GREAT LAKES LEARNING

LESSONS & ACTIVITIES BASED ON THE MONTHLY GREAT LAKES NOW PROGRAM

EPISODE 2202 | SHRINKING WINTER

THE GREAT LAKES ON THIN ICE

Image Credit: Great Lakes Now

OVERVIEW

This lesson will explore the phenomenon of **ice cover** as students learn about ways that winter is "shrinking" in the Great Lakes. They will engage with the science of phase changes as it relates to temperature.

LESSON OBJECTIVES

- **Know** about the impact that ice coverage ice has on the Great Lakes
- **Understand** how temperature relates to the freezing and melting of water
- **Be able to** engineer a thermos to minimize temperature changes to a hot beverage when exposed to cold temperatures

WHAT YOU'LL NEED

- Computer or mobile device with Internet access to view video and online resources
- Notebooks and pencils
- Chart paper
- Sticky notes
- Markers
- Lab supplies (see individual activities for a full list)
- Copies of the Student Handouts

INTRODUCTION

In this lesson, students will be introduced to the phenomenon of ice cover, particularly how ice covers the Great Lakes and how it is an indicator of climate during wintertime months.

They will learn about how energy is transferred during heating/cooling as well as during phase changes such as freezing/melting. The focus of the lesson will be the changes over time in the amount of ice coverage in the Great Lakes based on scientific data.

This lesson includes multiple activities that can span the course of several sessions or be adapted to fit the needs of your group's meeting format.

Some prior knowledge* with which students should be familiar includes:

- Temperature
- Temperature scales
- States of matter
- Measurement and graphing
- Linear equations (e.g., y=mx+b)

Follow this QR Code or hyperlink to the Episode Landing Page!

Check out our online collection of lessons for more activities related to these topics.

*****The sequence of these activities is flexible, and can be rearranged to fit your teaching needs.***

NGSS CONNECTIONS

Phenomenon: Ice Cover

- HS-ESS3-6
- SEP-2
- SEP-8
- SEP-5
- HS-ESS3-5
- MS-ESS2.C
- 5-PS1-2
- SEP-3

During the course of the lesson, students will progress through the following sequence** of activities:

- Class discussion to elicit or activate prior knowledge
- Teacher notes on energy storage and transfer
- Close reading a **graph**
- Watch a *Great Lakes Now* segment on ice coverage in the Great Lakes
- Class discussion to debrief video
- Read about **ice coverage in the Great Lakes** and **the shrinking ice in a Minnesota Lake**
- Conduct an experiment to measure the temperature of melting ice
- Investigate the effect that salt has on ice and use it to make ice cream
- Engineer a thermos to minimize temperature changes in a beverage

The lesson progresses through three major sections: **launch, activities, and closure.** After the launch of the lesson, you are ready to begin the lesson activities. Once finished with the activities, students will synthesize their learning in the closure.

If you use this lesson or any of its activities with your learners, we'd love to hear about it!

Contact us with any feedback or questions at: ***GreatLakesNow@DPTV.org***

TEACHER BACKGROUND INFORMATION

by Great Lakes Now Contributor, Gary G. Abud, Jr.

**This information can be presented by the teacher as notes to students at the teacher's discretion.*

Water is all around us. We are made up of water, and every living thing depends on it to sustain them. And while water is an abundant substance on earth, it has some very interesting properties that make it available to us in multiple forms: **solid** (ice), **liquid** (rain, bodies of water, etc.), and **gas/vapor** (steam, clouds, and more.)

The **water cycle** is a macroscopic process by which water cycles between the surface of the earth and the atmosphere. And during this process, **phase changes** take place. We observe regularly water changing phase all around us. From boiling water to cook noodles to seeing the snow melt during spring—just to name a couple instances—our everyday experience tells us that water can readily change.

Understanding phase changes at the macroscopic level is the focus for this lesson, during the wintertime especially, and so we will discuss two physical changes in more detail—**freezing** and **melting**—with regard to water. Winter in the Great Lakes depends on the formation of ice and snow from colder temperatures, but just what is going on when water freezes or melts?

