Matter
Lesson 6: Separating Pollutants

Grade: 5	**Length of lesson: 60 minutes**	**Placement of lesson: 6 of 7**
Anchoring Phenomenon: A healthy pond near a school has changed, and students see that there are a few dead fish in the pond.		
Unit Learning Goal: We can use our understanding of the particulate nature of matter and properties of matter to explain the world around us.		
Lesson Main Learning Goal: Some pollutant-water mixtures can be separated by evaporation where the water evaporates and the other matter is left behind. Matter is conserved during evaporation. Gas is matter that is made of particles too small to be seen. **Science and Engineering Practices** • Analyzing and Interpreting Data: Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. **Crosscutting Concept:** Scale, Proportion, and Quantity: Natural objects exist from the very small to the immensely large.		
Unit Central Question: How can we figure out what was mixed with pond water that could have changed the water?	**Lesson Focus Question:** Can we get the water to be safe again?	
Science content storyline: We can change the phase of water from liquid to gas and back to liquid. When water changes from liquid to gas, the salt or detergent stays behind, leaving pure water when it changes to liquid again. Gas is matter. Models can be used to show that matter, including gas, is made of particles too small to be seen. Matter is conserved through phase change.		
Ideal student response to the Lesson Focus Question: We know that filtering didn't take out either of these pollutants. When we boiled the polluted water, the water evaporated and the pollutants stayed behind. We learned this works by turning the water into a gas then back into a liquid. When it changes into gas, the same amount is still there, and gas is still matter.		

Preparation

MATERIALS NEEDED	AHEAD OF TIME
Teacher Resources: • Distillation video • PhET States of Matter simulation **Student Handout** • Lesson 6_HO1 *Distillation Apparatus Diagram* (1 per student) **Other Materials** • petri dishes with the evaporated pollutant-water mixtures • Distillation video • 1 container with polluted pond water to reference • hand lenses (1 per group)	• During or after Lesson 2, if you prepared petri dishes with mixtures so that the water could evaporate ahead of, this lesson, take out those petri dishes and labels. Note that students shouldn't touch them so that everyone can see the substances left behind and if those substances formed crystals (like the salt) those crystals will be fragile. • Review the information about the particulate nature of matter, particles of matter, and models in the *Content Background* document. • Prepare the handout. • Check the link to the PhET States of Matter simulation and set to liquid neon. https://phet.colorado.edu/sims/html/states-of-matter-basics/latest/states-of-matter-basics_en.html

Lesson 6 General Outline

Time	Phase of lesson	How the science content storyline develops
2 min	**Link to Previous Lesson:** Link to claims and evidence made in Lesson 5 to establish we have salt and detergent in pond water.	
5 min	**Focus Question:** Introduce today's focus question: **Can we get the water to be safe again?**	
5 min	**Setup for Activity 1:** Predict whether the water will conduct electricity before and after running through the distillation apparatus. Explain predictions based on thoughts about what will happen to the particles of water and salt in the distillation apparatus.	
15 min	**Activity 1:** Watch video of the distillation apparatus. Represent observations and ideas about what is happening at different points in the distillation demonstration using a model.	We can change the phase of water from liquid to gas and back to liquid. When water changes from liquid to gas, the pollutants stay behind, leaving pure water when it changes to liquid again.
5 min	**Follow-up to Activity 1:** Discuss how the particle model of matter can help us describe what happened to the pond water and the pollutants in the water. Look at evaporated petri dishes to make sense of what happened in the distillation.	
5 min	**Setup for Activity 2:** Discuss the word *gas* and current ideas about the term. Look at images about gas and share initial ideas about the images and what they mean.	Gas is matter.
10 min	**Activity 2:** Use the PhET simulation to show particles and phase change. Update models to reflect a particle model of gas.	Models can be used to show that matter, including gas, is made of particles too small to be seen.
5 min	**Follow-up to Activity 2:** Use the model of phase change to explain conservation of mass.	When liquid changes into gas, the same amount is still there, and gas is still matter.
3 min	**Summarize and Synthesize:** Summarizes the link among the science ideas explored today with the phenomenon.	
5 min	**Link to Next Lesson:** Link science ideas to the next lesson.	

