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Solving Dissolving

by Tessaly Jen and Emily Gibson
illustrated by Lydia Guadagnoli
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My Sister the Detective

My little sister, Maya, thinks she’s a detective. She’s always reading mystery books and pretending to solve cases. Maya can be annoying sometimes, but she’s usually okay.

I was taking care of Maya after school one day last week. Maya was bored, and she was starting to get on my nerves. I had to find something to keep her busy, so I said, “Let’s make lemonade!” I picked a few lemons from the tree in our yard and cut them in half, and then Maya and I took turns squeezing out the juice. I got the big pitcher out of the cupboard and filled it about halfway with cold water, then asked Maya, “Which do you want to add first, the sugar or the lemon juice?”

“Sugar first!” shouted Maya. I found the sugar in the cupboard and let her scoop a few spoonfuls of sugar into the water, then stir the mixture with a big spoon.
A Mystery

“We need to add more sugar,” my sister told me. “It all disappeared!” I looked at the water in the pitcher, and she was right that you couldn’t see the sugar anymore. The water looked clear. Still, I knew she had just added a whole bunch of sugar, and it couldn’t have gone anywhere! I poured some of the water into a cup so Maya could taste it. She said, “Hey, it’s sweet! So why can’t I see the sugar?”

I laughed and said, “It’s a mystery, Maya—the mystery of the disappearing sugar! You just found your first piece of evidence. That sweet flavor is a clue that the sugar must still be in the water, right?”

“Maybe so,” said Maya, “but I’d need more evidence to be sure.”
More Evidence

I had an idea about how to prove to Maya that the sugar was still in the water. “I bet I can get the sugar back out of the water,” I said.

“How?” she asked.

I held up the little cup of sugary water that Maya had tasted and said, “Let’s leave this water on the windowsill for a while.”

“It’s just going to dry up,” she replied. “What good will that do?”

“If there’s sugar in the cup, it will still be there after the water dries up. This way you’ll be able to see if the sugar is really still there in the water. When detectives need more evidence, they investigate, and that’s exactly what we’re going to do.”

Maya went over to the windowsill and watched the cup, waiting for the water to dry up. “It won’t happen right away,” I said. “You’ll have to wait a few days. Why don’t you come finish making lemonade with me now?”
Maya got really into our investigation, and she checked the cup every afternoon for the rest of the week. Each day, there was less and less water in the cup, but we still couldn’t see any sugar. “Maybe you’re wrong about the sugar still being in there,” Maya said.

Yesterday, when we got home from school, Maya ran straight to the kitchen to check the glass. “Diego!” she shouted as she showed me the thin layer of solid sugar at the bottom of the glass. “Look at this evidence! The sugar was still there!”
What Is Dissolving?

Later, Maya sat down across from me at the kitchen table and folded her arms across her chest. I felt like a suspect being questioned by a detective. “I still don’t get it. If the sugar is still in the lemonade, why can’t I see it?”

“Because it dissolved!” I said.

“Huh?” Maya said. “I don’t know what you’re talking about.”

“It’s like this,” I started to explain. “When we stirred sugar into the water, it spread out evenly in the water. The sugar dissolved, and that’s why it looked invisible to us.”

“So what?” my sister replied. “I should still be able to see the sugar, even if it’s spread out. I can see this, can’t I?” She picked up a grain of sugar to show me that it was visible, even though it was tiny.

“I know what you mean,” I said, trying to come up with another way I could explain what happens when something dissolves. “But stirring the sugar breaks up the grains into smaller and smaller pieces, until the pieces are so tiny that we can’t see them—much tinier than one grain of sugar.”

I could tell she still wasn’t getting it. To help Maya understand dissolving, I couldn’t just tell her about it—I’d have to show her what was going on. But how could I show her something too small to see?
Using Models

Just then, I thought of my science book from last year, which is full of pictures of things that are too small to see—molecules. They couldn’t take photos of the actual molecules, but the book shows lots of models that help make molecules easier to think about and understand. What we needed was some models of molecules.

I flipped through the book and found the right page. “I think this will help explain what dissolving means,” I told Maya.
The pictures on the page showed models of molecules in lemonade. I pointed to the model of a sugar molecule and explained, “The tiny pieces that the sugar grains broke down into are called molecules. Molecules are so small that even one grain of sugar is made up of trillions and trillions of them.”

Maya still looked kind of confused. Maybe these models were too complicated for her. I needed to show her something simpler, so I’d just have to draw my own model for her.
Dissolving at the Nanoscale

“Okay, Maya,” I said as I started drawing shapes on a piece of paper. “Take a look at this.” I drew triangles to represent the water molecules, then I added other shapes for sugar molecules.

