Lesson Plan

Why is ice so slippery?

For PhET Simulation: States of Matter: Basics

Overview

Working toward: MS-PS1-4
Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

Suggested pacing:
Up to two 50-minute instructional periods

Throughout The Lesson:

- **Sensemaking Prompts:** Questions that drive student thinking, explanation and making sense of the phenomenon.
- **Look Fors:** Observable indicators of student thinking and progress.

Materials

- **Student Supports:** Why is ice so slippery?
  - Includes standards guidance, key vocabulary and equitable participation supports
- **Article and article images:** Scientists finally know why icy surfaces are so slippery
- **PhET simulation on Newsela:** States of Matter: Basics
- **Worksheet:** Make a Model
- **Worksheet:** 3-Column Chart
- **Worksheet:** Claim, Evidence, Reasoning (CER)
- Chart paper/ board space
  - For collecting student ideas
- Colored pencils or markers
  - For model revision
- Science notebooks
- Sticky notes
  - For recording student ideas and questions
- Student devices (laptops/tablets)

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PhET INTERACTIVE SIMULATIONS University of Colorado Boulder

DEVELOPED IN PARTNERSHIP WITH nsta National Science Teaching Association

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Phenomenon Background For Teachers

Ice is known for being slippery, but the reason isn't obvious from looking at it. Ice is made of water molecules (H2O). In solid ice, these molecules are arranged in a fixed pattern and vibrate in place. At the surface of the ice, however, the molecules are not held as tightly because they have fewer neighboring molecules. This allows the surface molecules to move more freely than those deeper in the ice, forming a thin, liquid-like layer at the surface. This difference in molecular arrangement and motion at the surface reduces friction between the ice and other surfaces, making the ice feel slippery. In this lesson, students explore how the arrangement and motion of water molecules at the surface differ from those deeper in the ice, and how this difference explains why ice is slippery.

Phenomenon Image



From the article: Scientists finally know why icy surfaces are so slippery

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1 Display or hand out copies of the header image from the Newsela article, [Scientists finally know why icy surfaces are so slippery](). Ask students to examine the image. **Ask:**

- "What do you notice?"
- "What do you wonder?"
- "Have you ever had an experience like this?"
- "Why might ice feel different from other solid surfaces?"

2 Have students discuss their ideas with a partner for 2 minutes. As students talk, ask:

- "What is happening with the water molecules that make up the ice?"

Have each pair record their initial thoughts and questions on sticky notes. Collect them, read them aloud and then attach them to the class chart.

Sensemaking Prompts

- "Can you say more about what you notice?"
- "What are your questions about how this works?"
- "What might be happening that we cannot see?"
- "What ideas do we have so far about what might be causing this?"

Look Fors

- Students generate questions about the phenomenon.
- Students begin considering unobservable (particle-level) ideas.
- Multiple student ideas surface and are valued.
- Students distinguish between what they observe and what they are trying to explain.

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Initial Model And Development Of Investigation Question (10 min)

1 Hand out the Make a Model worksheet. Give students 5 minutes to create an initial model showing how they think water molecules are arranged and how they move in slippery ice.

2 Then, guide students to select or refine a class question based on their ideas (e.g., “Why is ice so slippery?”). Students will create a CER to answer this question in the lesson.

Sensemaking Prompts

- “What part of your model shows a relationship between two things?”
- “Where in your model did you use a question mark?”
- “Which question should we investigate together?”
- “What does your model show about how molecules are arranged or moving?”
- “At this point, can you make any predictions about what might cause people to slip on ice?”

Look Fors

- Models use drawings or symbols to show unobservable components (e.g., water molecules).
- Students compare how particles behave in solids versus liquids.
- Students attempt to show relationships between particle arrangement and motion (e.g., spacing, movement, or patterns).
- Question marks denote parts of the model the student is unsure about.
- Students include ideas they are unsure about and identify questions for further investigation.
- Models serve as a record of initial thinking, not a final, polished drawing.
- Multiple student ideas surface and are valued.