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
2 min	**Link to Previous Lesson** <u>Synopsis</u>: Link to claims and evidence made in Lesson 5 to review that the unhealthy pond water is made of particles too small to be seen.	Link science ideas to other science ideas. (Slide 1-2)	Before we begin today's lesson, I want us to review an important idea we have developed in earlier lessons. We have discussed that the polluted pond water in this container is made up of particles that are too small to be seen. In our last lesson, we decided that our evidence supported both detergent and salt in our unhealthy pond water. **I'd like you to turn and talk with a partner and share about when you picture this pond water zoomed *way, way* in, what is the model you create in your mind to picture this pond water?** **Who heard an interesting idea from their partner that they'd be willing to share with us?**	The water is made up of tiny particles that are too small to be seen. The other stuff in the water, like salt and detergent, is also made of particles. The mixture of the two would look like different types of particles—water particles and salt particles and detergent particles—all mixed together.

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
5 min	**Focus Question** Synopsis: Introduce today's focus question: Can we get the water to be safe again?	Set the purpose with a focus question. (Slide 3)	***NOTE TO TEACHER:*** *Adjust the next section to reflect student ideas from the summary of ideas from the previous lessons about the particulate nature of matter and questions from the Driving Question Board. If the class didn't generate any questions around removing the pollutants from the water, introduce the day's focus question yourself as the next step the class will need to investigate to help us figure out what to do with the pond water.* Thanks for sharing your ideas. The key ideas I hear you saying are that • water is made of particles too small for us to see. • the pollutants, salt and detergent, are also made up of particles too small to be seen. • we might be picturing the particles of the pollutants differently from each other because they have different properties. For today's lesson, let's take a look at some of the ideas we have clustered together on our Driving Question Board. This cluster of questions is all about wondering how we can remove the pollutants that are in the water. We are going to focus on this clump of questions today. After our last lesson, we know that there are salt and detergent in the water. During this lesson we'll work together to figure	

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		(Slide 4)	out this focus question: **Can we get the water to be safe again?** Turn and talk with a partner to share ideas that you have about ways we may be able to make the water safe again. **Who heard an interesting idea from their partner that they'd be willing to share with us?**	We tried running the mixtures through filters in Lesson 2, but that didn't get out salt or detergent. **How did we know?** When we used the circuit, the water still made a buzzing sound. We could send the water to the water treatment plant in our city.
5 min	**Setup for Activity 1** <u>Synopsis</u>: After the teacher explains the distillation apparatus, students predict whether the water will conduct electricity before and after running through the distillation. Students	Engage students in analyzing and interpreting data and observations. Engage students in communicating	***NOTE TO TEACHER:*** *Depending on the student ideas surfaced, adjust this next section to cite student ideas wherever possible.* We've tried using a filter to separate salt and water and that didn't work. Today we'll try another method to see whether it removes the pollutants from the water. **Could we boil water in a pond to clean it if needed?**	Maybe—you'd just have to take it out of the pond first.

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	explain their predictions based on their thoughts about what will happen to the particles of water and salt in the distillation apparatus.	in scientific ways. (Slide 5) (Slide 6)	This situation of boiling the water could represent different processes that happen in nature. Maybe people could take water out of a pond and boil it to see if it would make the water safe again. **Does anyone have any ideas about what else could happen in a pond that would be similar to this process?** ***NOTE TO TEACHER:*** *When the idea of evaporation comes up here, don't go into too much detail and let the class know you'll revisit the process after the demonstration. You may want to probe to see what they understand or you may want to save that line of questions until later. Don't go into detail about the causes, but let the students engage with the big concept of evaporation as a liquid turning into a gas. Distribute HO6.1* Distillation Apparatus Diagram*.* Take a look at the picture on your handout. This is called a *distillation apparatus*. We have a video that shows what happens when we turn on the hot plate. Let's name a few different parts of this system. The water is in a flask. This part is called aquarium tubing. On the other side is a test tube sitting in a beaker. You don't need to remember those names, but you could use them to help you refer to different parts of the system. **What do you notice about this setup?**	Evaporation. **What do you mean when you say "evaporation"?** The liquid disappears. I notice that there's water in the flask.

