiny thingies on the outside of the virus that the virus uses to attack your body's cells.

FLU VIRUS: Right. These thingies, my hemagglutinin.

HALE SHIELDS: We just call it H.

FLU VIRUS: And my neuraminidase.

HALE SHIELDS: And that goes by N.

ACE KILTER: These H's and N's are a little like virus fingerprints. They both come in many different forms. And each form has its own number. Enza, we're taking your prints.

FLU VIRUS: Oh, man.

HALE SHIELDS: So let's see. We got hemagglutinin type 3, so that's H3, and neuraminidase type 2. So that's N2.

ACE KILTER: I had a feeling you were an H3N2 kind of virus.

HALE SHIELDS: OK, Enza, that's all we need. We'll have you head to the lab with the other flu viruses we've collected.

FLU VIRUS: Oh, rad. Hopefully I can find a wave or two. You guys want to join?

ACE KILTER: Thanks for the offer. We've still got lots to do. You're only one of thousands of leads we've got to run down before we get to the bottom of this flu caper.

[MUSIC PLAYING]

MOLLY BLOOM: In real life, it's scientists not detectives who hunt down future flus. But they do use similar clues to Hale Shields and Ace Kilter. And they do take samples from hospitals around the world.

AVIVA: But unfortunately, the samples don't talk.

SAGE: And they certainly don't surf.

MOLLY BLOOM: It's not easy to predict which flu viruses will spread the most each year. And they don't always do a perfect job. But they try their best to make a good prediction every year.

HARVEY: (SINGING) *Brains On.*

MOLLY BLOOM: The flu is pretty common, but it can also be dangerous. Some people end up going to the hospital because of the flu. And it can be fatal for people who have weakened immune systems. That's why the vaccine is important.

SAGE: Unlike most vaccines, getting your flu vaccine is a yearly thing.

AVIVA: Yeah, why do we have a new shot every fall? And why is it always in the fall? People get sick in spring and summer too.

MOLLY BLOOM: Well, we've got an expert here to help us answer these questions.

AVIVA: Her name is Maryn McKenna.

SAGE: She's a journalist who writes a lot about viruses, bacteria, and public health.

MOLLY BLOOM: She's also the author of non-fiction books, like*Superbug* and *Big Chicken.*

AVIVA: Welcome, Maryn.

MARYN MCKENNA: Thank you.

SAGE: Why do we get a flu shot each year?

MARYN MCKENNA: That is a really good question. Here's why we do that. If you think about the shots that you got when you had to go into school, those are shots that you only get once or maybe twice in your life and then you're protected lifelong. That's because the disease organisms that you're being protected against, those are things like measles and mumps and diphtheria, don't change during your lifetime. Wherever they are out in the world, they are always the same. But flu changes every year.

Every year it changes its genetic makeup just enough that the protection we got from a shot last year doesn't last to this year. And we have to get the shot again.

AVIVA: Why is there a flu season?

MARYN MCKENNA: The reason there's a flu season where we live here in North America at the time that it is is that it's not the flu season down below the equator in the other part of the world. Flu viruses like to reproduce when the outside temperature is within a certain band. So when it gets into the colder part of our year, that's when flu is happiest. But in the warmer part of our year, which we consider not the flu season, it is the flu season down in places like Australia.

SAGE: Can animals get the flu?

MARYN MCKENNA: Yes, it is true that animals, some animals, can get flus. In fact, there's many, many different types of the flu virus. We talk about flus in terms of their H's and their N's. And those are the designations for proteins on the surface of the virus. And certain H and N combinations are better at infecting different species. Some of them infect us, some of them infect birds, some of them infect other species of animals. But lots of species can potentially get flu.

SAGE: Does the flu vaccine always work the same?

MARYN MCKENNA: That's a really good question. And in fact, the answer is no. And here's why. Now, we talked about how we're always tuning up the vaccine to whatever the virus is that's circulating in any particular year. But it takes a while to make a flu vaccine and, in fact, to make enough flu vaccine to give it to everyone who needs it during the flu season.

And in that time, which is sometimes as much as six months, the flu virus keeps changing. It doesn't stop and let us know what it's going to be and then not change again over six months. And so sometimes those changes send the virus in a different direction than people guessed. So in some years, the flu vaccine might only be 60% effective or 40% effective at preventing you from being infected with flu.