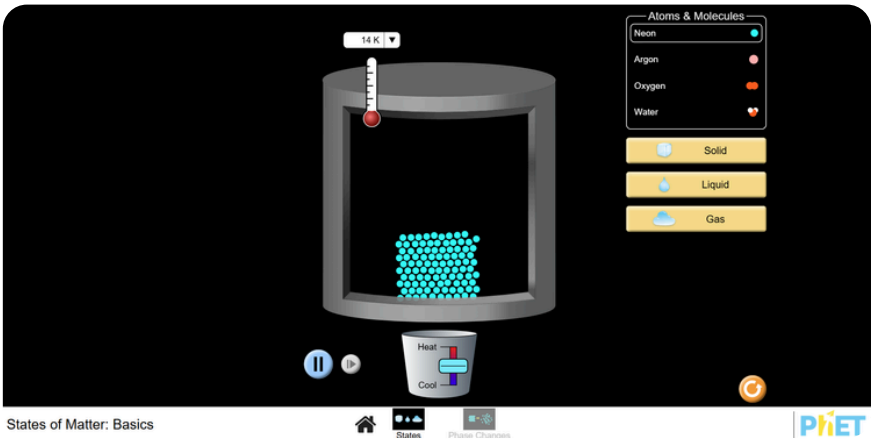
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Investigate: Modeling Molecular Behavior (20 min)

1 In partners or small groups, have students open the PhET simulation States of Matter: Basics.

Say:

- "Navigate to the 'States' section by clicking the box."



2 Have students select "Solid," "Liquid," and "Gas" using the buttons on the right side of the screen.

Ask:

- "What do the dots on the screen represent?"
- "How does the arrangement of dots (molecules) change when switching between states of matter?"

3 Have students switch from "Neon" to "Water" using the "Atoms & Molecules" list on the right side of the screen.

Ask:

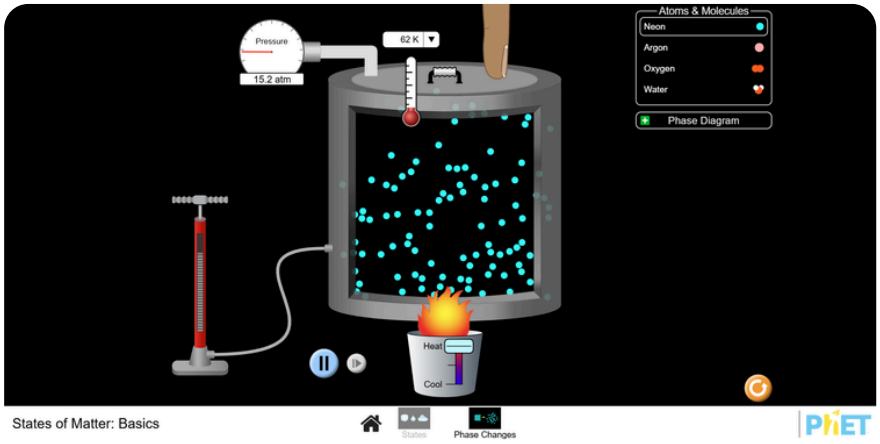
- "How does the arrangement of molecules in each state differ for water compared to neon?"
- "How are molecule arrangements for water in each state similar to what you saw for neon?"

4 Ask students to create a 3-Column Chart in their notebooks and record how molecules behave in solids, liquids and gases.

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5 Have students navigate to the “Phase Changes” section by clicking the box.

Have students pause to share their ideas with the class on how the simulation could help them understand how molecules are arranged and move in solids and liquids. Record responses on the class chart.



6 Ensure students are on the “Phase Changes” tab. Have them click “Water” in the right panel.

Prompt students to share what they notice with their partners or small groups:

- “What do you predict will happen to the arrangement of molecules if they begin to move more?”

7 Have students adjust the slider to make the system warmer or cooler. Guide them to describe what they notice about how particle motion and arrangement change. **Ask:**

- “When you move the slider to make the system warmer or cooler, what do you notice about how the particles move and how close they stay to each other?”
- “What do you notice about how close the particles stay to each other?”
- “How does the arrangement of the molecules change as their motion changes?”
- “When the system becomes warmer or cooler, what do you notice about the distance between the water molecules and how their pattern changes?”
- “What patterns do you observe in how molecules are arranged and move in solids compared to liquids?”
- “What patterns do you observe in particle motion and spacing?”