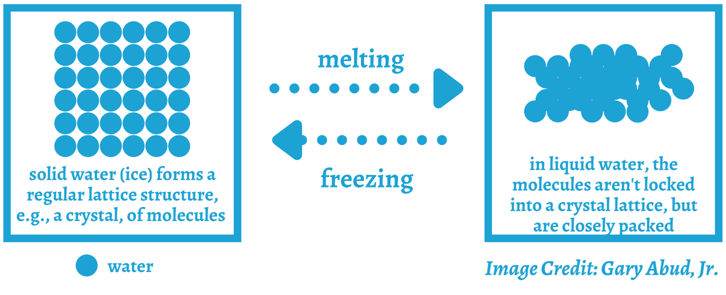

Image Credit: Gary Abud, Jr.

At the particle level, molecules of water have very weak forces of attraction between them. The hydrogens of one molecule are weakly attracted toward the oxygen of another. Known as hydrogen bonding, this intermolecular force keeps water molecules close together in the liquid phase, while the energy of their movement in all directions prevents them from being locked in place in a lattice structure.

You can think of it this way: since temperature is a measurement of the average kinetic energy associated with particle motion, at lower temperatures there is less energy to cause movement of the water molecules.

Thus, at a low enough temperature the water molecules won't be able to move enough to overcome the attraction between them and they will essentially get locked into place in a crystal lattice structure, this is **freezing**. As temperatures increase, the energy going into the system allows the molecules to overcome the intermolecular forces between them, which frees the molecules from the lattice structure and allows them to begin moving about more fluidly. This is **melting**.

Temperatures of a system can be graphed over time into what's known as a **heating or cooling curve**, showing how phases of matter change with temperature.

At large scale, the more water there is the more energy needs to enter/leave a system of molecules in order for it to heat/cool or freeze/melt. Thus, if winter temperatures don't reach cold enough levels, either the water won't freeze at all, say in a lake or river, or not all of the water will freeze.

Image Credit: Great Lakes Now

LESSON LAUNCH

A. Warm Up

The warm up is intended to be structured as teacher-facilitated, whole-group student discussion activities.

1. Before beginning the the warm up, have prepared and available a beaker with ice, another beaker of the same size with liquid water, and a third similar beaker with boiling hot water.
2. Ask students to observe the three beakers of water and to list out what they notice.
3. Now, ask them to consider how each system (e.g., the water inside the beaker) is the same as, or different from, the others.
4. Have students draw a particle diagram to illustrate what they think it looks like at the smallest possible level in each beaker.
5. Have students share and discuss their particle diagrams with the students around them before asking for volunteers to share what their diagrams looked like.
6. Draw a diagram of each beaker on the board that summarizes what students share and help the group reach consensus.
7. Now, ask the students to discuss with their peers nearby them how did the water get into these three different states, and what would need to happen to change the water in one beaker to be the same as the water in another beaker?
8. Invite students to share some of their ideas.
9. Guide them to pay attention to the words they use and eventually provide this diagram to organize their thinking on this:

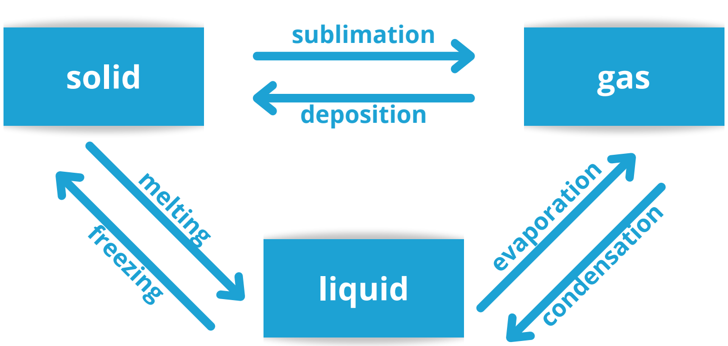

Image Credit: Gary Abud, Jr.

