SCENE: THE SCIENCE OF LEMONADE

Setting: Adam and Zena are at their Aunt Lucy's house after school with Olivia, mixing up some pink lemonade from a powder mix.

Olivia: Where's a pitcher? I'll fill it with water.

Zena: Nope, I make mine separately, because Adam makes it too sweet.

Adam: You don't make it sweet enough.

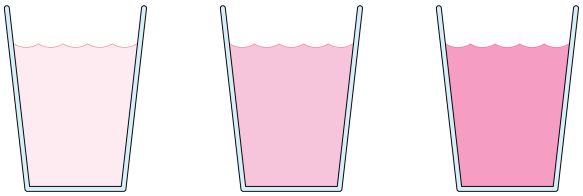
Zena: Yuck! Don't listen to him. Here's the right way to make it: put four teaspoons of pink lemonade powder into a glass, like this, and then fill the glass with water. Perfect!

Olivia: Okay. How many teaspoons of powder do you use per glass, Adam?

Adam: Oh, I don't measure, exactly. I just eyeball it. I put water into the glass, like this... Then I shake some powder out of the package, like this...and stir it a bit. Look at the color. It's about as pink as Zena's, which means it's not as sweet as I like it.

Olivia: That's kind of interesting: You can "see" how sweet it is by looking at the color.

Adam: Right. The **concentration** of sugar and of food coloring in the lemonade go together. If you add more powder, the sugar **concentration** and the pink food coloring **concentration** both go up. So I add a bit more powder and stir again. There! It's a nice dark pink. That should be good... Yup! Tastes about right.



sweet *sweeter* *sweetest*

Zena: Suit yourself, Adam. Olivia, let's get you a drink.

Olivia: Thanks. I'm not sure how much of the powder to use. I guess I'll try four teaspoons, like Zena. It'll be easier to add more powder and make it sweeter than to take it out once it's mixed in. (*Olivia makes herself some lemonade and takes a sip.)* Hmm. Actually, even that is a little too sweet for me.

Zena: If you want it less sweet, you can just **dilute** it with a little more water.

Olivia: "**Dilute**"?

Zena: Yeah, **dilute**: Make it less **concentrated**.

Adam: Sure. You'll have the same amount of powder mix dissolved in your glass, but when you **dilute** it with more water it'll be less **concentrated**.

Olivia: There! It's not as pink now...and it's not as sweet. Good.

Zena: Hey, do you think that when we mix the pink lemonade powder in with the water, we get a chemical reaction, like we were learning about last week in Ms. Quintanilla's class? I mean, we're making a new substance, right?

Olivia: What new substance? Pink lemonade? That's just water with sugar, flavoring, and coloring mixed in, isn't it? I don't think we're making a chemical reaction and producing some kind of pink lemonade molecules...are we?

Zena: Why not? There's obviously some kind of change, and we learned in class that chemical reactions change matter. Maybe water reacts with the powder and makes a new compound.

Adam: Well, wait a minute. I don't think pink lemonade can be a compound. Look at our three glasses. Mine is the darkest pink and sweetest. Olivia's is the palest pink and the least sweet. And Zena's is in between. We learned that a compound combines different elements in *definite proportions*: all water has two atoms of hydrogen per one atom of oxygen, and so on. But we've got three samples of pink lemonade and each one combines its ingredients in different proportions. So if pink lemonade doesn't have definite proportions, I don't think it can be a compound.

Olivia: Yeah, I think it's just water with powder dissolved in it.

Zena: So is "dissolving" not a kind of chemical reaction? It's definitely a change. Is dissolving a kind of change that doesn't involve a chemical reaction?

Adam: I think it could be. We did learn that not all changes in matter are chemical reactions. Remember: when a nail rusts, that's a chemical reaction, but when it just bends, that's a physical change rather than a chemical reaction. So maybe dissolving is another kind of physical change that doesn't involve making new compounds. Maybe dissolving just mixes the molecules of different compounds together.

Olivia: The powder has sugar molecules, and I suppose the coloring and flavoring also come in the form of molecules. Maybe all those molecules just get mixed in with the water molecules. And if the molecules don't change, there's no chemical reaction.