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				I notice the test tube at the end is empty. I see the hot plate under the flask—I'm predicting that will make the water boil.
			In the flask, there is some salt water. Based on our work with properties, we know salt and detergent share several of the same properties—they both spread out evenly when they're mixed with water and they stay in the water when we filter the mixture. Since it isn't safe to boil detergent, we're just going to study salt water in this video, but because of the shared properties between salt and detergent, what we learn today about salt will also apply to detergent and whether we can separate water and detergent from each other. Let's think about what we know about the properties of salt water. **If we were to test the salt water in that flask for electrical conductivity, what do you think would happen?**	The buzzer would go off. It would conduct electricity. **What's your evidence to support that claim?** When we tested the salt water for its properties, it conducted electricity.
		(Slide 7)	In the video, they're going to turn the hot plate on and boil the salt water. Take a moment to think about what you predict will happen when the salt	The water will get bubbles in it.

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			water boils. **Would anyone like to share their predictions?** We have this prediction out there that water will go through the tubing and end up in the test tube. **Who agrees? Who disagrees?** We'll see what happens when we watch the video. From our investigations we know that salt water conducts electricity. **If it were to go through the tubing and end up in the test tube, do you think the water in the test tube will conduct electricity?** Let's see a thumbs up for yes, thumbs down for no, and you can put a thumb sideways if you're not sure. I'd love to hear from a couple of people on either side. **Why do you think so or not?**	The level of the water will go down. The water will get pushed through the tubing and end up in the test tube. I think the water will turn into gas. **What do you mean when you say "turn into gas"?** I think it will turn from liquid into a gas like air. I think it will because the salt water will just go through the tube. **Why do you think that?** The tube won't change the water. I think it won't conduct electricity because the salt is like dirt, and the dirt just stays in the pond.

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		(Slide 8) (Slide 10)	Take a look at your diagram. We'll watch what happens to the salt water in the video. Then I'll ask you to use this diagram to represent what happened during the demonstration. See the zoomed-in circles on here? When we're done watching the video, you'll show in each of those circles what you think was happening with the particles. As we watch, I invite you to share what you notice. I want you to think about how our understanding of this saltwater mixture as being made of different types of tiny particles too small to see may help explain what you notice. Let's try to use our CSW sentence stems. While we watch, try to use #1 ask why and how questions, #2 observe, #4 think of an idea that explains your data and observations, #6 listen to others' ideas and ask clarifying questions, and #7 agree or disagree with others' ideas or add onto someone else's ideas. **Any questions about your job for right now?**	
15 min	**Activity 1** <u>Synopsis</u>: Teacher shows the video of the distillation demonstration. Students draw to	Engage students in using and applying new science ideas in a variety of	***NOTE TO TEACHER:*** *Play the video and elicit student observations as it plays. Once the video is done, have students refer to their diagram of the distillation apparatus. Emphasize the zoomed-in circles and that students will now use them to show what they think was happening with the particles at each stage. You might note as they*	

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	represent their observations and ideas about what is happening at different points in the distillation demonstration. <u>Main science ideas</u>: We can change the phase of water from liquid to gas and back to liquid. When water changes from liquid to gas, the pollutants stay behind, leaving pure water when it changes to liquid again.	ways and contexts. (Slide 11)	*work who shows water and salt particles in the flask and only water particles in the test tube. Also look for the configuration of the particles where there is water vapor. Do students represent liquid and gas particles differently? If you note differences, you may want to ask those students to share their model or explain their thinking with the whole class.* Let's take a moment in small groups to look at how others represented what they thought was happening in the distillation apparatus. Go ahead and put all your papers together in front of your group, and at first, you'll take a couple minutes to just observe one another's ideas. Once I signal that it's time to start discussing, share similarities and differences that you notice among all the diagrams. Please note, this isn't a time to agree or disagree with each other, but you may want to ask clarifying questions to understand why someone represented their ideas in a particular way. **Who would be willing to describe or show us some of the similarities, differences, and questions that came up during your discussion?** ***NOTE TO TEACHER:*** *If you don't consistently see matter represented as particles, you may want to ask the class if anyone noticed a diagram that was effective in showing how the matter in the*	I drew my particles as H_2O, but the other people in my group just drew them as circles. We all showed both salt particles and water particles.

