But Why: A Podcast for Curious Kids

How Does Slime Work?

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[Jane] Hey everyone, it's Jane. This is *But Why: A Podcast for Curious Kids* from Vermont Public Radio. I'm Jane Lindholm. On this show, we take questions from curious kids, just like you, and we find answers.

This week, we're talking about sticky things like slime and glue. And we'll talk about explosions. The branch of science we're focusing on today is called "chemistry". Chemistry is basically the study of stuff and what it's made of and how different substances interact with one another, sometimes even combining to make new stuff.

Our guest today is someone who really loves chemistry. Her name is Kate Biberdorf, and she teaches at the University of Texas. A while back, she was invited to do a chemistry experiment on TV. And then she was asked to be on TV doing these things every month. Soon she found herself on national shows airing across the U.S. and, before she knew it, she was just known as "Kate the Chemist". Her job now is to blow things up, make fun potions and basically teach people about how cool chemistry is. Sounds pretty awesome, right?

[Kate] I know! I am the luckiest person in the world for that to be my career path and to do it with kids and make it fun, hopefully get them excited about science. I mean, it's just a win-win.

[Jane] When we got Kate the Chemist on the line to answer some of your questions, I couldn't wait and I blurted out my own question about what exactly explosions are.

[Kate] A typical explosion…you're usually looking at some form of combustion. And a combustion reaction is when you take a source of fuel, you treat it with oxygen or react it with oxygen, and then you have two products form. So you get water and carbon dioxide. So you have something that you explode using oxygen. And when that happens, it loses tons of thermal energy in addition to carbon dioxide and water. So it's super fun, but very much loaded in chemistry.

[Jane] Does it make it more exciting to know what's happening rather than just hear a big boom?

[Kate] I think so. To me, I want to know exactly the chemistry of everything that's happening around me. So how cement is made or why we salt our roads, if you're living up north, or how gasoline works. I want to know why all of that works from a molecular level. So how is one molecule interacting with another molecule to actually get what we see as makeup or sunscreen or any of this stuff.

[Jane] OK. Explosions aside, there are lots of other cool things to learn about when we talk chemistry. And you've sent us a couple of great questions about slime. Here's the first one.

[Sam] Hi, I'm Sam and I'm from Dublin, Ireland. I'm six years old and my question is why is slime sticky?

[Kate] Why is slime sticky? Good question. So slime is sticky because molecules are attracted to each other. They have serious attractions called intermolecular forces.

[Jane] Wait, wait. In order to know what intermolecular forces are, we should probably know what molecules are. A molecule is basically the smallest piece of something that can still be called that thing. A water molecule is the teeniest, tiniest piece of water that's still identifiable as water. A molecule is way smaller than you can see with your own eye. But if you could break down a molecule even further, a molecule is made up of atoms and atoms are made up of protons and electrons.

[Kate] An electron is a negatively charged particle that exists in an atom. So it is attracted to something called a "proton" that is a positively charged particle. So negative and positive are attracted. The electron is the negative one.

[Jane] Everything in the world is made up of atoms, but the number of protons and electrons in an atom is what determines what kind of element the atom is. The combination of different elements is what makes different substances. So a molecule is a bond between different atoms that, when they combine, they make something new. Remember I was talking about water before? Well, a water molecule is two hydrogen atoms joining forces with one oxygen atom or, here's how Kate puts it:

[Kate] A molecule is formed when two atoms come together to form a bond. So this means that the atoms share electrons and form this really cool unit like a team. And now these atoms join together to form a molecule. They are now going to move around the world together in a team forever. So you're never going to see one atom by himself. They're always going to be joined up with its partner in a molecule.

[Jane] If you took that molecule apart and separated the atoms, you'd no longer have that thing. For water, if you separated the hydrogen atoms and the oxygen atom, you wouldn't have water anymore. And remember, molecules are really tiny. They are something like 1.56 trillion molecules in one drop of water! OK. What does all of this have to do with slime? Well, let's get back to that concept of intermolecular forces. “Inter” means “between”, so intermolecular forces are the push and pull between molecules. [00:05:53] Those forces are what makes slime sticky.