B. Bridge to Learning

After the warm-up activity has concluded, help students prepare for the learning that is about to come.

1. Ask them to discuss with a partner what happens at the particle level when water freezes and, separately, when it melts. Have them draw particle diagrams that visually represent their thinking.
2. Invite a few groups to share their particle diagrams and thinking with everyone.
3. Help the class come to a consensus on what they think is going on at the smallest possible level during the phase changes of water to form ice or melt it.
4. Draw a summary particle diagram on the board for the class and inform them that this will be a model for them to think about ice formation on the Great Lakes.

C. Close Reading a Graph

Inform students that they are about to analyze a graph of ice coverage data on the Great Lakes over the past five decades. Their task is to pay close attention to what's going on with the ice coverage over time. So, either share the link with individual students, or show the entire group on your display, of **this graph of Historical Great Lakes Ice Cover** from the Great Lakes Environmental Research Laboratory. Have students discuss with a partner, and write out 4 sticky notes of observations about, what they notice with the data and how it trends. Then, collect and display the stickies for all to see and discuss as a class. Last, ask students to make connections between the graph, the beakers of water, and their earlier particle diagrams.

D. Background Information Notes

Explain that this graph shows trends over time with ice coverage, which allow scientists to forecast future ice coverage, and continue on to provide students notes from the Teacher Background Information.

ACTIVITY 1: WATCH A GREAT LAKES NOW SEGMENT

This activity is a video discussion of a *Great Lakes Now* episode segment.

First, inform students that they will be watching a segment from *Great Lakes Now* that discusses the impact that warmer and shorter winters are having on ice in the Great Lakes. During the video they need to jot down four things they took away from watching the video using the **4 Notes Summary Protocol**.

Then, if students are not already familiar, introduce them to the 4 Notes Summary Protocol, which they will use after they finish watching the video, where they write down one of each of the following notes:

- **Oooh!** (something that was interesting)
- **Aaah!** (something that was an ah-ha moment)
- **Hmmm...** (something that left them wanting to know more)
- **Huh?** (a question they have afterward)

Next, have students watch this segment from episode 2202 of *Great Lakes Now* called, **Shrinking Winter**.

Last, have students complete their individual 4 Notes Summary and then discuss those in groups of 3-4 students.

Teaching Tip*: *Use the Student Handouts to help students organize their thinking in writing around each of the lesson protocols.

Post-Video Discussion

After the groups have had time to go over their 4 Notes Summaries, invite a handful of students to share out some of their notes, eliciting at least 1-2 of each of the 4 Notes and listing those somewhere for the whole group to see.

Ask students to turn back and talk with their groups to make connections between the video and what they did in the warm-up activity with the candle, asking them:

How is what we saw in the video the same as what we discussed earlier in this lesson? How is it different?

After giving the groups some time to talk, bring the whole group back together for a shareout and discussion of ideas.

In this culminating discussion, the goals are to help students make connections between the warming of temperatures during winter months and the inability of water to freeze as much or as often as it once was able to.

Once the discussion finishes, have each student write a "**Sum It Up**" statement in their notebooks. This is a single sentence that captures the big idea of what was just learned.

Have 2-3 students share out their **Sum It Up** statements before concluding this activity.

ACTIVITY 2: READ ABOUT ICE COVERAGE

This activity aims to provide students further understanding of the impact that diminishing ice coverage has on the Great Lakes by reading about ice coverage in the Great Lakes and the shrinking ice in one Minnesota Lake.

In this activity, students will use a **Think Pair Square Protocol** for discussing the two articles that they will read.

First, have students partner up and distribute the two articles entitled:

1. **Great Lakes Researchers Predict Record-Low Ice Coverage** from *Michigan Radio*, and
2. **Minnesota Lake Ice Shrinking as Climate Change Warms Winters** by Mohamed Ibrahim from *The Associated Press*

Have one student read article 1 and the other read article 2. Allow time for students individually to read their article, and ask them to jot down 3 things they learned in the article.

