

[MUSIC PLAYING]

MOLLY BLOOM:

You're listening to *Brains On*, from American Public Media.
We're serious about being curious. I'm Molly Bloom.

There's an interesting trend happening right now in kitchens,
at schools, and all over YouTube. Kids everywhere are making
homemade slime--

[SQUELCHING]

--that stretchy, gooey, slurpy, stuff. To make it, you just need
a few simple things, like laundry detergent and Elmer's glue.
In fact, we've got a video showing you one recipe at
brainson.org. Maybe you already know about this stuff or
maybe you don't. But a lot of our listeners are way into it.

[MUSIC PLAYING]

[AUDIO PLAYBACK]

- Well, slime is--
- --sticky, stretchy--
- --squishy, slimy.
- Slime is--
- --hmm--
- --a stretchy gooey substance.
- Imagine m but you can play with m and it's much more stretchy.
- It's slime. How is it not gross?
- I think it's so cool to watch it get spread across and--
- I like turning it over and over.
- It looks so cool and you can add different colors and sparkles to it.
- It's really fun to play with.

[END PLAYBACK]

[MUSIC PLAYING]

That's Ashley, from Burke, Virginia, Charlie, from Rockville, Maryland, Ava, from Los Angeles, California, and Irene, from Minneapolis, Minnesota, and they are slime obsessed. Today, on *Brains On*, we are also slime obsessed. What is it and why do we like touching, and poking, and squeezing it? Let's find out.

Today's episode was inspired by this question.

[AUDIO PLAYBACK]

- Hi, my name is Ava. I'm 11 years old, from Los Angeles, California. I love to make slime. My question for *Brains On* is, how does sticky glue become slime when you add laundry detergent?

[END PLAYBACK]

MOLLY BLOOM:

Yeah, what is happening when you make slime?

[AUDIO PLAYBACK]

- Ah, this is a great question.

[END PLAYBACK]

MOLLY BLOOM:

To help us find an answer we called up Raychelle Burks. She's an Assistant Professor of Chemistry, at Saint Edward's University, in Austin, Texas.

[AUDIO PLAYBACK]

- I have a PhD in chemistry, and a Master's in forensic science, and a Bachelor's in chemistry, so I'm a big dork.

[END PLAYBACK]

MOLLY BLOOM:

Right there with you, Raychelle. She told us the magic starts when you add something called sodium borate to water. In laundry detergent, these are already mixed, but some slime makers do it themselves.

[AUDIO PLAYBACK]

- And when you add that compound, sodium borate, into water, it makes an anion, which is a negatively charged compound.

[END PLAYBACK]

MOLLY BLOOM:

So remember molecules, those tiny atomic structures that make up, well, pretty much everything? Sometimes, they interact with other molecules to become a new compound. Sometimes that compound is either positively-charged or negatively-charged. It has to do with how many tiny particles, called electrons, the compound ends up with. When water and borate form a new compound, that compound has a negative charge. It also takes on a special shape.

[AUDIO PLAYBACK]

- I like to describe it as, if you looked at your hand, you could turn it into a bit of a claw, so you could grab stuff, right? And that's what this ion does.

[END PLAYBACK]

MOLLY BLOOM:

Next, this grabby ion meets the glue and starts grabbing. Glue is made up of something called polymers. These are just strings of molecules, bonded together. Raychelle says you can think of a polymer like a long, rubbery, spaghetti noodle.

[MUSIC PLAYING]

[AUDIO PLAYBACK]

- And so when glue is just glue, it's just a bunch of loose spaghetti noodles, all sliding past each other.

- Sliding by.

Whoop, there I go.

- Coming through.

- But once you add in the borate compound, you've added in a bunch of claws. And what that does is, one claw grabs one sticky, glue polymer.

- Whoop, gotcha.

- Another claw grabs another one.

- Hup, gotcha.

- And that means that, now, two polymer strands are actually connected through these kind of a claw bridge.

- Hmm, I seem to be stuck.

- Gah, I can't get away.
- That means that the polymers can no longer be slippery and slidey past each other. They're actually connected. This happens all over the glue, with all of that borate.
- Eh, grabbed you.
- I got you.
- Oop, pulling you in.
- Oh can't get away from that one.
- And so it goes from being slippery, slidey spaghetti noodles to being like spaghetti the next day, when it's left over and you stick a fork in it, and you pull it up, and it's one giant mass of connected, dried out, spaghetti noodles. That is what is happening here. So borate is actually connecting these polymer spaghetti noodles, and clumping them all together, and giving us what we call slime.