[Kate] Just like any time where you pull something out of the dryer and there's lint that's kind of stuck in a little bit of a way to your clothing, or maybe hair is stuck to it in an electrostatic interaction, that’s kind of why slime is sticky. It's because molecules are attracted to each other and they get stuck to each other because they're so attracted. But because it's an intermolecular force, you can pull them apart like we do with slime. That's why we can get that long, gooey wonderfulness that happens when you spread your arms apart as far as possible.

[Jane] Slime is sticky because those molecules want to stay together….not as much as the molecules in something solid want to stick together…but more than the molecules in something that's pure liquid want to stick together. Now, slime is sticky, but it's still not glue. At least not if you make it right. So what makes glue sticky? That's what two curious kids want to know.

[Isaac] My name is Isaac. I’m five and half years old. My question is how is glue sticky?

[Cara] I’m Cara and I’m eight years old, I live in New York City, Far Rockaway and my question is what makes glue sticky?

[Jane] Glue is sticky because it not only wants to stick to itself like we were just talking about with slime, but it also sticks to whatever you attach it to. The wetness of the glue helps it “adhere”, or stick, to whatever surface you put it on. And then when the glue hardens and turns solid, those glue molecules want to stick to each other even more. So they're sticking to the surface and to each other. And actually, glue is one of the main ingredients in slime. That's the part that makes the slime stick to itself. Glue is more technically known as “polyvinyl acetate”. But then you add another ingredient to that polyvinyl acetate to make the slime feel more like something that's not quite liquid and not quite solid. So you might add dish detergent or the liquid people wash their contact lenses in to make the slime the perfect consistency.

[Kate] Glue plus this extra piece, like contact solution, and you create a polymer which is a really long, big, long molecule. And so slime is something

that is a big, long, sticky polymer. Whereas glue is much, much shorter. So it's tinier pieces. So that's the difference, it's the size of the molecule.

[Jane] You've mentioned a couple of the ingredients in slime. And Sophia wants to know why all of those ingredients come together and they work to make slime.

[Sophia] I made slime out of glue, baking soda and water and Tide detergent. I want to know why that worked.

[Kate] So just like with any recipe when you're making cookies or a cake, every single ingredient has its part. So when we're making cookies, we need the flour to give it the substance, really the weight of the cookie. And then we need the sugar to give it the sweetness. We also have the salt to kind of counterbalance the sweetness and balance out that flavor. So every single ingredient has a role for that cookie. In slime, specifically, every single ingredient that you use has a role. So I'm not sure which ones you mentioned in the list because there are so many different ones, but the main two pieces you have to have is glue because that's your polyvinyl acetate, and then you have to have something that usually provides a source of boron. And so that's why I highly recommend the saline solution or the contact solution, because that's an easy way to have access to these molecules that have boron in them. And when the boron and the polyvinyl acetate come together, that's how you actually form that beautiful polymer. So every single ingredient has a role. Everything else is kind of for fluff. So the water is probably to give it a nice texture. I like to add shaving cream to mine to give it a puffiness. So it's very kinesthetic and a quite good stress relief, honestly.

[Jane] Coming up, we'll learn about how things glow in the dark and how explosions happen. Plus, Kate offers a fun and safe experiment you can try at home.

[Jane] We're learning about chemistry with Kate Biberdorf, otherwise known as "Kate the Chemist". Moving on from slime and glue and all things sticky to things that glow.

[Mackenzie] My name is Mackenzie and I'm 5. I'm from Washington. My question is how does glow in the dark stuff work?

[Dexter] Hi, my name is Dexter, I'm 4 years old. I live in Oceanside, California and my question is how do things glow in the dark with no batteries?

[Kate] Well, so this is a loaded question because the chemistry of glowing in the dark is *extremely* complicated. So I'm going to try to keep it simple by using just a basic analogy. So in a traditional chemical reaction…not glow in

