ICE IS WATER, WATER IS ICE: MELTING AND FREEZING

LESSON DIRECTORY

PHOTO GALLERY

This lesson invites young students to inquire about phase changes, about what happens as water changes into ice and as ice changes into water, observing ice melting and freezing under a variety of conditions.

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SCIENCE & LITERATURE

Einstein recounts how thinking about ice led to the atomic theory

The totality of all sensory experience can be "comprehended" on the basis of a conceptual system built on premises of great simplicity…. The rise of atomism is a good example. How may Leucippus have conceived this bold idea?

When water freezes and becomes ice—apparently something entirely different from water—why is it that the thawing of ice forms something which seems indistinguishable from the original water? Leucippus is puzzled and looks for an "explanation." He is driven to the conclusion that in these transitions the "essence" of the thing has not changed at all. Maybe the thing consists of immutable particles and the change is only a change in their spatial arrangement. Could it not be that the same is true of all material objects which emerge again and again with nearly identical qualities?

This example is meant to illustrate two things. The theoretical idea (atomism in this case) does not arise apart from and independent of experience; nor can it be derived from experience by a purely logical procedure. It is produced by a creative act. Once a theoretical idea has been acquired, one does well to hold fast to it until it leads to an untenable conclusion.

— Albert Einstein, *On the Generalized Theory of Gravitation.* (Scientific American, Vol.182, No. 4, April 1950)

Albert Einstein, the great 20th Century physicist, reflects on the history of science, going back to Leucippus in the 5th Century B.C. in ancient Greece. From common everyday experience, we take for granted that when ice melts, it becomes water; when water freezes, it becomes ice. But what explains how the same substance can take such different forms? Wondering about ice leads us to thinking about what everything is really made of.

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CONCEPT OVERVIEW

This lesson invites young students to inquire about phase changes, about what happens as water changes into ice and as ice changes into water, observing ice melting and freezing under a variety of conditions.

Concepts:

- Phase Change
- Atomic theory

This lesson provides a concrete experience of:

- Ice melting.
- Water freezing.
- Evidence that liquid water and solid ice are different phases of the same substance.

PRE K–GRADE 2 CONCEPTS

- When solid ice is warmed to its *melting point*, it melts into water.
- When liquid water is cooled below a temperature known as the *freezing point of water* the liquid water becomes solid ice.
- As water changes into ice, or ice changes into water, its properties also change. For example, as water freezes, its takes up more space.
- Water can be a liquid or a solid and can go back and forth from one form to the other. For example, if water is turned into ice and then the ice is allowed to melt, the amount of water is the same as it was before freezing.

GRADE 3–5 CONCEPTS

- When ice is warmed to its *melting point*, it melts into water.
- When liquid water is cooled below a temperature known as the *freezing point of water* the liquid water becomes solid ice.
- The melting-point and freezing point of a substance are essentially the same. The term used depends on whether the substance is being heated or cooled.
- A thermometer can be used to measure how cold water needs to be as it freezes. But not all thermometers measure the same range of temperature.
- As water changes into ice, or ice changes into water, its properties also change. For example, as water freezes in an ice cube tray, it forms layers at the outside, like a shell, and the inside freezes last. The melting and freezing occurs at the surface layer.
- The amount of space taken up by water increases when it is frozen into ice—its expansion can even break the container it is in.
- When ice melts, the resulting water occupies less volume than the solid ice.
- The mass, size, and volume of ice can be measured.

LESSON SUMMARY & OBJECTIVES

Within the range of temperatures and pressures on Earth, water exists naturally as a gas, as a liquid, and as a solid (Melting Point/Freezing point: 0° Celsius or 32° Fahrenheit at 1 atmosphere, the air pressure at sea level; Boiling point: 100° Celsius or 212° Fahrenheit at 1 atmosphere).

Objective 1: Notice that water and ice are the same substance.
While we might take it for granted, the realization that liquid water and solid ice are essentially the same substance is intellectually profound and leads us toward precursor understanding of an atomic theory, the idea that all matter is made up of tiny indivisible particles (atomos—means indivisible) (i.e., how do we explain the essential sameness of the different phases of water?).

Objective 2: Notice that the liquid that results from ice melting is water.
We observe the phase change from solid ice to a liquid—and realize that the liquid is water. Ice is water in a different form. This provides precursor understanding of phase changes explained in terms of kinetic theory, the motion of particles that make up materials (i.e., how do we explain how materials change phase?).

STANDARDS

PROJECT 2061 BENCHMARKS:

4D The Physical Setting Structure of Material
GRADES K–2, PAGE 76

- Things can be done to materials to change some of their properties, but not all materials respond the same way to what is done to them.

GRADE 3–5 PAGE 77

- Heating and cooling cause changes in the properties of materials. Many kinds of changes occur faster under hotter conditions.