MOLLY BLOOM:

[END PLAYBACK]

Of course, unlike a clump of spaghetti, you can't see the individual polymer strands in slime, since they're so small. But it's this interaction, happening on the microscopic level, that gives slime its texture. So now, we have slime, which brings us to our next question.

[AUDIO PLAYBACK]

- Hi, my name is Luke, and I am eight years old, from Los Angeles, California. My question for *Brains On* is, what's state of matter is slime-- solid or liquid?

- It is what we like to call-- it's got a really cool name, after Isaac Newton-- it's a non-Newtonian fluid.

[END PLAYBACK]

MOLLY BLOOM:

Non-Newtonian-- to understand this, let's start with regular, old Newtonian fluids. 17th-century scientist Isaac Newton thought how well a liquid flows depends on how warm or cold it is.

[AUDIO PLAYBACK]

- Let it be known, the warmer the fluid, the smoother the flow. The cooler the fluid, that flow be slow. Newton, out.

MOLLY BLOOM:

- So that is actually called a Newtonian fluid, when temperature affects how easily it moves. Well, there are these what are called non-Newtonian fluids, where it's not just temperature that affects them. It can be, like, a force, like a shearing force, like you pulling on it, or you poking at it.

- Raychelle Burks says, for these non-Newtonian fluids, pressure and force actually change how runny they are.

- How they respond to the stress is different. So if you take slime, and you yank it really fast, with a really high force, you can snap it right into, like breaking a pencil, like, if you just snapped a solid. But if you took the same slime, and you just applied the same force but over a longer time-- not that sharp application of force-- the slime would just stretch, like a big piece of taffy candy.

- Think of water. It's a classic Newtonian fluid. If you throw it against a wall, well, it splashes everywhere. That force doesn't change how it behaves. But if you threw slime against a wall, it would smack, almost like a solid. But if you poured slime slowly into a bowl, it would flow, more like a thick liquid. That's classic non-Newtonian fluid behavior. Raychelle says slime isn't the only non-Newtonian fluid out there. There are others, like quicksand, or Silly Putty, or even something you might have in your refrigerator.

[END PLAYBACK]

This characteristic, how thick or runny a liquid is, is called viscosity. You can easily see this in lots of common liquids, like honey. Cold honey is a really gooey and thick, but heat it up and it's more slippery and more runny.

[AUDIO PLAYBACK]

[END PLAYBACK]

[MUSIC PLAYING]

[AUDIO PLAYBACK]

So how we treat it gives us kind of different properties that we're seeing. Sometimes it acts like a liquid, or like a thick, like a honey-- very viscous, but still all in one piece. And sometimes we apply a force, and it snaps, like we would expect from a solid.

[END PLAYBACK]

[AUDIO PLAYBACK]

- A food item that's also a non-Newtonian fluid is ketchup. If it's in the bottle, and anyone's ever wrestled with a ketchup bottle, you know that it can be a bear to get out of the bottle. But once you give it the right amount of force, it just moves straight out of the bottle. So it has some really interesting properties when you apply just the right force, in just the right way.

[END PLAYBACK]

MOLLY BLOOM:

So slime, this cool, non-Newtonian fluid, happens when borate, water, and glue mix. You can get the borate lots of ways, like using laundry detergent or contact solution. Some recipes call for Borax, which is used as a cleaning product. Now, an important safety note-- this Borax stuff can sometimes irritate the skin. So be very careful if you decide to use it.

Check with your parents first. Don't rub your eyes or face while playing with slime, and wash your hands when you're done. If you'd rather skip the Borax, there are lots of recipes without it online. Have your parents help you find one and get creative. Add food coloring or glitter. While your researching your recipe, let's tune in to Slime Time.

[AUDIO PLAYBACK]

[STATIC]

[STEFON ALEXANDER, "SLIME"] Slime, yeah. I love slime. Let's make slime. Hey, you want to make some slime? Let's make slime. It's about as fun as can be.

First, let me tell you all the stuff you'll need. You'll need a big bowl and a bottle of glue. White, clear, or glitter glue-- it's up to you. You need baking soda, not baking powder. So double check it, before you get started. Some eye drops, or contact solution, a spatula or something to mix-- now, let's get to it.

Make slime. Yeah. Let's make slime. Now, open the glue and pour it all into the bowl. It's real sticky, so don't lose control. Now open the eye drops or contact stuff, put in a few drops. Take it slow, there's no rush.

After you drip 10 drops or so, start mixing it in. Start mixing it in. OK, baking soda-- how much you need? You never know. So start with a little and stir it in as you go. A few more eye drops, a little more baking soda, in no time, you got slime.

Now mix it up. Mix it up. Mix it up. Mix it up, yeah. Now pick it up. Pick it up. Squish it in your fingers. Mix it up.