But here's a really important point. Even if that imperfect vaccine doesn't keep you from catching the flu, it will make your symptoms much less serious.

SAGE: Thank you, Maryn, for talking to us and answering our questions.

MARYN MCKENNA: Thank you for having me on. It was fun to talk to you.

MAN: Ba ba ba ba ba ba ba ba ba ba*Brains On.*

MOLLY BLOOM: All right. Let's get back to that mystery sound. Here it is one more time.

[SCRAPING AND SQUEAKING]

All right. I think Sage guessed first last time. So Aviva, let's hear your guess first.

AVIVA: I no longer have any clue.

MOLLY BLOOM: Well, tell me one thing you heard.

AVIVA: I know there was something scraping on something.

MOLLY BLOOM: So, Sage, what are your new thoughts?

SAGE: It's definitely something scraping, but there's a squeak in it that I missed last time. And I'm not really sure what that is.

AVIVA: Maybe there's a dog toy in it.

SAGE: Maybe.

MOLLY BLOOM: Are you ready for the answer?

SAGE: Yes.

AVIVA: No. Yes. No.

SAGE: Yes. No. No.

MOLLY BLOOM: Here is the answer.

JARIS: Aloha, my name's Jaris.

RYDER: Hi, my name is Ryder.

BOTH: Aloha from Honolulu, Hawaii.

RYDER: That was the sound of us husking a coconut. The best way to husk a coconut is to use the sharp end of a pickaxe and wedge up the husk.

JARIS: After you husk it you hit it on a sharp, hard object to open it up, like a corner of stair. We get our coconuts from the coconut tree in our backyard.

[MUSIC PLAYING]

MOLLY BLOOM: Vaccines work by using weakened or dead versions of germs to train your body's immune system.

AVIVA: But the idea of building immunity through exposure started with variolation a long time ago.

SAGE: We have to get flu shots every year because the flu virus is constantly changing.

AVIVA: Scientists track these changes like detectives so they can make better vaccines for the next flu season.

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

SAGE: *Brains On* is made by Sanden Totten, Marc Sanchez, and Molly Bloom.

MOLLY BLOOM: Menaka Wilhelm is our fellow and shares her contagious love of science with us. We had engineering help from John Miller, George Newman, and Veronica Rodriguez. We also had production help from Kristina Lopez and Ruby Guthrie. Special thanks to Debra Winter, John Huddleston, Kate Gostic, Caroline Champlin, Danny Rosales, Taylor Kaufman, Sean Campbell, Melanie Renee, Shari Mitchell, Sam Chu, Eric Ringham, and Vikki Kreckler.

SAGE: Now, before we go, it's time for a moment of--

SAGE AND AVIVA: Ummmm

JULIANNE: How can liquid travel through a straw, even going up.

NICOLE SHARP: So it's easy to make liquid flow upward through a straw because you have the weight of the entire atmosphere helping you out. Hi, I'm Nicole Sharp, and I'm an aerospace engineer. If you have water in your glass, it just stays there because gravity is holding it in the glass. So you might wonder why it is that you can use a straw to pull the fluid up. And the answer is, there's a lot of stuff going on that you can't see.

You have an entire sky worth of air sitting above you that's constantly pressing down on you. It's pressing down on the glass. And it's pressing down on the fluid in the glass. And essentially what you do by putting your mouth on the straw and sucking is you give that fluid and escape route. And all of the weight of the sky pressing down basically allows the water to flow up the straw and into your mouth.

We can drink through straws because we have cheeks, and that allows us to use suction. But there are a lot of animals that can't create that kind of suction, in part because they don't have mouths that close the same way that ours do. So if you have a dog or a cat, for example, you've probably noticed that they stick their tongue out and stick it in the water and then pull their tongue up and water comes with it.

If you actually look at that in high speed, they're touching their tongue to the surface, pulling it up really quickly, and that causes a little column of water to come up after their tongue. And then they just close their mouth around it.

[MUSIC PLAYING]

SAGE AND AVIVA: Um. Um. Um.

MOLLY BLOOM: What are you talking about? It's not the end of the episode. It's time for the Brain's honor roll. These are the brilliant listeners who send us their questions, ideas, mystery sounds, and keep this show curious.

[LISTING HONOR ROLL]

SAGE AND AVIVA: Thanks for listening

SAGE: (SINGING) *Brains On,* where we're serious about being curious. How was that?