the dark, so a traditional chemical reaction… what happens is electrons are basically at the bottom of the stairs. They absorb energy. They run up the stairs and then they run back down the stairs. So that's a typical chemical reaction. When the electrons run up the stairs, they need energy. So they run, run, run, run. And then when they get to the top of the stairs, they're going to run right back down. And when they come back down, they're going to scream and release the energy and color. So we see that in the source of fireworks, we see them giving off red colors and blue colors and greens. And so that's when the electrons are coming down. But it's a really fast process because the electrons can run down the stairs. Now in glowing in the dark, we have to flip it around a little bit. And so the energy is not as easily translated from up and down stairs. So now what we have to think about is that the electron is now at the bottom of the stairs, same as before. Energy comes in, usually from the sunlight or, here, lights in your house. It absorbs the energy, your electron runs up the stairs. Now, this time, instead of just running down the stairs and releasing green, red, purple, blue, this time, it's going to flip over and do a handstand. So instead of using its feet to run down the stairs, it's going to use its hands. And so the process is so much slower as he goes from step to step to step as it slowly goes all the way down the stairs. When it gets to the bottom the stairs, that's when the glowing in the dark finally stops because the energy has been all used up going from the bottom to the top and then back down. And so the glowing in the dark process happens because the energy is able to stay within that electron for a really, really, really long time. Just like it happens with normal chemical reactions but with glow in the dark, it stays in that electron for so long that we can hold that energy and give off that light even after the lights have been turned off. So, glow in the dark is extremely complicated from a chemistry perspective, but basically what happens is these molecules can absorb energy, they hold on to it for a really long time and they can slowly release it in the form of like glow sticks or any other glow in the dark type of tattoo or anything like that.

[Jane] Well, some animals even glow in the dark, right?

[Kate] Yeah, absolutely! So, chemiluminescence, you've got bioluminescence. Those animals are pretty cool. I think there's a form of algae, as well, that gives off this beautiful luminescent glow. Fireflies are pretty cute.

[Jane] And to the question that we got from Dexter about batteries, can you go a little deeper into explaining the difference between something that's glowing in the dark and giving off light versus electricity?

[Kate] So something that has electricity…from this standpoint, like a battery…is when electrons move from one place to another place. So kind of

think like if you're jumping from one cliff to another cliff, like you're jumping over something, and so your electrons are going to move from one piece of metal to another piece of metal. And that's typically what happens in a battery. But for something like chemiluminescence or something glowing in the dark, in order for the reaction to happen, the two molecules actually have to interact with each other. So you'd have to stir them up together or force them to interact or have some kind of connection. So a battery…you actually have the molecules separated, or the metal separated, from each other and the electrons are jumping from one molecule to the other. But with something like glow in the dark, you physically have to mix the molecules together so they can interact in order to have the chemical reaction.

[Jane] OK. To be totally honest, I still don't really understand exactly how things glow in the dark, but I like the image of running down the stairs, screaming and releasing all kinds of colors. I promised explosions. And here's a question about a very small explosion that some people like to try at home.

[Aleeza] My name is Aleeza. I'm from Philadelphia, Pennsylvania. I'm seven years old and my question is why, when mixed together, do Diet Coke and Mentos explode?

[Kate] Ah, fantastic question! So when you add Mentos to Diet Coke…Mentos is a specific candy that has these nucleation sites. So think like little holes all over the candy. Next time you have one, look very closely at it and you'll see these. As soon as a Mentos, (Mentos plural?, I don't even know), when you drop one into the Diet Coke, all the carbon dioxide immediately is attracted to these little sites. And so, just like, you drop it and "Boom!" all of a sudden the carbon dioxide [makes swooshing noise] gets sucked all the way over to the candy. When that happens, especially if you add more than one Mentos candy, then all of the carbon dioxide quickly goes from the outside, or wherever it is inside of that Diet Coke, from there all the way to the center. When this happens, the molecules slam together and build up pressure, which actually forces the molecules to shoot out through the top of the soda high, high up, hopefully outside into your backyard. It's a fantastic reaction. The reason we use Diet Coke is actually just because it doesn't have the sugar content. It uses a sweetener called, "aspartame". And so sugar is really, really sticky. And so it's much more difficult to clean up and makes the experience a lot less fun if your hands are sticking together. So we usually just use diet sodas to make the clean-up and the experiment more fun and less sticky.

[Jane] Kate, do you remember the first experiment you did as a kid before you knew what you wanted to do and before you even really realized you were, you know, being a chemist? Do you remember being a child and doing chemistry experiments?