Yeah, you got slime. Let's make slime. Yeah. My slime is so cool, my slime is so fun. My slime's so weird, man, it blows my mind.

When you're all done making and playing with your slime, get a sandwich bag. Save it for next time. I make slime. Do you make slime? I make slime. We can all make slime. Let's make slime.

[END PLAYBACK]

That song and slime recipe comes from Stef Alexander, a rapper with the Doomtree collective. He's also a father and slime aficionado.

[AUDIO PLAYBACK]

MOLLY BLOOM:

- That song is going to be stuck in my head for sure.

Would you say it's as sticky as slime?

Hey, Sanden. Hey, Marc. Are you guys here to talk about your next debate?

- Yeah, we've been flexing our mental muscles.

- Practicing our pronunciations-- elocution, elocution. We're ready.

We just need the next topic.

- We've argued, which are better-- bridges or tunnels?

- We've pitted fire against lasers.

- And we've meowed about cats. Are they evil or just misunderstood?

- Our next debate is about-- well, we don't know.

- That's where you come in. We want to know what you'd like us to tackle in our next "Versus" episode. Is it going to be Bears versus Bobcats?

- Planets versus stars?
- Is cereal a soup?
- What?
- I mean, think about it, right? Soup is just a liquid with stuff floating in it. That's what cereal is.
- That's crazy. Soup has vegetables in it.
- Yeah, but cereal has grains. And you could argue that--
- Whoa, whoa, whoa, save it for the debate, guys. But yeah, send Marc and Sanden your ideas, at hello@brainson.org. Thanks guys.
- No problem, Molly. Totally a soup.
- Not.

[END PLAYBACK]

[MUSIC PLAYING]

MOLLY BLOOM:

If you're a teacher interested in using *Brains On* in your class, drop us a line at that same email address, hello@brainson.org. Put "teachers list" in the subject line and we'll feed your lesson plans with upcoming episode ideas. Not a teacher? No problem. We still want to hear from you. You can send drawings and questions to that same email address, like Abe did, from Chevy Chase, Maryland.

[AUDIO PLAYBACK]

- How in the world do snakes smell through their tongues? My name is Abe.

[END PLAYBACK]

MOLLY BLOOM:

We'll answer that one at the end of the show, in our Moment of Um. Plus, you'll hear the latest group of inductees to the prestigious and exclusive Brains Honor Roll.

[ENGINE REVVING]

Are you listening to this in the car, or you'll be in the car soon, or maybe you have a summer road trip coming up? Well, whether you'll be on the road or staying put, we're really excited to share our special summer series with you. This June, we're releasing five special episodes, answering all of your many questions about cars.

Here's just a few of them. How do engines work? Why do some people get carsick? What will the car of the future be like? And most importantly, how are monster trucks different than cars?

And for our newsletter subscribers, we'll be sharing some cool activity sheets we're putting together to keep you busy in the car, whether you're running to school or driving across the country. If you want to subscribe to that newsletter, you can do that by visiting our website brainson.org.

You are listening to *Brains On*. I'm Molly Bloom. Now, let's get back to slime. Some of you told us that the first time you saw slime was on social media. In fact, videos of people playing with slime can get hundreds of thousands of views. Why are people so obsessed with watching it and playing with it? Our chemistry friend Raychelle Burks thinks maybe it has to do with how weirdly slime behaves.

[AUDIO PLAYBACK]

- It doesn't do what we expect it to do, because we expect things to be either a liquid or a solid. We usually don't expect things to kind of exist in this middle realm.

[END PLAYBACK]

MOLLY BLOOM:

We also asked our slime experts, Ashley, Ava, [? Charli, ?] and Irene, to weigh in.

[AUDIO PLAYBACK]

- After you make it, it's fun to feel and play with.

- I think it's fun to make. And everyone doesn't think it's fun, some people think it's stressful. But I think it's, like, relaxing and fun, and you get a fun end product, in my opinion.

- My mom used to say slime is gross because of the sounds. But I think it's actually very relaxing and calming.

- It's actually just, like, a nice consistency, and it's satisfying, and it releases stress.

[END PLAYBACK]

MOLLY BLOOM:

[? Charli ?] gave us another explanation for why she thinks so many people like watching slime videos.

[AUDIO PLAYBACK]

- I think it's because of the ASMR. I don't know what it stands for but I hear people say it I think that's why people watch it, because it sounds amazing and satisfying

[END PLAYBACK]

MOLLY BLOOM:

ASMR-- what is that? We asked Nick Davis, a psychology professor at Manchester Metropolitan University, in the United Kingdom.

