GREAT LAKES LEARNING

LESSONS & ACTIVITIES BASED ON THE MONTHLY GREAT LAKES NOW PROGRAM

EPISODE 2304 | MAPLE SYRUP AND STORING ENERGY

SWEET SWEET ENERGY

OVERVIEW

This lesson will explore the phenomenon of maple sap production in the Great Lakes, as it pertains to chemical energy storage and transfer, in contrast with mechanical energy storage and transfer in wind turbines. Students will model the production of maple syrup from sap by making simple syrup and perform a distillation experiment with cola.

LESSON OBJECTIVES

- **Know** how climate change can affect maple syrup production
- **Understand** how maple sap is an energy source for trees and syrup is produced from it
- **Be able to** use the laboratory technique of distillation to separate the components of cola

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

Maple syrup is a sweet, delicious topping that many people love to have on their pancakes, waffles, french toast, oatmeal, and many other foods. But it is also a source of energy for people that comes from a different source of energy for trees. Have you ever wondered where maple syrup comes from or how it's made? Well, it all starts with maple trees. And it only happens at a certain time of year as winter gives way to spring. That means that changing temperatures due to climate change can affect maple trees and affect syrup production. That's why syrup producers are working hard to adjust for the effects of climate change and keep up the syrup production. Next time you have maple syrup on your breakfast, you can appreciate all the hard work that went into making it.

This lesson includes multiple activities, including lab 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:

- states of matter
- macromolecules
- energy storage and transfer
- familiarity with chemistry lab equipment

particle diagrams

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

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

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

NGSS CONNECTIONS

Phenomenon: Maple Sap Production

- ESS3.D
- MS-ESS3-3
- HS-PS1-4
- SEP 2
- SEP 3
- SEP 4
- SEP 6
- SEP 7

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

- Class discussion to elicit and activate prior knowledge about **energy**
- Close reading of a heat map
- Teacher notes on maple syrup production
- Watch segments from *Great Lakes Now*
- Class discussions to debrief the videos
- Read about **wind turbines in Cleveland**
- Conduct an experiment to distill cola and another to create simple syrup

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. You can select the activities that are best suited for your learners and teaching goals, and then sequence them in a way that makes sense within your learning progression and the scaffolds of the lesson.

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

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

Canada is typically known for its maple syrup, but did you know that the entire Great Lakes region is plentiful with maple trees? And those Great Lakes maples produce plenty of sap to turn into syrup. Before you can put maple syrup on pancakes and waffles, we have to understand the process that produces syrup, because maple trees don't actually produce syrup. So how do we get maple syrup? It all starts with sap.

Maple sap is a vital source of energy for maple trees. During the winter, trees store energy in their roots as starch. In the spring, as temperatures rise above freezing, the starch stored in the roots is converted into simpler sugars and transported up the tree through the xylem tissue to its cells. Through a variety of chemical reactions, energy is stored and transferred, allowing it to power other chemical reactions necessary to cellular functions in the tree. In the same way, when people eat maple syrup a similar result occurs. By metabolizing the syrup, people can utilize the maple trees as a source of energy for body functions.

Getting maple syrup from sap begins with the maple trees in the early spring months when they are producing sap. Maple sap is essentially a dilute solution of simple sugars like sucrose or glucose or fructose, which come from broken down starches (complex sugars), The sap flows through the xylem tissue from the roots to the upper parts of the tree, where it provides energy for bud growth, leaf expansion, and other metabolic processes in the maple trees during spring. The sap flows because of a difference in pressure between the roots and the top of the tree, caused by changes in temperature and pressure. During the day, the sun heats the tree, causing the sap to flow upward.

At night, the tree cools down, and the sap flows back down towards the roots. The amount of sap produced depends on several factors, including tree health, the presence of pests or diseases, but notably temperature—this is why climate change can impact maple syrup production.