Then, give students time after reading to brief their partner on the article that they read, because they won't read it for themselves. Have students discuss which 3 points they noted from each article and how those points connect to each other.

Next, have two student pairs join up, standing near each other to form the four corners of a square, to discuss the article and what they talked about in their pairs.

Last, have each group come up with a summary statement of the most important point from their discussion and ask for a volunteer in each group to share that most important point with the whole group.

Image Credit: Great Lakes Now

As student groups share out their most important point, record their ideas on the board and have students copy the list of student ideas down into their notebooks.

After the shareout is complete, ask students to return to their groups and discuss one last question based on the article:

How do the predictions made in article 1 connect to the observations made in article 2?

After giving the groups some time to discuss this question, invite conversation from the entire class to compare the main aspects of each article.

Further Reading on the Subject:
An additional article discussing ***disinformation on climate change*** *and how it affects our ability to address climate change issues and impact is available from* Great Lakes Now *for students to read and discuss with one another, again, using the* ***Think Pair Square Protocol****.*

***Teaching Tip*: Use the Student Handouts to help students organize their thinking in writing around each of the lesson protocols.**

ACTIVITY 3: ENGINEER A THERMOS

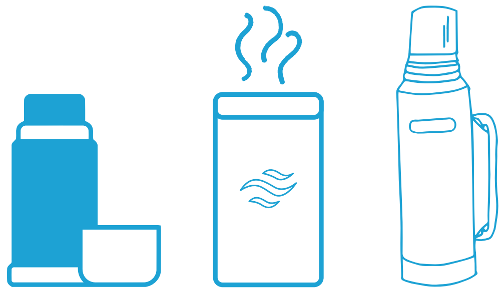

Image Credit: Gary Abud, Jr.

The purpose of this experiment is for students to build a container (thermos) that can hold a 16oz Styrofoam cup containing 250mL of hot water and maintain the temperature of the water as high as possible for 30 minutes.

Context:
During winter months in the Great Lakes, ice fishermen and other winter sport enthusiasts want to enjoy a hot beverage but don't want their beverage to cool down before they can drink it. So, students will be researching materials that can help to keep a hot drink hot over a half-hour time period by engineering a thermos container for a styrofoam cup.

This is an engineering challenge that can be done outside of class individually by students or with one partner. Any Household materials are acceptable. Alternatively, the teacher can gather a variety of materials to have in class and students can design their thermos in class after researching the available materials.

Guidelines:
1. The thermos may be any shape, but no larger than 0.25m x 0.25m x 0.25m in size
2. The container must be able to fit a 16oz Styrofoam cup (which will hold the water)
3. The teacher will provide the styrofoam cup to students on thermos testing day
4. The container should be completely closed on all sides, e.g., should have a lid, but needs to have an access point on the lid for a thermometer to reach the water
5. Thermometers will be provided on test day
6. Thermos designs may not include a device that transfers energy into the system (e.g., a hot plate) of your thermos
7. Thermos designs should be pre-tested by students before bringing it in for test day.

First, communicate the project, with its guidelines and timeline, to students. Emphasize that the objective is not as much to create a portable usable thermos but to keep the water as warm as possible for the entire testing period.

Then, allow students time to research materials in, or outside of, class and make their build.

Next, have students create a write up or presentation that explains the research and design behind the thermos they created. Later, after test day, they'll include their test results.

Last, on thermos test day, provide students one 16oz styrofoam cup filled with 250mL of boiling water and have students complete the testing procedure listed below:

Testing Procedure:
1. Each thermos group will be provided a 16oz Styrofoam cup and 250mL of boiling water
2. Thermometers should be inserted into the thermos immediately after adding hot water through the opening directly into the water
3. Record initial temperature of the water
4. Record the temperature of the water every 30 seconds for 30 minutes.
5. After recording the final temperature, students should create a line graph showing how their temperature changed over time.
6. Students should calculate their relative temperature change from start to finish and determine what percent temperature change they had overall. For example, 100˚C starting, 70˚C final temperature would be a 30˚C change and a 30% temperature decrease from original temperature, e.g., a 70% heat retention
7. All groups should list their data on the board so that each thermos can be compared and ranked for evaluation on the contest criteria by temperature change (ΔT).
8. Divide groups' data into quartiles to compare how each performed to others
9. Remember the lower the ΔT the better!