I explained to Maya that when she stirred the sugar in the cup, the spoon broke up big clumps of sugar molecules.
Then the water molecules stuck to each sugar molecule and carried them away from the clumps.

As she kept stirring, all the sugar molecules separated from each other and stuck to water molecules. The sugar molecules spread out evenly through all the water in the cup.

“Do you see this last model I drew? This shows the sugar completely dissolved in water,” I told Maya.

“Oh, I get it,” she said. “Cool!”
Some Things Won’t Dissolve

I thought we were done talking about dissolving, but this afternoon, Maya asked, “Diego, do you remember Grandma’s cinnamon lemon cookies?”

“Sure,” I said. “Why?”

“Well, I was thinking about how yummy cinnamon and lemon taste together. Can we try adding cinnamon to lemonade and see if it dissolves?”

“Okay,” I said. “Why not?” I had homework to do, but I decided one more investigation couldn’t hurt. I helped her make a new batch of lemonade and get the cinnamon from the cupboard where we keep the spices.

Maya added some cinnamon to her glass of lemonade and stirred it, the same way she’d stirred the sugar. The cinnamon didn’t dissolve, though—it just floated on top of the water. “I don’t get it!” she whined. “Why won’t cinnamon dissolve in the lemonade?”

I looked at the cinnamon floating on top of Maya’s lemonade. “Well, I just realized that I left an important piece of information out of the model I drew for you,” I said, getting out the pencils and paper again.
“Sugar dissolves in water because sugar molecules are **attracted** to water molecules. The water molecules pull the sugar molecules away from the clump of sugar, almost like a magnet pulling a paper clip across a table.”

“Are the water molecules actually little magnets?” Maya asked me.

“No, but molecules can be like magnets. Some molecules are attracted to other molecules like some metals are attracted to magnets. Do you see how these water molecules act like a magnet, and the sugar molecules are like the paper clips being pulled toward them?” I said, pointing to my model.

“Because those sugar molecules can be pulled away by the water molecules, sugar can dissolve in water. Another way to say that sugar can dissolve is to say that sugar is **soluble** in water.”
“What about cinnamon?” Maya asked. “It didn’t dissolve.”

“Cinnamon is different—it’s not soluble in water. I’ll show you.” I picked up my pencil and drew another model to show Maya that the molecules that make up cinnamon were not attracted to the water molecules. I drew the molecules that make up cinnamon as round circles and the water molecules as pointy triangles, because those two shapes won’t fit together.

“See how the molecules that make up cinnamon stay clumped together?” I asked. “That’s because they aren’t attracted to water molecules. No matter how much you stirred the mixture, the water molecules would never be able to pull the clumps of molecules that make up cinnamon apart. You know cinnamon is not soluble in water because it doesn’t dissolve.”
Solving the Mystery

I feel kind of proud that my models helped Maya solve the mystery of the disappearing sugar. Now she knows: when solid ingredients like sugar seem to disappear in water, they don’t really go anywhere. They just break down into molecules that are too small to see. The molecules spread out as the water pulls them away from each other. That’s called dissolving. Case closed!

That’s what I thought, anyway. . . . After dinner, I went into the kitchen and found Maya with a whole bunch of cups lined up on the table. She was pulling ingredients out of the cupboards. “What are you up to?” I asked.

“Hey, Diego,” she said. “Let’s find out what else dissolves in water!”
Glossary

**attract**: to pull on an object, even without touching it

**dissolve**: to mix evenly into a liquid by breaking apart into pieces that are too small to see

**evidence**: information that supports an answer to a question

**explain**: to describe how something works or why something happens

**investigate**: to try to learn more about something

**investigation**: an attempt to find out about something

**mixture**: matter that is made of more than one substance

**model**: something scientists make to answer questions about the real world

**molecule**: a group of atoms joined together in a particular way

**nanoscale**: the size of things that are too small to see, such as molecules

**soluble**: able to dissolve in water or another liquid
Books for *Modeling Matter*:
Made of Matter
Break It Down: How Scientists Separate Mixtures
Science You Can’t See
Solving Dissolving
Food Scientist’s Handbook

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Solve the mystery of the disappearing sugar!

Diego and his little sister, Maya, are making lemonade one afternoon when Maya wonders what happened to the sugar she added. The sugar disappeared, but the lemonade still tastes sweet. It’s a mystery, and Maya loves mysteries. Diego helps her follow the evidence until she solves it. Along the way he teaches her all about the hidden world of dissolving.