Maple trees typically produce sap for a few weeks in the spring, usually in late February or early March, and the sap flow stops once the tree begins to produce leaves. During this time, people can collect sap from the maple trees by drilling a small hold in the trunk of the maple tree and attaching a spout into the hole with a bucket underneath to catch flowing sap.

Once the sap has been collected, it's time to turn it into maple syrup by boiling it in a pan to reduce the amount of water. As the sap boils, the water evaporates, leaving behind a thick, sweet syrup. Finally, the syrup is filtered to remove any impurities and bottled for people to enjoy.

Overall, maple sap is an essential energy source for the tree, providing the necessary sugars for growth and metabolism in the early spring when other energy sources may not yet be available. While sap and syrup both come from maple trees, they are different products. Sap is a clear liquid and comes directly from the tree. It is mostly water with some minerals and sugars, but it is not sweet to the taste. Syrup, on the other hand, is a darker brown color and is much more concentrated with sugars than sap. It gets its color when the natural sugars in the sap are caramelized during the heating process. The longer the sap is boiled, the thicker and sweeter the resulting syrup will be.

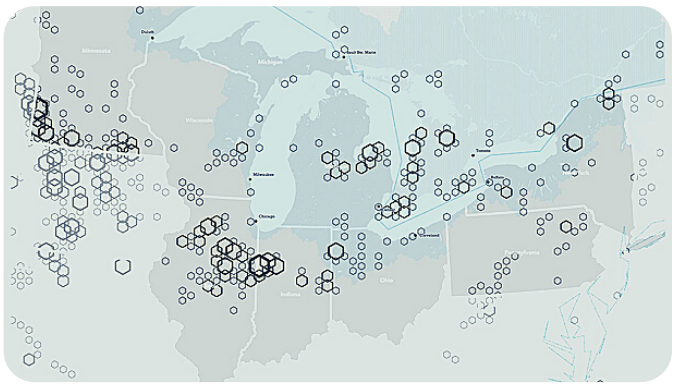
It takes about 40 gallons of sap to make just one gallon of maple syrup!

LESSON LAUNCH

A. Warm Up

The warm up is intended to be structured as teacher-facilitated, whole-group student discussion activities. It helps students to begin thinking about the topic at the center of the lesson.

1. Ask students to list out on a piece of paper five things that come to mind when thinking of **energy**.
2. Have students pair up with a partner to share their five ideas with each other. If any ideas appear on both lists, have students circle those.
3. Then, engage students in a whole-group discussion to ask them to share any ideas that were circled.
4. Generate a list of the circled ideas.
5. Ask for volunteers to share any ideas that were not circled that they think are really important to include in this topic.
6. Generate a separate list of those ideas.
7. At the end of making the two lists, have students copy down one single list of all the circled ideas and important ideas in their notebooks or on their paper.
8. Ask students individually to rank the ideas in the list from most to least relevant.
9. Ask for some students to share which term should be most relevant and why they think that is. Engage the whole group in discussion to arrive at consensus about the most relevant idea related to **energy** that they already know about or that came to mind during this exercise.



B. Close Reading a Photo

Ask students to discuss with a partner what a heat map is, and then solicit a few responses to determine if they understand (and to explain to them if they don't) the concept of a heat map. Then, make the following image of **this heat map of wind turbines in the Great Lakes** available for students to look at. You can distribute copies of the image to partners or display it on screen for everyone to see at once. Have students study the map and ask them to draw conclusions that can be supported by evidence from the heat map about the following questions:

1. where are there the most number of wind turbines in the Great Lakes?
2. why might the wind turbines be distributed in the Great Lakes as they are?

Then, invite students to share their ideas and facilitate a class discussion to arrive at some consensus about the questions.