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			distillation apparatus was made of particles too small to be seen. You may want to show a clear example from the student work of this with a document camera if you have one or holding it up for the class if it feels like some students would benefit from seeing that concept represented. If you end up showing an example to the class, give students time to add particles to their diagram.	Some people showed the salt particles in all the parts, but some people only showed it in some parts of the diagram. **Where were the places some people had salt and others didn't?** Some people showed it just in the flask, but other people showed it mixed with the water all over.
5 min	**Follow-up to Activity 1** Synopsis: Discuss how the particle model of matter can help us describe what happened to the pond water and the pollutants in the water. The teacher shows the class the evaporated petri dishes as they make sense of what happened in the distillation.	Engage students in using and applying new science ideas in a variety of ways and contexts. (Slide 13)	In your model of the distillation apparatus, you all started to think about what happened to the salt. Thinking about the salt will help us answer our Lesson Focus Question: Can we get the water to be safe again? **Do we have any evidence to help us answer the question of whether there is salt in the test tube in the end?**	I know that there can be salt particles in the water even if you can't see them, so I put them everywhere because we know they were in the water in the beginning. Yeah, but the water at the end didn't conduct electricity, so that means there wasn't any salt in the water. **We've heard evidence to support two different ideas**

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			We have evidence that could support either claim: there is salt in the test tube or there is *not* salt in the test tube. **Which claim's evidence is stronger?** I have something else I'd like to show you as we think about this question. These petri dishes had samples of different water and pollutant mixtures in them. They've been sitting out for about a week now. Be careful to not touch them as you look at them because they're very delicate. **What do you see?**	**about the salt particles. What do others think?** That there is no salt in the test tube. **Why is that claim stronger?** Because we know plain water doesn't conduct electricity and salt water does. The water in the test tube didn't conduct electricity, so there can't be salt in there. But the salt is soluble, so we know we can't see it in the water. And since it's dissolved, it wouldn't make any sense for it to not travel with the water into the test tube. Yeah, but if there was salt in it, the water would conduct electricity, but it doesn't. Different crystals or powdery materials.

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			If these mixtures originally had water in them and now this is all that's left behind after a week, what do you think happened? **How do these petri dishes connect to what we observed in the Distillation video?** **What does that tell us about whether and how we can make polluted water safe again?** Now that we've figured out that we can separate the water from the pollutants, we're going to dig a little more into what happened with the water in this distillation setup.	The water disappeared, and the pollutants stayed behind. **When you say disappeared, what do you mean?** It evaporated or turned from a liquid to a gas. **What evidence do we have to support that?** We can see there isn't any water here, but this looks like salt crystals. The water left both the petri dishes and the flask, and the pollutants stayed behind. You can make water safe again by boiling it, but we don't know how you can boil water in a pond.
10 min	**Setup for Activity 2** <u>Synopsis</u>: Discuss the word *gas* and students' understanding of the term. Show some images that convey key ideas about gas and get		**Can anyone offer us some ideas about what happened to the water in this distillation system?**	It left the pollutant behind and became pure water again. It was a liquid, and when it boiled it turned into a gas then turned back into a liquid on the other side.

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	students' initial ideas about these images and what they mean. <u>Main science idea</u>: Gas is matter.	(Slide 14)	We've had the term *gas* come up a few times today. **When you hear the word *gas*, not like what we put in a car but in terms of what happened to the liquid water in the flask, what do you think of?** I'm going to show you some images that relate to gas. (*Display the slide with the images of the full and empty CO_2 canisters and the empty and full balloons.*) First, I want you to think about what each of these images shows us. Both of these pairs of images show us containers that have more and less gas in them. **What do you notice or wonder about these images? What can they tell us about gas?**	I think of air. **So, air is gas?** Yes, air is gas. **Can anyone offer another example of or different information about gas?** The balloons look different when they're blown up compared to when they're deflated. **What does that tell us about gas?** That it takes up space. One of the canisters weighs less. **So, what does that tell us about gas?** That gas weighs something. Because they took the gas out of the container, and now it weighs less. But you can't see or feel gas. I don't think gas weighs anything. It's not like solids or liquids – we can't pick them up.