[AUDIO PLAYBACK]

- ASMR, which stands for Autonomic Sensory Meridian response, which is a very strange, relaxing, tingly feeling that some people get, that might be triggered by calming things in their environment, like having their hair touched or something like that.

[END PLAYBACK]

MOLLY BLOOM:

Nick has studied ASMR, and he says it's sort of a calm chill on your head or your spine. Some people get it when their back is scratched. Others get it from hearing soft sounds, like the faint crinkling of plastic, like in this clip from YouTube.

[AUDIO PLAYBACK]

[CRINKLING]

[END PLAYBACK]

Maybe you know what ASMR is or maybe you don't. It doesn't happen to everyone. But Nick says, people who get that tingling sensation often get it from similar situations.

[MUSIC PLAYING]

[AUDIO PLAYBACK]

- A lot of people get triggered by whispering sounds, or people paying close attention to them. So if you're in a situation, like a haircut, where somebody gets very close to you, that seems to trigger people's sort of relaxed, tingly sensation. I mostly found that the sorts of things that triggered ASMR seem to be related to feeling very comfortable in another person's presence. So it's like being, maybe, when you're being cuddled by your mother, when you're very young. It takes you back to that sort of sensation.

MOLLY BLOOM:

[END PLAYBACK]

Nick says his team has never studied slime specifically, but he thinks that when people play with it, it makes soft sounds, sort of like the sounds you hear from someone's mouth when they whisper in your ear. For some people, those sounds trigger ASMR. Of course, all of these ideas are just theories. They're sort of educated guesses about why we might like slime.

In order to get a solid answer, we're going to need more research. If you've got a theory about why people love slime, feel free to send it to us at hello@brainson.org. Is it the sound, the texture, the colors? Let us know.

And speaking of sounds, we almost forgot-- it's time for the--

[WHOOSHING]

SPEAKER:

Mystery sound.

MOLLY BLOOM:

Here it is.

[AUDIO PLAYBACK]

[CLANG]

[END PLAYBACK]

Did you catch that? Here it is, once more.

[AUDIO PLAYBACK]

[CLANG]

[END PLAYBACK]

Got your guess? Here's the answer.

[AUDIO PLAYBACK]

- I'm Eli [? McGinnis. ?] I am 10 years old. That was the sound of my dad hitting a whiffle-ball with a metal bat. This sound was recorded in my yard, when my family was playing baseball together. I don't play in a baseball team but I love to hit baseballs in my yard with my family. I like to use different kinds of bats, like plastic, wood, and metal, and like to compare the different sounds they make.

[END PLAYBACK]

MOLLY BLOOM:

Thanks, Eli! Play ball.

[CLANG]

Now, before we end, we're going to give shout outs to the latest group of brainiacs to join the Honor Roll. But first, we're going to answer Abe's question, about how snakes smell with their tongues. It's our Moment of Um.

CREW:

Um, um, um, um, um, um, um, um, um, um, um, um, um, um, um.

[AUDIO PLAYBACK]

- My name is Carol Spencer and I'm a Staff Curator of Herpetology at the University of California, at Berkeley, at the Museum of Vertebrate Zoology. Herpetology is a study of amphibians and reptiles. And I take care of the specimens we have here in the museum.

[BEEPING]

Snakes are actually great at smelling in a couple of different ways. And they smell, still, with their nose. But the way they smell with their tongues is, they have an organ in their mouth. And so they can pick up something with their tongue, either chemicals or little pieces of something that are floating around in the air, on the tips of their tongue. And then it goes into the top of the roof of the mouth, and actually touches this organ called the vomeronasal organ.

[MUSIC PLAYING]

And they are able to sense the sort of taste and smell, using this organ. It's called the vomeronasal organ because it's right by these two bones, called the vomer and the nasal, who for humans are right in the front of your face. But for a snake, it's on the top of their head.

So they can sense anything-- things they're trying to eat. They can sense predators-- something that's trying to eat them. Or they can even sense their mates.

And so and the coolest part about it, to me, is that because they have-- snakes and lizards all have forked tongues-- their tongue can actually sense direction then. So they can tell if something is, like, in front of them or on the side. And apparently they use this a lot more than they actually do their sense of smell

[END PLAYBACK]

MOLLY BLOOM:

Whoa, snakes are cool. And speaking of cool, here's the latest group of kids to power the show with their drawings, questions, and awesome ideas. It's the Brains Honor Roll.

[MUSIC PLAYING]

[LISTING HONOR ROLL]

I Thanks for listening and stay curious.

CREW:

Ba, ba, ba, ba, ba, ba, ba, ba, ba, ba-- *Brains On.*