Zena: Hmm. Okay, maybe mixing the molecules of the water and the pink lemonade mix is like mixing white rock gravel and black rock gravel. You could mix white and black gravel in different **concentrations** and get mixtures that would be different shades of gray when you looked

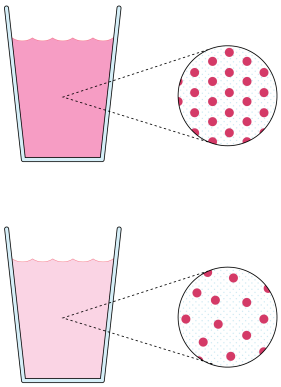
at them from a distance. But there wouldn't actually be any grey rocks; the white and black rocks would all be the same as before. Maybe our glasses of lemonade are like that.

Adam: Well, I'm not sure. But I've got a **solution**. Hey, Aunt Lucy?

Aunt Lucy: (*coming into the kitchen)* Hi guys. What's up?

Adam: We were wondering whether you get a chemical reaction when you stir pink lemonade powder into water. We figured if there was a chemical reaction, there would have to be a new compound, and we weren't sure whether pink lemonade is a compound, because it isn't made with consistent proportions of ingredients. Some pink lemonade is **diluted**, like the weak stuff Zena likes...

Concentration is a **rate**: there are more food coloring, sugar, and flavoring molecules ***per unit of volume*** in highly **concentrated** pink lemonade than in less **concentrated**, more **dilute** pink lemonade.



Zena: And some is more **concentrated**, like that sickeningly sweet stuff Adam drinks.

Aunt Lucy: Um, okay. Well, when we talk about **concentration**, we're usually talking about a chemical **solution**, not a compound.

Oliva: A **solution** like the answer to a problem?

Aunt Lucy: No, I'm using the word **solution** in a different sense, related to the word "dissolve." A **solution** is what you get when you put compounds together and instead of a chemical reaction you get a **homogeneous** mixture. In a **homogeneous** mixture, the particles are evenly mixed together, the way the water molecules, sugar molecules, flavor molecules, and coloring molecules are in the pink lemonade. Samples taken from different parts of a **homogeneous** mixture will be exactly the same.

Adam: So are all mixtures **homogeneous**?

Olivia: No, I don't think that would make sense. If we made a smoothie in a blender and you took a sip, you might get a lump of banana. In another sip, you might get more strawberry, or more orange juice, or whatever ingredients you mixed into your smoothie.

Aunt Lucy: Right. A smoothie would be an example of an uneven, lumpy, **heterogeneous** mixture. Samples taken from different parts of a **heterogeneous** mixture may have different substances.

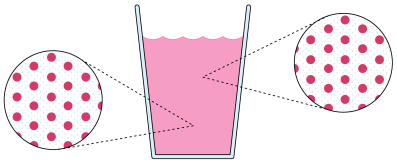
Zena: So when stuff dissolves and makes a **solution**, is that a kind of chemical reaction?

Aunt Lucy: No, dissolving is usually thought of as a physical change, not a chemical reaction. There are other physical changes, too, like when a substance changes from solid to liquid to gas—for example, water changing from ice to liquid water to steam. Those are called **phase** changes. A substance doesn't change its chemical composition just because it melts or evaporates. Water is still H_2O, whatever **phase** it's in.

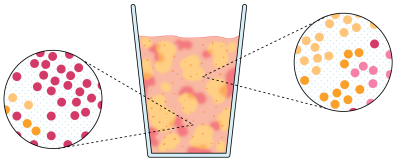
Olivia: And water is still H_2O even when it's got sugar molecules and other molecules from pink lemonade powder dissolved in it. It's still water, even though it's not pure water.

Aunt Lucy: Exactly. In fact, you can divide substances into pure and impure substances. Elements and compounds are pure substances. Another name for pure substances is "chemicals." Mixtures are impure substances, because they combine two or more pure substances. Within mixtures, you have **homogeneous** mixtures (also called **solutions**) and **heterogeneous** mixtures.

Homogeneous pink lemonade mixture (a **solution**)



Heterogeneous fruit smoothie mixture (not so smooth at a molecular level, so *not* a **solution**)



Zena: Wait, slow down. Let me grab some paper. Can you repeat that? We're supposed to make a poster about chemistry in Ms. Quintanilla's class for next Tuesday. If we use these categories, maybe we can make a kind of map for categorizing all kinds of matter.

Olivia: I think I'll do my poster on **concentration**. I can do the whole thing with pink lemonade!

Aunt Lucy: And I think I'll have a spoonful of this pink lemonade powder. I like it straight up, with no water!

Adam: Go Aunt Lucy! Now that's what I'm talkin' about!

Zena and Olivia: Eeeeeew!