**Note: teachers can choose to evaluate these projects and their thermos outcomes according to a criteria that best suits the format of their learning setting.*

ACTIVITY 4: THE TEMPERATURE OF MELTING ICE

The purpose of this activity is for students to measure the temperature of a sample of water through phase changes and to graph the temperature over time in order to understand what happens to the temperature of water when it melts.

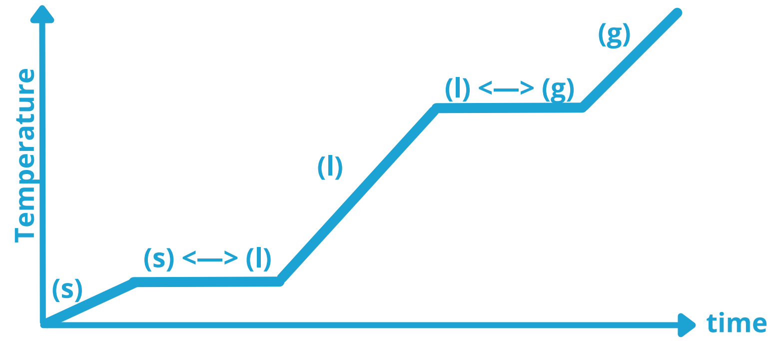

Image Credit: Gary Abud, Jr.

Materials Needed:

- 500mL beaker
- thermometer
- ice
- heating element (such as a hot plate)
- ring stand with thermometer clamp

First, inform students that they will be working with a group to measure the temperature of a sample of water as it is heated. The objective is for them to take frequent temperature readings (every 10 seconds) until all of the water has been completed heated (e.g., reaches a boil).

Then, have students fill their beakers with ice and place them on the hot plate. Have students position the thermometer in the ice so that it can read the temperature. Caution them not to let the thermometer touch the beaker so that they are measuring the temperature of the ice and not of the glass.

Next, have students turn on the heating element to high while the thermometer is positioned to measure the temperature of the ice. Have them continuously record measurements of the temperature at 10-second intervals while heating. They should continue recording temperature data until the water reaches a boil. Remind them to take some observations of what is going on at different points during the heating, including at what time it starts melting, finishes melting, boils, etc.

They should observe the water go from solid (s) to liquid (l) to gas, e.g., vapor, (g) phase.

Last, have the groups graph their data as a line graph of temperature versus time and annotate on their graph at different points what state(s) of matter were present in the water system (e.g., beaker).

Once they complete their lab and have their data graphed, engage the entire group in a discussion to analyze the physical meaning of the graph. In other words, what does the graph tell us about what was happening in the system over time—what story does this graph tell?

Help students to make connections between the graph, their observations, and what they think was happening at the particle level within the system during heating. You can have them draw particle diagrams and discuss with their groups how that relates to their data.

Ultimately, you'll want to help them to notice that even though they continued adding energy to the water system, there were times at which the energy caused changes in the motion of the particles (e.g., the particles moved around and kinetic energy changed, thus temperature changed) and other times where the energy added must have done something else, as evidenced by the relatively constant temperature, e.g., the energy went into overcoming attractive forces.

ACTIVITY 5: USING SALT TO MELT ICE

The purpose of this activity is for students to learn how salt affects the freezing point of water, helping to melt ice in the winter.

Materials Needed:

- zipper-lock quart bags
- ice
- large-crystal salt (coarse kosher or rock salt)
- thermometer

First, inform students that they will be working with their groups to learn how salt causes ice to melt. Provide them the materials and have them fill the bags approximately with equal amounts of ice and record the initial temperature of both bags and tightly seal one of them.