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8 Transition to a whole-class discussion and ask:

- “What patterns do you notice in how molecules are arranged and move?”
- “How does the simulation help you understand how particles behave in solids compared to liquids?”
- “What does the simulation NOT show about how molecules behave at the surface of ice?”
- “What questions do you still have about how ice behaves at the surface?”

9 Revisit the class chart, rereading the ideas students raised at the beginning of the lesson. Have students record new student observations and questions on sticky notes, then affix them to the class chart.

Optionally, you can remove sticky notes that students feel have been addressed.

Look Fors

- Students begin to describe differences in particle motion, spacing, and arrangement.
- Students identify patterns in solids vs. liquids.
- Students recognize that motion is related to changes in arrangement.
- Students identify limitations of the simulation.

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Revise Initial Model (15 min)

1 On the Make a Model worksheet, under Revise Model, have students model how water molecules are arranged and move in ice. Avoid the "Final Model" section, as they will complete it later. Encourage students to use their model to show what they think is happening.

Guide students to include:

- Water molecules (H_2O), using circles, symbols, or labels.
- Arrangement of molecules and how they are organized (e.g., close together, in a pattern, spaced out).
- Arrows or other symbols to show how molecules move.
- Where the surface is and how it might be similar to or different from the inside.
- An indication of how particle arrangement and motion are connected (e.g., spacing vs. movement).
- Words or short phrases to explain what the model shows.
- Question marks or notes showing uncertain ideas.

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2 Place students into groups and ask:

- “How are the water molecules represented in your model?"
- “What do you think is happening at the particle level in ice?”
- “How might the surface be similar to or different from the inside?”
- “What questions do you still have about how the surface might behave?”

Then have students share and compare models. **Ask:**

- “Identify one way your partner represented molecular motion differently than you. How could you combine your two ideas to make a clearer model of how molecules are arranged and move, especially at the surface?”

Sensemaking Prompts

- “How does your model show how molecules are arranged and move, especially at the surface?”
- “How does the arrangement of water molecules in your model relate to their motion?”
- “How could that relationship help predict what is happening at the surface of the ice to cause the phenomenon of slipperiness?”

Look Fors

- Models show the relationship between particle arrangement and motion, linking them to a possible prediction for the phenomenon (slipperiness).
- Models use visual cues (such as arrows or spacing) to represent the relationship between how fast a particle moves and how much space it occupies.
- Students propose possible differences between surface and bulk.
- Students include uncertainty in their models.
- Students revise ideas based on peer feedback.

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Read To Refine Thinking (20 min)

Day 2

1 Take about 5 minutes to review key ideas about how molecules are arranged and move in solids and at the surface of ice.

2 Have students open the Newsela article, Scientists finally know why icy surfaces are so slippery, or hand out the leveled PDFs.

3 Have students individually read the article and highlight key information. Ask them to pay specific attention to the section, "When Ice Gets 'Frustrated'" (how molecules behave at the surface of ice).

Ask the whole group:

- "What new information does the article provide about how molecules behave at the surface of ice?"
- "How does molecular structure at the surface differ from the structure deeper within the ice?"
- "What evidence from the article supports that the surface behaves differently?"
- "How does this new information help explain why ice is slippery?"
- "How does this connect to your model?"

Sensemaking Prompts

- "What specific evidence from the article supports that idea?"
- "How is this different from what the simulation showed?"
- "What does this suggest about friction at the surface compared to other solid surfaces?"
- "How does this compare to your original thinking?"

Look Fors

- Students describe that surface molecules move more freely.
- Students use article evidence to support ideas.
- Students begin connecting structure to function (slipperiness).
- Students notice that the simulation does not account for the difference in molecular motion noted in the article.