[Kate] I do, yes. And a shout out to my mom for being wonderful and allowing me to do this because she set up one of our bathrooms as being like a kid-safe bathroom. And so we could do whatever we wanted in this bathroom. We could combine anything together in this huge green bowl. So that was shampoos or bath salts or conditioners or anything like that. We could mix it all together and observe the bubbles and all the different fun concoctions we could create. We used food coloring one time. After that, it was banned. So I'm sure we made some awful mess. But she at least let us continue to mix shampoo and conditioner together. But we were doing that at age four or five or so.

[Jane] Experimenting and mixing things together to see what happens is a really fun way to learn about chemistry, but it can also be very dangerous. So you should always check in with your adults before you do any experiments. And Kate has other suggestions for how to make sure you stay safe.

[Kate] I always tell kids, “Do not touch anything that has cleaning supplies related to it at all.” If you don't want to do the chore related to it, don't touch it. So if it's a toilet bowl cleaner, I'm sure you don't want to clean the toilets. Don't touch that cleaner. And just anything like that. You don't want to mix any type of cleaners together because you can release lots of different types of gases, usually ones that contain chlorine and many different forms of chlorine gases can be toxic and can be super, super dangerous. So I would heavily encourage you to mix your soaps and your shampoos together, try different soaps, try your dishwashing soap and your laundry detergent soap. See what happens. If you have gloves, wear gloves. Obviously, in this time, be a little careful about dipping into your safety kit but, yeah, be careful what you mix together.

[Jane] And maybe ask an adult to help you?

[Kate] I definitely think you should ask an adult to help you. One hundred percent. Thank you for that.

[Jane] Will you give us one experiment from your new book that you think we should all learn how to do, that would be super cool?

[Kate] There is this one that I'm in love with lately, and I think it's just because kids are sending me pictures of themselves doing it. They're having a lot of fun. And it's called, “The Bubble Snake”. And it is this super easy experiment. All you need is a plastic soda bottle that you've cut in half. You just need the top two or three inches of a soda bottle, a plastic bottle. A water bottle would work as well. And then what you're gonna do is take an old rag and use a rubber band to strap the old rag to the bottom of that plastic soda bottle. From

there, in a small bowl, just add a half a cup of water to a quarter cup of dish soap and then stir that up. Then with your soda bottle rag apparatus, flip that over so that you're now looking at the bottom of the rag and take food coloring, if you want to. And just color the entire bottom with food coloring. I love my pinks and my reds and my brighter colors, but go for whatever color you like. Once that rag is covered in food coloring, flip your apparatus over. Dip it down into that bubble water concoction you made. Pick up the soda bottle, let the food coloring drain because it will drain off for about two seconds, so let it drain for two seconds. Bring that up to your mouth and then blow as hard as you possibly can into the mouth end of the plastic bottle and you will see this incredible bubble snake form. If you're outside, the wind can usually pick it up and it floats around kind of like a kite. And I I absolutely love that one, because the science is that you're exhaling. And for one of the first times, especially with little kids, you can see that you're exhaling molecules, that they take up space, that you're releasing your nitrogen gas, your carbon dioxide, and your oxygen and water…all these different things that you're releasing when you exhale.

[Jane] Yeah, I was looking at that one and I actually can't wait to try it myself.

[Kate] It's super fun. Just this morning, I had a friend text me and say they were going to try the bubble snake and he's 32. So I think they're fun for anybody who's maybe bored, has a little bit of extra time on their hands.

[Jane] No, adults would never want to do something fun with food coloring and bubbles. Come on!

[Kate] I know, right?

[Jane] Well, Kate, it's been awesome to talk with you. Thank you very much for talking to us about chemistry and answering our questions, but also giving us some new experiments to try.

[Kate] I appreciate it. Thank you for having me on.

[Jane] That was Kate Biberdorf, also known as "Kate the Chemist". Her new book is called *The Big Book of Experiments*. You'll find the bubble snake and slime and explosions and lots of other things in that book. And that's it for today. Now, if you have a question about anything. Have an adult record it. You can send the audio file to questions@butwhykids.org. We will do our best to get an answer for you. *But Why* is produced by Melody Bodette and me, Jane Lindholm, at Vermont Public Radio. Our theme music is by Luke Reynolds. We'll be back in two weeks with an all new episode. Until then, stay curious.