Then, have students add about 100g of salt to the other open bag of ice and tightly seal it. Have each student touch both bags and record their subjective observations of how cold the bags feel and what they notice about the phases of water present in each bag at the start.

Next, have students shake both bags gently (careful not to cause them to open and spill!) for approximately five minutes. Have students again feel each bag so they can record their subjective observations of how cold the bags feel, and have them list out what they notice about the phases of water present in each bag. Is any salt still visible? Have them open and record the temperature of each bag with the thermometer.

Last, have students analyze their observations and the temperature changes from before to later in the experiment. They should draw a particle diagram to represent each bag at the start and end of the five minutes.

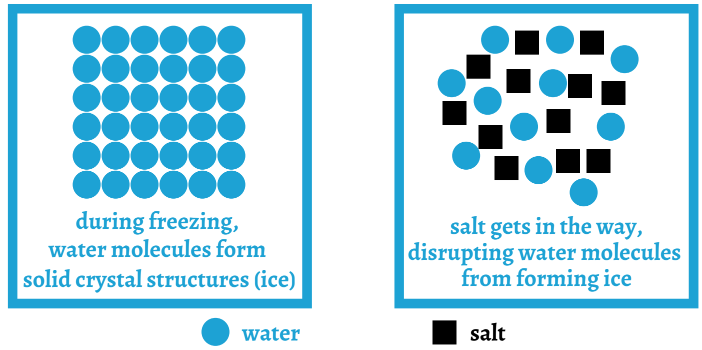

Image Credit: Gary Abud, Jr.

Engage students in a whole-group discussion about their results, helping them to notice agreement among their experiences with the ice. Elicit ideas from their particle diagrams to help them explain and understand how the salt interrupts the ability of the water to freeze at its normal temperature.

Explain to them this is known as **freezing point depression**, a product of adding extra particles to a substance like water that interrupts its ability to form hydrogen bonds, causing it to need colder-than-normal temperatures in order for its molecules to come together and freeze. The more particles there are (e.g., the more salt added to the bag in this case) to interrupt the freezing process, the more the freezing point gets lowered—this ultimately means the water would remain a liquid at colder temperatures.

Check for understanding by having students turn and talk with a partner to explain freezing point depression to each other and then elicit some student explanations of it to the whole group.

Finally, ask students to discuss freezing point depression with their groups and apply this concept to explain why people might put rock salt on their walkways during the wintertime when it snows.

ACTIVITY 6: MAKING ICE CREAM IN A BAG USING SCIENCE

The purpose of this activity is for students to apply the science of **freezing point depression** to generate an ice water system that's cold enough* to freeze dairy and make ice cream.

Materials Needed:
- zipper-lock quart freezer bags
- zipper-lock gallon freezer bags
- 3-5 cups of ice
- 3 teaspoons vanilla extract
- 2 tablespoons of sugar
- 1/4 cup coarse kosher salt
- 1/2 cup whole milk
- 1/2 cup heavy cream
- sundae toppings
- plastic cups & spoons
- measuring cups and spoons

First, inform students that they will be working with a partner to apply what they learned about freezing point depression in **Activity 5** to make ice cream in a bag. Provide them the materials.

Then, have students add the heavy cream, whole milk, vanilla extract and sugar to the quart bag and tightly seal it. Direct them to eliminate as much air from the bag when sealing as possible.

Next, have students add ice and salt to the gallon bag, and gently mix the two together, before putting the sealed quart bag inside the gallon bag and tightly sealing the gallon bag shut with everything inside. Direct them to not eliminate air from the gallon bag when sealing it shut. Have students gently shake, flip, and knead the gallon bag for about 5 minutes. They should notice that the bag will get colder to the touch as they experienced in **Activity 5**. They can use a towel, gloves, or take turns shaking the bag when it is too cold to the touch.