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Review, Revise Model And Compare Evidence (10 min)

1 Have students return to their Make a Model worksheet and draw another revised model in the Final Model box. Explicitly outline the expected revisions. Share these criteria for the Final Model:

- Show the distinction between the bulk ice (fixed, vibrating molecules) and the surface layer (more freely moving, liquid-like molecules), and
- Show the relationship between this difference in molecular arrangement and motion and how it explains slipperiness.

Students should ensure their final model clearly meets these expectations using evidence from the simulation and article.

2 Students then write a reflection, citing:

- Evidence from the simulation.
- Evidence from the article.
- What they changed in their model and why.

Sensemaking Prompts

- "Does your model show any differences between the surface and the inside of the ice?"
- "How could those differences help explain why ice is slippery?"
- "How does your model connect what is happening at the particle level to what we observe?"
- "Which part of your model is based on evidence from the article, and which part is based on the simulation?"

Look Fors

- "Models show clear revisions based on new evidence.
- Students represent differences between surface and bulk molecules.
- Students cite specific evidence.
- Students explain how molecular structure and motion relate to slipperiness.

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Evaluate: Explain The Phenomenon (15 min)

1 Hand out the Claim, Evidence, Reasoning (CER) worksheet.

Ask:
- "Why is ice so slippery?"

Students should:
- Use evidence from both the simulation and the article to explain how the arrangement and motion of water molecules at the surface differ from those deeper in the ice and how this explains why ice is slippery, even when it is very cold.

Claim

A one-sentence explanation of why ice is slippery even when it is very cold.

- Look for something like, "Ice is slippery because the difference in molecular arrangement between the bulk ice and the surface creates a liquid-like layer on the top of the ice."

Evidence

One piece of evidence from the PhET simulation and one from the Newsela article. Students may also include what their model shows.

- "The simulation showed that molecules in solids... and in liquids..."
- "The article explains that molecules at the surface..."
- "The model shows that..."

Reasoning

Support for how those pieces of evidence explain that ice has a thin, liquid-like layer of molecules at its molecular level, this happens because ..."

- "The structure and motion of the molecules result in... which explains..."
- "Differences in how molecules move and are arranged at the surface result in...which explains..."

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Share And Revise

After students have completed the CER, have them share their draft with a partner and provide peer feedback. Provide sentence stems:

- "I like how you said _____"
- "Maybe you could make this more clear by _____"
- "I like how you used _____ as evidence. Maybe you could include _____ as well."

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2 Allow students to edit their own responses based on partner feedback.

Sensemaking Prompts

- "What specific detail from the article explains the ice surface?"
- "How does that evidence explain what's happening at the molecular level?"
- "How is the surface of the ice different from the inside of the ice?"
- "Which part of your evidence comes from the article, and which comes from the simulation?"

Look Fors

- Students create a claim statement explaining that ice has a thin, liquid-like layer of molecules at its surface, which makes it slippery.
- Claims describe how molecular arrangement and motion at the surface differ from the bulk ice.
- Students may mention that the simulation shows that in liquids, molecules move more freely and are less rigidly arranged than in solids.
- Students' explanations should clearly connect structure (how molecules are arranged and move at the surface) to function (why ice is slippery).

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Final Reflection (5 min)

1 Ask students to reflect on how their thinking changed and identify evidence that helped them explain the phenomenon. Provide sentence stems to help students reflect:

- "At first, I thought..., but now I think..."
- "My thinking changed when..."
- "One idea that helped me understand was..."
- "My model changed because..."
- "My understanding of the surface of ice changed when..."

Sensemaking Prompts

- "What changed your thinking about why ice is slippery?"
- "What evidence helped you understand how molecules behave at the surface of ice?"
- "How does what you learned about molecular structure help explain why ice is slippery?"
- "How did a conversation with a classmate help you refine your explanation of the ice's structure?"

Look Fors

- Students describe how their thinking changed.
- Students reference specific evidence from the article, simulation, or their model.
- Students explain how their model was revised based on new evidence.
- Students connect molecular structure and motion at the surface to the function of slipperiness.
- Students recognize that scientific ideas are refined as new evidence is gathered.

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