NSES:

Content Standard B Physical Science: Properties of objects and materials
GRADES K–4, PAGE 127

- Material can exist in different states—solid, liquid, and gas. Some common materials, such as water, can be changed from on state to another by heating or cooling.

ESSENTIAL QUESTION

How do we explain the essential sameness of a substance when it takes different forms as it goes through phase changes?

How can we explain that when solid ice melts, it becomes liquid water and that when liquid water freezes, it becomes solid ice? What is the importance of understanding that ice melts and water freezes? What makes water ice melt? What makes liquid water freeze?

ACTIVITY QUESTION

What patterns do we notice as we observe details of melting and freezing?

What can we learn about water ice by watching it melt and freeze in a variety of ways? What observations about melting and freezing can we record? What can we say, draw, or write about ice melting and water freezing that we can look at, touch, and examine in class?

BACKGROUND

More than Just Water Ice

Even as we examine water ice in these activities, a planetary scientist would not want us to harbor a misconception that water ice is the only kind of ice we are interested in as we explore ice in the Solar System. In the context of space science, a variety of substances can form ices. Some substances that exist primarily as gases on Earth can exist as liquids and solids on other solar system worlds, depending on conditions of temperature and pressure.

We need to identify the kind of ice we mean. Different kinds of ices exist in different conditions. On Earth, the term "ice" generally refers to water ice (H_2O). "Dry ice" refers to frozen carbon dioxide (CO_2): dry in the sense that it sublimates directly from a solid to a gas, without going through a liquid or "wet" phase. There are other kinds of ices that exist in laboratory conditions on Earth and naturally in other places in the Solar System. On Mars, both water ice and dry ice occur naturally, because of the temperature and pressure conditions there. Similarly, cold outer planetary worlds like Pluto have water, carbon dioxide, methane, and ammonia ices.

Most of the time, when we mean *water ice*, we can just use the word *ice*.

Noticing Patterns: Reading A Phase Change Diagram

When we think like scientists, we look for patterns that help us understand the phenomenon. By watching closely as ice melts and water freezes, we can notice fundamental patterns of nature that apply to matter in general.

Scientists have examined melting and freezing under many different conditions and have put together all their observations and have come up with a way of showing the general principles of melting and freezing.

They illustrate the process in what's called a "phase change diagram." You can read it like a map of what happens to water (or anything else) at different temperatures and different pressures.

We haven't talked much about pressure, except to point out that sea level is usually what we call 1 (one) atmosphere. Melting, freezing, and boiling points shift at different pressures.

The effect of different pressures becomes noticeable, even on Earth. You might notice this when you read recipes that call for boiling an ingredient. The recipe will tell you to boil it several minutes longer at higher altitudes. If you live high in the mountains, for example, and you wanted to make a hard-boiled egg, you would need to boil the egg *longer* than you would boil it at sea level. Why?

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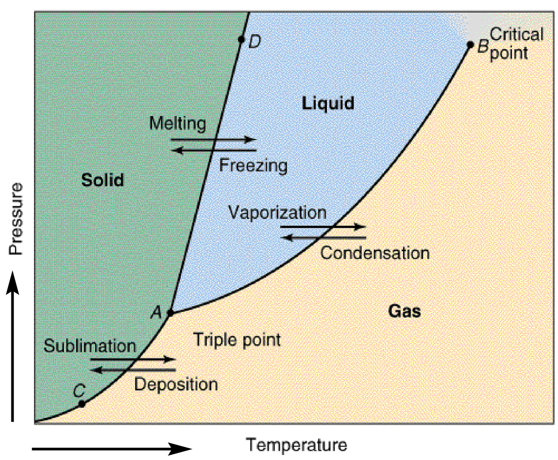
At sea level the boiling temperature is 212° F or 100°C. At higher altitudes, there is less air pressure. Water will boil at a lower temperature, depending on the elevation. As a general rule, the temperature decreases by 1 (one) degree for every 540 feet of altitude (0.56 degrees C for every 165 meters). So the egg may be boiling, but the water is cooler than at sea level, so it takes longer to cook it as much.

How to Read a General Phase Change Diagram

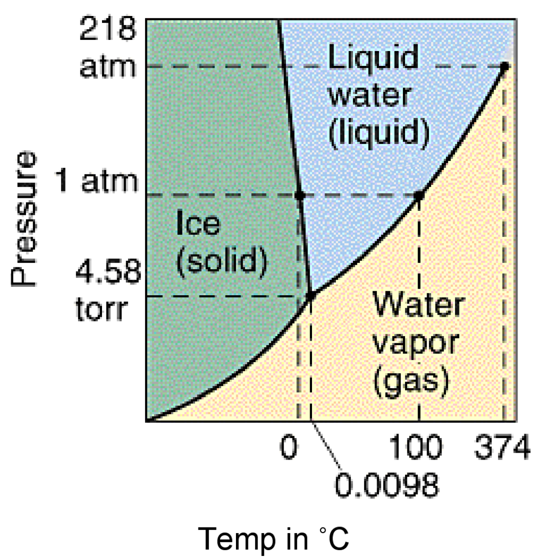


All matter can change phases. Above is a general phase change diagram that describes how ALL matter changes. We are most familiar with solid, liquid, and gas phases.* We have been exploring the phase change between solid and liquid, melting and freezing.