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		(Slide 15?)	It sounds like we have lots of different ideas about what gasses are like. Let's take a moment to capture how we're thinking about gasses right now. If you use evidence from these images to support your model, let us know what evidence you're connecting from the image to your model. I want you to consider what you would see in these pairs of images if you were to zoom way, way in, just like we've been doing with our mixtures. With a partner in your notebook, draw a quick sketch of what you picture inside an empty balloon and inside a full balloon and what you picture inside these two carbon dioxide canisters. You have 5 minutes to capture your ideas in your notebook. We're going to look at a representation for how scientists picture gasses. I want you to think about whether you can make any links between what we've learned about our mixtures when we zoom way, way in and how a gas may look when we're zoomed in.	(Possible student discussion as they draw.) There is nothing inside the empty canister and empty balloon. The full canister and the full balloon should have matter represented in some way, such as dots or dashes.
10 min	**Activity 2** Synopsis: Use the PhET simulation to show		We started our lesson today by observing a process that separated pollutants from water. We noticed that the water changed—we said it seemed to turn into a gas then back into a liquid.	

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	particles and phase change. Update models to reflect a particle model of gas. <u>Main science idea</u>: Models can be used to show that matter, including gas, is made of particles too small to be seen.	(Slide 16)	Now that we've captured some of our ideas about gasses, we're going to look again at the PhET simulation that gives us an idea about how scientists picture gasses when you zoom way, way in. ***NOTE TO TEACHER:*** *Pull up the PhET States of Matter simulation and select neon in the liquid phase to start. Zoom in so students can't see the "neon" label.* We've looked at how we represent particles that are liquid. Remind us, **what do you notice about how these particles look in a liquid?** Next, just like we did today with the distillation apparatus, we'll apply some heat. (*Start to raise the temperature on the simulation until some particles break away from the mass and start to bounce around the container. If you can, pause it so some particles are at the bottom as a liquid and some are bouncing around.)* Raise your hand when you notice the movement of the particles changing and you'd like to describe what you're observing. I'm going to keep applying the heat until the movements of all the particles have changed. If we	They're moving and all kind of around the bottom of the container. Some of the particles are leaving the cluster at the bottom and flying off by themselves. They're flying all around the container.

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		(Slide 17)	look at this model of gas particles, how does this zoomed-in picture compare to what you all drew for the balloons and the carbon dioxide canisters? **How many of you showed empty space in your sketches? How many of you showed "stuff" but maybe not particles like we showed in our water and pollutant models? How many of you showed particles?** One really important idea that scientists know is that the gas all around us. While it may look and feel like empty space, it isn't actually empty. Gas is made of particles just like liquids and solids are. Since the particles are more spread out so we can't see gasses like we can see liquids and solids. There is more empty space between the particles in a gas. Turn and talk with a shoulder partner about what happened today to the water particles in the distillation apparatus. Be sure you use the words "liquid" and "gas" when you're talking about the particles.	Our model shows particles closer together than those are. We didn't show that they're moving in ours. We didn't show particles in ours—it was all empty space. We drew ours all in a grid and organized. Those are just zooming around like crazy.