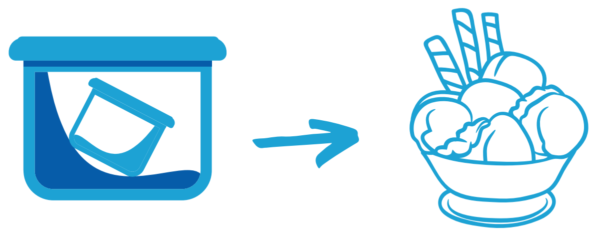

Image Credit: Gary Abud, Jr.

Last, have students determine when their ice cream is frozen** enough to their liking. For a traditional firmer "scoop" ice cream, they might want to shake it a little longer; however, for a more "soft serve" style ice cream they might prefer to stop shaking the bag earlier.

Once they are done shaking their bags, direct them to carefully remove the quart bag and wipe it off before opening it and pouring the ice cream out into containers to eat. This is to reduce the chances of getting salt water into their ice cream.

Students can split their ice cream into two servings, add toppings, and enjoy with their partner.

Once done cleaning up, ask students to draw a particle diagram and provide a written explanation to show what happened in the ice cream experiment.

**Note: the freezing point of water at sea level is 32°F and the freezing point of cream at sea level is 27°F. Typical ice would not be cold enough to freeze the dairy in this experiment and produce ice cream, which is why the salt must be added to depress the freezing point and make the system colder.*

***If the ice cream is not freezing, students may have neglected to add salt to their ice or may need more salt for that amount of ice.*

LESSON CLOSURE

After the conclusion of all the activities, help students to make connections* between everything they did in the lesson and what they learned overall by:

A. Compare and Connect

Initiate a discussion with students where you ask them to identify ways in which each activity corresponded to the other activities. This could be in terms of what was done, what was learned, or specific moments of the activities that corresponded with others. Guide students to refer to each other's thinking by asking them to make connections between specific features of the activities and how they all connect to the big ideas of the lesson. Make sure to invite students to connect other students' responses to their own ideas in the discussion.

B. Lesson Synthesis

Give students individual thinking and writing time in their notebooks to synthesize their learning, by jotting down their own reflections using the **Word, Phrase, Sentence Protocol.**

In the Word-Phrase-Sentence Protocol, students write:

- A **word** that they thought was most important from the lesson
- A **phrase** that they would like to remember
- A **sentence** that sums up what they learned in the lesson

C. Cool Down

After the individual synthesis is complete, students should share their synthesis with a partner.

After sharing their syntheses, have students complete a **3, 2, 1 Review** for the lesson with their partner, recording in their notebooks or, optionally, on exit ticket slips to submit, each of the following:

- **3 things** that they liked or learned
- **2 ideas** that make more sense now
- **1 question** that they were left with

Invite several students to share aloud what they wrote in either the synthesis or 3, 2, 1 Review.

Lastly, ask one student volunteer to summarize what has been heard from the students as a final summary of student learning.

**Optionally here, the teacher can revisit the learning objectives and make connections more explicit for students.*

***Teaching Tip*: Use the Student Handouts to help students organize their thinking in writing around each of the lesson protocols.**

NAME: ______________________________

A Word, Phrase, Sentence Protocol

What is a **word** that you thought was most important from this lesson?

What is a **phrase** that you would like to remember from this lesson?

What is a **sentence** that sums up what you learned in this lesson?

3, 2, 1 Review Protocol

What are **3 things that you liked or learned** from this lesson's activities?

-
-
-

What are **2 ideas that make more sense** now to you?

-
-

What is **1 question that you were left with** after this lesson?

-

NAME: ______________________

4 Notes Summary Protocol

OOOH!	AAAH!
Something that was interesting to you	*Something that became clearer; an "ah-ha" moment*
HMMM...	**HUH?**
Something that left you wanting to learn more	*Something you questioned or wondered*

Sum It Up Statement:

Summarize your group discussion about your 4 Notes Summaries below:

NAME: ______________________

Think Pair Square Protocol

THINK

Write down your own individual ideas

PAIR

Summarize what you and your partner discussed

SQUARE

Summarize what your group discussed