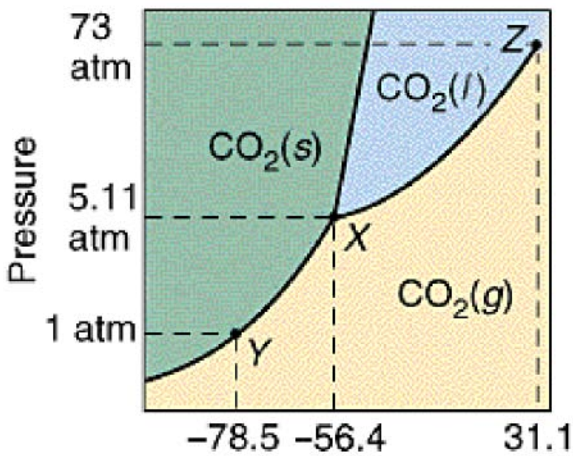
The phase change between liquid and gas is called vaporization and condensation. The triple point is a temperature-pressure point where the change could go either way, solid, liquid, or gas. Sometimes, a substance changes directly from a solid to a gas (like dry ice) without melting first. This is called sublimation and a vapor becoming solid is called deposition.

*Matter changes to a *plasma* phase past the Critical Point (B) as temperatures and pressures become extreme, like in a star. At the other extreme, as matter approaches absolute zero (well below point C) matter changes to a phase called the *Bose-Einstein condensate*.

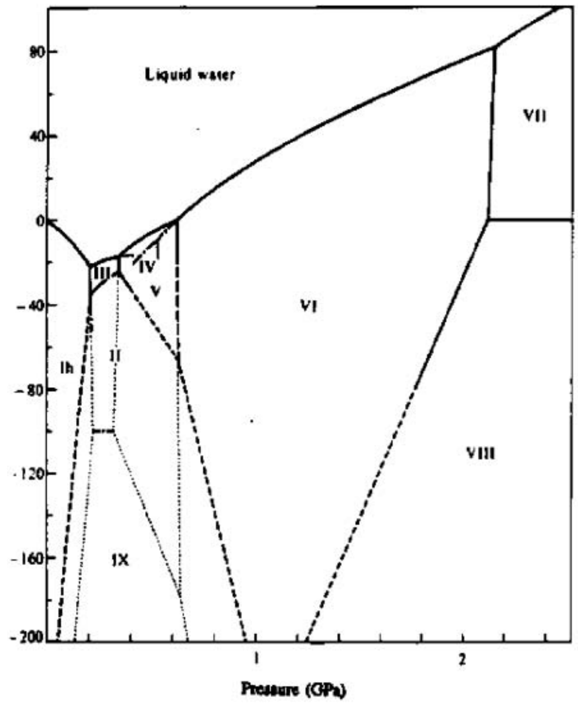
Phase Change Diagram for Water



Phase Change Diagram for Carbon Dioxide (Dry Ice)



Advanced Phase Change Diagram for Ice



This is a more detailed phase change diagram for water, used by scientists interested in the physics of ice. Each Roman numeral (I through IX) labels a completely different KIND of water ice—nine different ways ice can form at different combinations of pressure (along the bottom) and temperature (in °C along the left side). On Earth, only one kind of ice exists in nature. The ice we know is Ice Ih (hexagonal ice).

(Courtesy of Hermann Engelhardt, discoverer of Ice IV)

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ACT OUT THE SCIENCE

The Story of: The Ice that Melted
Mime and Narration Activity: Movement Integration Mediating Experience
Participatory warm-up:

Everyone, stand up. Shake out your hands. Imagine that you are a water molecule. Your hands and shoulders are the places where you can connect with other water molecules around you. But we're going to connect without actually touching.

Get a partner. Face your partner. Place your hands stretched out in front of you, almost, but not quite touching your partner's hands. Imagine that a field around your hands attracts your partner's hands and hold it close by—and we'll call that, forming a bond.

So we're going practice some different ways of showing how we can use this field to form bonds. Let one partner use the field to "attract" the other partner's hands in slow motion.

Good. Now imagine that your shoulders also attract the hands around you. Roll through you shoulders, create a field and draw your partner's hands toward your shoulders. Any combination of bonding between hands and shoulders is okay.