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		(Slide 18)	***NOTE TO TEACHER:*** *Either ask students for these key ideas or summarize them yourself, but make sure someone says these ideas in the whole-class discussion before they return to their models.* These are some of the ideas I heard you all mention: • There are particles in a gas. It isn't just empty space. • The individual particles didn't change what they looked like, but they did change how they moved. The particles in a gas started moving faster and "broke away" from the particles in a liquid state as they evaporated. The particles in a gas state randomly zoomed all around the entire container. Now I'd like you to go back to your distillation apparatus diagram *and* the sketches you made of the balloons and carbon dioxide canisters with your partner. Take a minute and add to or change the ideas you originally showed. Be sure your sketches show that gas is made of particles too small to be seen.	The particles changed from liquid to gas. But the individual particles didn't change—they just moved differently. They spread out and bounced around more in the whole container.
5 min	**Follow-up to Activity 2** <u>Synopsis</u>: Use model of phase change to explain conservation of mass.	(Slide 19)	One idea that's important to keep in mind is that water in nature doesn't usually boil. (*Note if someone brought up this term* earlier.) **Does anyone know the name of a process that happens in nature where liquid turns into a gas, like we saw today?**	Evaporation.

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	<u>Main science idea</u>: When liquid changes into gas, the same amount is still there and gas is still matter.		Exactly. If we saw a puddle in nature one day and it was gone the next day, we would know the water evaporated. That means the liquid turned into a gas. **Did the water vanish or disappear?** ***NOTE TO TEACHER:*** *The goal here is to follow up the activity by helping students make a connection between the ideas they talked about today and what happens in nature.* Now I have a hard question I want you to consider. Remember in Lesson 3 when we talked about conservation of mass? **Can anyone think about how the science idea of conservation of mass—where the same amount of matter exists even when it changes or seems to vanish—may apply when we think about evaporation?** Good! We know from our understanding of conservation of mass that even when it evaporates or boils, the same number of water particles exist—they are just in a different phase. We can't see the gas water after it evaporates, but let's say there were 100 liquid water particles. **After all that water evaporates, how many gas water particles would we have?**	No, it just changed from a liquid to a gas. I mean, it did vanish because you can't see it anymore, but it's still there, just as a gas. Even when water evaporates, there's still the same amount of water even though we can't see it. One hundred.
3 min	**Summarize and Synthesize** <u>Synopsis</u>: Summarizes the link among the	Summarize key science ideas. (Slide 20)	We started the class by considering whether we can make pond water safe again. A big science idea that we want to remember is that when a pond gets polluted, we can filter out some of the pollutants, like dirt. Others, like oil, fertilizer,	

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<tr><td></td><td>science ideas explored today with the phenomenon.</td><td></td><td>detergent, and salt, we can’t filter out. They’re hard to get out once they’re in there! We can separate the pollutants from the water by turning the water into a gas—it’s just that then the water leaves the pond and leaves behind all the pollutants. Does anyone have questions about that?

Now that we know what it takes to remove the pollutants from the water, is boiling the water in a pond an easy or practical way to clean the pond water?</td><td>No.
How would you boil a pond?
That might hurt the fish that live there.</td></tr>
<tr><td>5 min</td><td>Link to Next Lesson

<u>Synopsis</u>: Teacher links science ideas to the next lesson.</td><td>Link science ideas to other science ideas (next lesson).

(Slide 21)</td><td>PROGRESS TRACKER
Let’s see if we can summarize what we have figured out so far. In your notebook, continue your Progress Tracker. Let’s fill in today’s focus question and what we figured out about it.

<table><tr><td>Question</td><td>What I figured out</td></tr><tr><td>Can we get the water to be safe again?</td><td>We know that filtering didn’t take out either of these pollutants. When we boiled the polluted water, the water evaporated, and the pollutants stayed behind. We learned this works by turning the water into a gas</td></tr></table></td><td></td></tr>
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<tr><td></td><td></td><td>(Slide 22)</td><td><table><tr><td></td><td>then back into a liquid. When it changes into gas, the same amount is still there, and gas is still matter.</td></tr></table>
As we wrap up our time today, let’s take a look at our Driving Question Board. Are there any questions that we answered today that we can add a check to? Are there any new questions that we thought of today? Let’s add those to the board.

NOTE TO TEACHER: Link ideas from the Driving Question Board to the next lesson, if possible. If not, link to the next lesson by forecasting its goal.

For our final lesson, now that we know pollutants can be difficult to remove from water, it seems like we should think about how to prevent the pollutants from getting into the pond. Next time, we’ll think about how the pollutants got into the pond in the first place.</td><td></td></tr>
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