

[MUSIC PLAYING]

**JESSICA:** Hi. I'm Jessica. And today, I'm going to be talking about a chemical demonstration I like to call "Mirror, Mirror."

In this demo, MIT'S Dr. John Dolhun will demonstrate Tollens' Test, a chemical test created by this man, Bernhard Tollens, a German chemist born in the late 1800s. So let's watch Dr. Dolhun perform this demonstration here at MIT as part of the Cambridge Science Festival.

**JOHN DOLHUN:** OK, so I'm going to be careful. And I'm going to pour my first substance into the flask.

My second substance, down to the last drop.

And my third substance.

And we're going to do a little shaking. We're mixing some things together.

**JESSICA:** So what did Dr. Dolhun do? Well, he added three solutions to the flask. Solution 1 was glucose in water. Solution 2 was a mixture of silver nitrate and ammonium nitrate. And Solution 3 was sodium hydroxide, which is a base. So let's focus on the second two solutions first.

When you mix solutions 2 and 3, two things happen. First, you form  $\text{Ag}_2\text{O}$ , which is insoluble in water. So it precipitates out as a brown solid.

The sodium hydroxide reacts with ammonium and  $\text{H}^+$  plus to produce ammonia,  $\text{NH}_3$ . This dissolves the precipitate. And you end up with  $\text{Ag}(\text{NH}_3)_2^+$ , which all has a positive charge. This is soluble in water, and it's called Tollens Reagent.

Now, the positive charge is borne by the silver. So what we have in solution is essentially silver ions. Now looking at Solution 1, glucose looks like this. We don't really care about this whole part of the molecule. So we're going to call it R for "the rest."

So glucose is basically this. And this part of the glucose is going to start reacting with the silver ions. Let's watch what happens.

**JOHN DOLHUN:** I don't see anything happening. Do you? OK, still working on it. I'm getting tired here. Something happening?

**AUDIENCE:** It's silver. It's

**JOHN DOLHUN:** Oh, my goodness, I can see myself.

Well, this is a real workout, I'll tell you. So what we've created here is a beautiful silver mirrored flask.

**JESSICA:** So look at that. Dr. Dolhun has created a beautiful silver mirror. It almost looks like a Christmas tree ornament. And a silver ornament could, in fact, be made this way.

So here's what's happening. Electrons from here, the glucose, get transferred to the silver, reducing it to silver zero. Silver zero is insoluble in water. It's just silver metal, and it's precipitating out on the inside of the flask, forming the beautiful silver mirror that we see.

Now, this process is called "reduction." And whenever something is reduced, something else is oxidized. So the glucose must be getting oxidized. It becomes this.

An oxygen was added here. Now, this process is similar to metabolism in our bodies. We remove electrons from the sugar we eat, and transfer them to the oxygen that we breathe.

In a reduction reaction like mirror, mirror, there might be energy released. In your body, this energy is harnessed in chemical bonds, stored for later. The point of Tollens' Test was not to produce silver mirrors, although a similar reaction is used for that today. The point was to distinguish between two types of sugars-- ones containing aldehyde and ones containing ketones. Let me draw those.

The difference is that in an aldehyde, the carbon is connected to a hydrogen. And in a ketone, the carbon is connected to another carbon. Aldehydes are more reactive than ketones, so they will react with the silver ions, while the ketones will not.

That's it for me. Hopefully, you enjoyed this video. And I will see you next time.

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