Remember that you are only ALMOST, but not quite really, touching. Use the field to form bonds. Slowing, oh so slowly, let's connect everybody to each other, hand to hand, hand to shoulder, shoulder to shoulder.

Water is present when bonds connect very loosely. You can show this by letting your arms be more relaxed. Ice forms when the bonds form more rigidly and in a geometric arrangement (a hexagonal tetrahedron). You can show this by stretching your arms out, as if you were ready to give a bear hug.

Ice takes up more space than water. OK, *freeze*. In fact, now, you ***are* frozen; you are a block of ice.** Now, we're going to act out the story of *The Ice that Melted*.

The following table annotates the narrative storyline in terms of suggested ways to have children act it out using mime movement and connected to the intended conceptual understandings.

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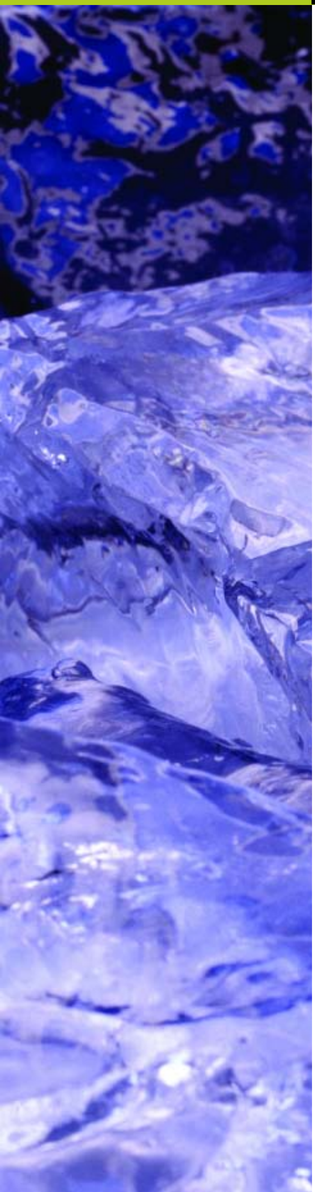
Narrative	Movement	Concept
One winter in a faraway place in the Solar System, there was a huge block of ice. It shivered with delight. It loved its ccccoldness.	Start from where the warm-up has led everyone bonded more or less in the hexagonal structure of ice.	A block of ice has a geometric structure, reflecting its molecular structure, held together by hydrogen bonds.
The inside of the block of ice was c-c-cozy with its wonderful c-c-coldness.	—the children, frozen, are likely to show some slow motion, as long as they keep the idea of the bonds intact and the motion is slow, the image communicates the concept intended.	There is a difference between the inside and the surface of ice. Even frozen ice moves randomly. Only when the temperature gets very cold, below 80 K, does it really become close to "stillness." The outer surface is a quasi-liquid or at the melting point, liquid water is present.Water molecules form bonds that loosely connect, break and reconnect when it is liquid and more rigidly connect when it is ice.
The outer surface of the block of ice had a slipperiness, but still, it stayed happily frozen.		
Even when the sun shined through the winter air, it was below freezing and the block of ice laughed because the sunlight tickled as it shined through the perfectly clear block of ice.	The outer surface may have some broken bonds, and show a little more movement.	
Then one day, something strange began to happen. The season began to shift from winter to spring, and a warmth blew in. A blanket of warm air began to surround the block of ice.	Let the teller of the story be the Sun and the Warmth, using broad expressive gestures.	
At first, nothing much happened—but then, at the slippery surface, it became slipperier and slidier—it was as if the warm air were calling out—come play with me!		

Narrative	Movement	Concept
Little by little, some of the slippery, slidy surface, slid slowly down into a splish-splash puddle of meltwater. The inside was still enjoying its cold frozenness, but with each newly revealed surface slipped and slid. Eventually, the block of ice even began to float in the growing puddle.	Each time we mention the Warmth—a special movement that involves everyone might be invoked. Little by little, children at the surface respond to the active imagery of melting.	Melting occurs at the surface areas.
But then, night came and the warmth slinked away. As the coldness returned even the splish-splash puddle refroze, forming new bonds that clicked into place. All night long, the block of ice and the frozen puddle played.	It's okay to stop the action, if necessary, to guide children in how to show and conceptualize the sequence: surface melting, puddle forming, the block of ice, as a whole, floating a bit.	Phase changes can go back and forth many times, ice into water, water into ice.
In the morning, an even a bigger warmth arrived. The frozen puddle melted again. The surface of the block of ice slipped and slid, floating about until the last bit of ice melted away into the splish splash puddle that had now grown into a pond, ready to spring into life.	The "puddle" does not return to the block of ice, but freezes where it now is. As the children playing the expand their space, that its, as the "puddle" gets larger, and the remaining "ice" gets smaller, the more floating occurs, reflected in the way the children move about.	
And that's the story of **The Ice that Melted.**		The cycle of ice and water is critical for life to form.

Small Group Mime Activity: *Movement Integration Mediating Experience*
Invite students to form small groups (about three to five students), to create their own mime and narrated story about ice melting. Encourage students to act out a sequence based on observations they made that resulted in new insights.



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MATERIALS

The lesson enables students to experience larger chunks of ice than they usually get a chance to see, whether homemade ice frozen in a variety of containers or block ice obtained from the local ice company. ***For all lessons, to record reflections, observations, calculations, etc.*** Science Notebooks: writing and drawing utensils.

Demonstration

Pre K–2: Drinking glass, ice cubes

Grades 3–5: Small block of dry ice, saucer or small plate

Main activity

- One or more one 25-pound blocks of ice (or home-made chunks of ice).
- A matching amount of ice cubes.
- Plastic trays large enough to display ice and hold meltwater.
- Enough clear plastic cups for each child to observe ice cubes melting.
- Work gloves (to handle the ice safely).

Science Instruments

- Magnifying lenses.
- Light sources.
- Thermometers or digital temperature sensors.
- Time pieces (stopwatch or clock with easily read face and second hand).

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DEMONSTRATION

Concept: Ice and water are both essentially the same substance

Young children are usually familiar with ice, in some form. This lesson takes the ordinary experience of ice and places it into the context of scientific observation, description, testing, predicting, and devising explanations.

The experiential aspect of melting an ice cube in the hand, feeling the coldness, the wetness, and describing the process, gets the minds of the children thinking about ice and what it is. This lesson includes a variety of melting and freezing scenarios.

PRE K–2

Silliness Demonstration.

It may be wise to practice this "bit" beforehand, so the timing works out just right.

Before the demonstration begins, warm up a dish by setting it in the sunlight, or near a lamp. When you are ready to begin, set the dish out for all to see.

Make a big deal about carefully setting a small ice cube on the dish, letting everyone know that a special activity about ice is coming up.

Meanwhile, leaving the ice aside, do some other business without any reference to the ice cube *that takes just long enough for the ice cube to melt completely.*

Return to the dish and discover that the ice cube *IS GONE! "Whoa! Where did the ice cube go? I left it right here? Did anyone see where it went? Wait a minute, someone took my ice cube and left me a pool of water? What's going on?"*

Engage students in a clue-gathering discussion to sort out about what happened to the ice cube.

Students are likely to help the teacher realize that the water IS the ice cube, now melted. Once it becomes clear that the ice cube has melted into water, the teacher can express the amazement about that equivalence, and what factors are involved that makes it water or ice.

Could it happen again?

To the delight of the children, the demonstration is likely to be enjoyed several times in a row.

3–5

The Amazing Ice Demonstration

Materials:

- bowl of ice and an equivalent bowl of water.
- “magic box” large enough to conceal both bowls.

Ladies and gentlemen, I am about to transform this bowl of ice cubes! I will place it in this magic box—and *Presto! Change-o!*

Amazing! It has changed into: *a bowl of water!* How extraordinary! And now even more amazing, another transformation! *Abracadabra!* A bowl of ice again!

After a few moans and groans—what, you think I have two bowls? All right you caught me—I now reveal the bowl and ice and the bowl of water. But tell me, what would we really need to do to make this transformation work, for real?

If we agree that something about water and ice is the *same*, how do we account for how they are *different?*

For example, we could think up a variety of equations, such as:

ice = water below 32° F (at sea level)

water = ice above 32° F (at sea level)

ice = frozen water

water = melted ice

MAIN ACTIVITY

PREPARATION

Set up one or more stations for small groups of students to observe ice melting under a variety of conditions e.g. under tables in the classroom, in the sunlight coming through a window, outside in the sun, outside in the shade.

Examples of exploratory zones:

1. Observe a block of ice: Stabilize the block of ice on a bed of ice cubes in a plastic tray, so that it does not slide around.
2. Observe an ice cube: Place the ice cube in a clear plastic cup.

TEACHING TIPS

Explore

Though we take it for granted that it is natural to recognize that ice is a solid form of water, when we pose the question about how this can really be, our minds must grapple with wondering what really happens as ice melts? What does temperature have to do with it? How does the structure of water change? Ask questions that guide students' thinking toward precursor understanding. To explore freezing, you may need to rely on teaming up with parents and family members to observe freezing at home. Or plan a field trip to the local ice company. Invite a representative of the local ice company into the classroom.

Diagnose

Listen to student ideas about melting and freezing. Listen particularly to their proposed explanations. Use what you hear to guide them as they focus on describing the details of different situations of melting and freezing.

Design

Listen for opportunities to encourage students to design ways to test out their own ideas. For example, the idea that an ice cube will melt faster in the sun than in the shade can be tested by setting up a systematic comparison.

Discuss

The atomic theory may be so pervasive that even young students have heard about it. In this context, learning about the conditions under which water ice melts and liquid water freezes gives us an opportunity to lay the foundation for talking about the molecular structure and geometry of water and ice.

Use

This lesson builds observation and measurement skills. Results can be displayed on timelines and graphs. Students can draw their own phase change diagrams.

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WARM-UP AND PRE-ASSESSMENT

Predict How Ice Will Melt In Different Situations

Young children will generally predict that the ice will melt. The idea is to pose questions that encourage students to refine their predictions in ways that may help them watch for details that reveal the properties of ice: How does it melt? Little by little? All at once? Does it make a difference whether it's in direct sunlight or near something warm? Does it melt differently when surrounded by air or when surrounded by liquid? What if the temperature of the surroundings is below freezing? Will the ice still melt?

PROCEDURES

PART 1.

Observe Ice Melting

Select a variety of ways to observe the phenomenon of ice melting. Have students ask questions, make observations, draw, and write what they experience. For example, here is a list of several different ways to observe the phenomenon of ice cubes melting:

1. Watch an ice cube melt on a dish or in a clear plastic glass.
2. Let an ice cube melt in your hand.
3. Put an ice cube in cold water, time its melting.
4. Put an ice cube in warm water, time its melting.
5. Pour cold water into a glass of ice cubes.
6. Pour warm water into a glass of ice cubes.
7. Put an ice cube in the shade.
8. Put an ice cube in direct sunlight.
9. Put an ice cube under a warm lamp.

Or come up with your own ideas…Have an ice cube melting race.

Large ice blocks often take several hours or even a couple of days to melt:

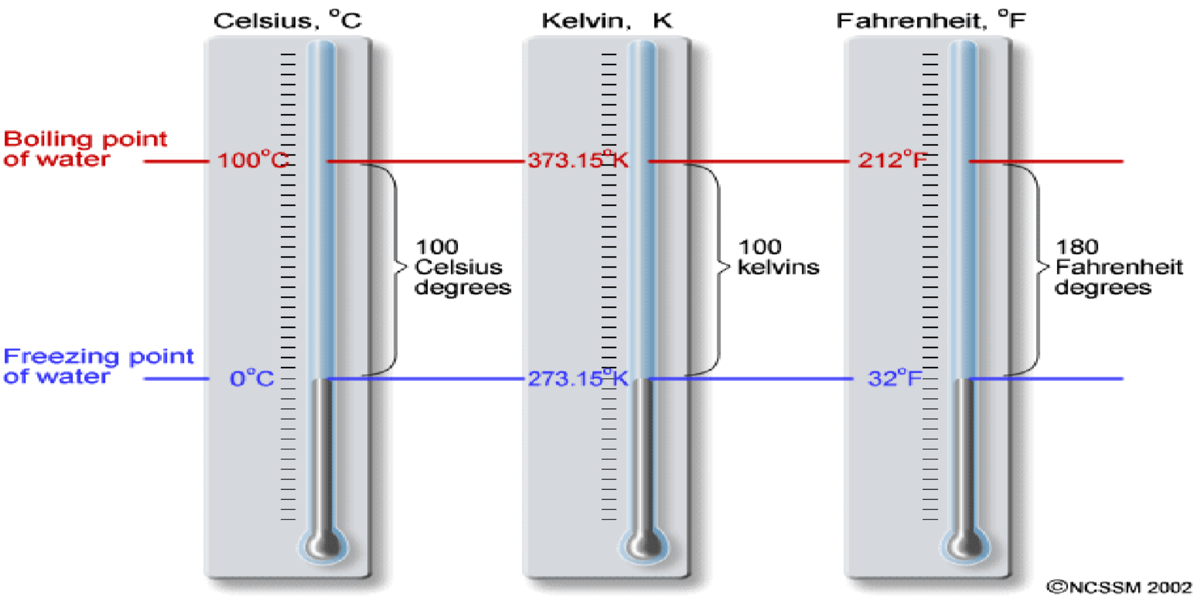
10. Watch the big block of ice melt.
11. In the sun/in the shade.

Have students generate questions about what they notice about ice melting.

Ask students to discuss their questions about melting and freezing in ways that lead to proposing their own explanations. As a whole group, work through a way to design a test of one of the student-generated ideas. Look at a range of designs from simple to complex, for example:

- Watch ice melt: describe.
- Watch ice melt: describe and note timeline.
- Watch ice melt: describe, note timeline and temperature.
- Watch ice melt: describe, note time, temperature, and record as a digital photo.
- Plan control and variables: melting inside, outside, in the sun, in the shade.
- As a whole class, conduct a study on the melting of the large block of ice, which normally takes a couple of days.
- What temperature measurements are relevant? Air temperature in room? Air close to the ice? The ice surface? Meltwater? Internal ice temperature?
- Illustrate the patterns in a diagram or a graph.

Adding a thermometer can arise out of questions: How cold is the ice? How cold is my hand after holding the ice? Help students notice that different thermometers are calibrated for different purposes. The thermometer used to measure whether you have a fever measures a different range than a thermometer we use to measure the temperature of ice.



Source of image: North Carolina School of Science and Mathematics http://www.dlt.ncssm.edu/TIGER/chem1.htm

Temperature Scales

The Kelvin Scale's Absolute Zero point (0 K) corresponds to the point at which molecular motion is still. At one atmosphere of pressure (sea level), water becomes ice at 273K. The Celsius or Centigrade Scale sets 0° C at the freezing point of water. What is the significance of 0° F, on the Fahrenheit Scale? It's the freezing point of ice with salt in it at a concentration similar to ocean water.

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Observations and measurements connected to melting

This table is a list of typical observations and measurements that can you can use to guide young students toward active scientific inquiry about ice:

Observations	Measurements
a. When you touch water ice, you can feel that ice is cold.	a. Use a thermometer to measure how cold the ice is. (What kind of ther-mometer do we need to measure close to the freezing point of water?)
b. If you put the palms of your hands together, they feel warm.	b. Use a thermometer to measure how warm it is in the space where you put the palms of your hands together.
c. If you put a little piece of ice in the palm of your hand, the ice melts and changes into water. The palm of your hand feels colder and wetter than it was before.	c. Use a thermometer to measure the change of temperature on your hand where the ice melted.
d. If you put a little piece of ice into a clear plastic cup, you can watch the ice melt into water.	d. Use a thermometer to measure the temperature of the air inside the plastic cup.
e. As it melts, the ice appears to shrink and more water appears.	e. Draw a time-sequence picture of the melting process.
f. If you put the ice in direct sunlight, it melts faster.	f, g, h, i. Use a stopwatch or clock to measure how long each melting takes place.
g. If you put the ice near a direct light source that radiates heat, the ice melts faster.	
h. If you put the ice in the shade, the ice melts more slowly.	
i. If you put the ice in a cold place, it melts more slowly.	
j. If you start with water in the cup the ice floats, shrinks, then disappears (joining the water in the cup).	j. Measure the amount of water; after the ice melts, measure again.
k. If you put some ice cubes into water or pour water over some ice cubes, you sometimes hear and see the ice crack.	k. Describe the conditions that are present when the cracking sound happens; why does the ice crack?

PART 2.

Observing Water Freezing

Note: Having students observe freezing may be difficult if a freezer is not easily accessible at the school, or if less than wintry conditions exist outside, but may be a wonderful parent-involving homework activity.

Invite students to predict what will happen to water placed where the temperature is below freezing. Young children will generally predict that the water will freeze. The idea is to pose questions that encourage students to refine their predictions in ways that may help them watch for details that reveal the properties of ice: *How* does it freeze? Little by little? All at once? What part of the ice freezes first? Does it make a difference whether it's in a freezer or in freezing weather? What if the temperature of the surroundings is above freezing? Will the water still freeze? What happens if the water is in a container that stretches?

Select a variety of ways to observe the phenomenon of water freezing. Have students ask questions, make observations, draw, and write what they experience.

1. Put meltwater back in the freezer, check on it periodically to observe how it freezes.
2. Put water in an ice cube tray or other open plastic container into the freezer; check on it periodically to observe how it freezes.
3. Put water into an empty plastic water bottle, and then freeze it.

Check the progress of the freezing water at a regular interval of time: once every ten, fifteen, or twenty minutes until it is completely frozen. At each interval, draw what you see, take a picture, and/or describe it in words.

The key is to assure that learners concentrate on the nature of the phenomenon, as they perceive and express that ice is a form of water. As observations are recorded and shared, encourage children to generate questions, make speculations, propose explanations and devise a variety of ways to test their ideas.

Observations and measurements connected to freezing

This table is a list of typical observations and measurements that can you can use to guide young students toward active scientific inquiry about ice:

Observations	Measurements
■ Water is liquid; as it sits in a container inside a freezer, it freezes, changing into solid ice. Water hardens into ice as it freezes; the liquid phase disappears (becoming the ice). (Freezers do not usually permit direct observation of the freezing process. In a wintry climate, freezing can be directly observed outside.)	a. Compare water level to ice level in a container b. Temperature of the freezer c. Temperature of the air around the water d. Temperature of the water
■ The freezing starts on the top surface; first a layer of ice forms; sometimes you can see bubbles frozen in.	e. Measure the ice thickness at time intervals f. Describe the layering of ice at time intervals
■ As an ice cube freezes, the top, sides and the bottom freeze first, leaving liquid water inside, which later freezes.	■ Describe how the last bit of water expands inside the shell of ice
■ Sometimes wisps of ice spike upward from an ice cube.	g. Describe the shape and measure the height of the spike

Noticing the details about melting and freezing will lead to insights in other ice exploration activities as well, for example:

- Notice that as ice cubes freeze the center freezes last; and
- Notice that ice cracks when placed in a warm liquid or when a warm liquid is poured over ice—connects to the geometry and structure of ice and can be used to build understanding from the experience of this lesson.

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DISCUSSION & REFLECTION

Lead a follow-up discussion based on questions such as:

- How are water and ice different from each other?
- How can we test to find out if water and ice are the same substance?

How does ice melt and freeze?

The surface is where the action is. At the molecular level, ice is solid because the water molecules have formed strong hydrogen bonds in a crystalline lattice. At the surface, many of the hydrogen bonds are broken and dangling. You may notice that there is a layer, a quasi-liquid film on the surface of the ice that is exposed to the air or liquid around. At this surface, depending on the temperature and pressure conditions, water molecules are either breaking (melting) or forming (freezing) hydrogen bonds.

How do other things melt and freeze?

Water ice is dramatic because we can experience its phases changes quite often. While we don't usually think of it this way, a rock can be thought of as a chunk of ice, too. Under great pressure and high temperature, a rock can melt—volcanoes are the result of liquid magma rising to the surface. The hot molten lava *freezes* into solid rock. Places like Europa may even have water ice volcanoes. What else can we think about in terms of melting and freezing?

Melting and Freezing in Nature

This lesson focuses on ice melting and water freezing. This topic can be further explored in the context of learning about weather and the water cycle, by extending the phase change exploration toward an understanding of evaporation and condensation. The issue of air pressure as a factor comes into play when learning about clouds and how raindrops and snowflakes form. We can connect to understanding Earth's climates by mapping out where ice can form.

CURRICULUM CONNECTIONS

Phase changing phenomena

Literature abounds with examples of human encounters with conditions of melting or freezing. Many stories tell accounts of how human beings cope with such conditions.

Students' observations of ice melting and freezing may get their story-writing imaginations going. While our focus is to draw out the science learning from these experiences and to create new knowledge about ice, watch for ways build upon the language, visual, or kinesthetic learning potential.

Listen for possible curriculum connections based on the questions that emerge from the children's observations.

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ASSESSMENT CRITERIA

Exemplary

- Students ask a rich and extensive range of questions about ice melting and freezing, touching on the notion of the atomic theory (upper grades).
- Students observe and record a rich range of observations about ice melting and freezing and relate it to prior shared experiences.
- Students write and illustrate a personal ice melting experience and share it dynamically with both a small group and the whole group.
- Students display observations drawn from their science notebooks with a rich display of timelines and graphs.
- Students identify and extend science questions drawn from direct observation and extended research about ice melting, water freezing.
- Students extend making speculations toward forming hypotheses and designing ways to test hypotheses.
- Students relate ideas to whole context of exploring ice in the Solar System.

Emerging

- Students ask a rich range of questions about water ice melting, and liquid water freezing.
- Students make speculations about possible explanations about how and why it happens.
- Students write and illustrate a description of direct observation of ice melting and water freezing and share it with both a small group and the whole group.
- Students identify basic science questions drawn from the direct observation of ice melting and water freezing.
- Students observe and record a rich range of observations about ice.
- Student display results using techniques of timelines and graphs.

Formative

- Students ask basic questions about how and why ice melts and water freezes.
- Students recognize that water ice and liquid water are the same substance.
- Students identify basic science questions drawn out of the context of melting and freezing.
- Students observe and record basic observations about melting and freezing.

RESOURCES

Literature Resources

Children's stories about ice melting, for example the ice-cracking stories of the Anishinaabe people.

From Ice to Rain, Marlene Reidel et al Carolrhoda books ASIN: 0876141572

Water in the Atmosphere, Isaac Nadeau, Powerkids Press 2003 ISBN: 0823962628

Internet Resources

http://earthobservatory.nasa.gov/Newsroom/NewImages/images.php3?img_id=15341
Melting of Greenland Ice Shelf over the years

http://earthobservatory.nasa.gov/Newsroom/NewImages/images.php3?img_id=8257
Breakup of Larsen Ice Shelf Antarctica

http://nsidc.org/gallery/earth_observatory/
Great source for images of ice on Earth

http://www.windsorct.org/icecube/
A day in the life of ice

http://www.lsbu.ac.uk/water/phase.html
Phase diagram in detail

Images

Link to image gallery

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