C. Bridge to Learning

After the warm-up activity has concluded, help students prepare for the learning that is about to come by having them create a visual diagram to show storage and transfer of energy in a system such as a wind turbine. (Note: their diagrams should have energy transferring from a kinetic mode of storage in moving air and turbines, transferring to storing electrically at the end of the system.) Similarly, have them create a second diagram for how people get energy from eating carbohydrates (sugars) such as from maple syrup, showing the path from sunlight to eating syrup.

D. Background Information Notes

Explain that we are about to learn more about how energy is being harnessed to power communities and the way it transfers through plant and animal food chains in this lesson. Then provide **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 *Great Lakes Now* segment discussing a project to store energy underground in the Great Lakes. During the video they need to jot down four things they took away from 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 the segment from episode 2304 of *Great Lakes Now* called **Storing Energy Underground**.

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 *Great Lakes Now* video and what they remember from the warm-up activities.

How is what we saw in the video related to what we discussed earlier during the lesson launch activities?

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 goal is to help students make connections between the video segment and what they discussed during the launch activities earlier in the lesson about what they knew about **energy.**

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 THE WIND TURBINE DEBATE

In this activity, students will read about the arguments for and against installing wind turbines near Cleveland, OH.

Wind turbines offer an ongoing source of renewable energy to communities that use them; however, they have pros and cons to installing them, especially in the waters of the Great Lakes.

In this activity, students will use a **Think Pair Square Protocol** for discussing what they will read about this very topic.

First, have students partner up and distribute the article **Winds of Change: Wind turbines on Lake Erie spark big support and big debate** by James Proffitt from *Great Lakes Now*. Allow time for students to individually read the article, and have them jot down three things they took away from the article using the **Rose Thorn Bud Protocol**—in their notebook or using the handout.

Then, give students time after reading to discuss the article that they read with their partner. Have students share their rose, thorn, and bud with each other, including how those points connect to each other. The pair should come up with a statement to summarize all of their article takeaways.

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. Encourage them to come to a consensus about which point they found most important or interesting in the article.

Last, have each group craft a summary statement of the most important point from their discussion and ask for a volunteer in each group to share that key point with the whole group. As student groups share their most important point, record their ideas on the board and have students copy the list of student ideas down into their notebooks. Once the shareout is complete, ask students to return to their groups and discuss one last question based on the article:

Should they add the wind turbines in the Cleveland community? Why or why not?

You can keep this as a class discussion based on the article itself, or this can be extended into a writing assignment, presentation project, or further research on the topic to allow students to engage more deeply with the issue.

Teaching Tip:
If the reading level of the article is going to be tough for some students to read individually, have partners or small groups read the article together aloud while each follows along.

ACTIVITY 3: 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 *Great Lakes Now* segment discussing how climate change is affecting maple syrup production in the Great Lakes region. During the video they need to jot down four things they took away from 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 the segment from episode 2304 of *Great Lakes Now* called Is **Climate Change Coming For Your Pancakes?**

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 *Great Lakes Now* video and what they remember from the warm-up activities.

How is what we saw in the video related to what we discussed earlier during the lesson launch activities?

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 goal is to help students make connections between the video segment and what they discussed during the launch activities earlier in the lesson about what they knew about **energy.**

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 4: MAKE SIMPLE SYRUP

The purpose of this experiment is for students to model the process by which sap is turned into syrup by making simple syrup, which is a common sweetener that is often used in desserts or beverages.

Materials:

- A 500mL beaker or a 1qt saucepan
- A hotplate or other heat source
- Measuring cups or an electronic balance
- 1 cup of granulated sugar (approx. 200g)
- 1 cup of water (approx. 240mL)

First, inform students that they will be working with a group to model model the process by which sap is made into syrup.

You may wish to explain the science behind it first. It's a process known in cooking as reduction, or in science as concentration, whereby a solution of sugar and water has some of the water removed by boiling it off, leaving behind the sugar and less water. The process eventually reduces the amount of water, but maintains the same amount of sugar, which increases the density of the solution thickening it until it reaches a desired concentration and consistency more like syrup.

Procedure:

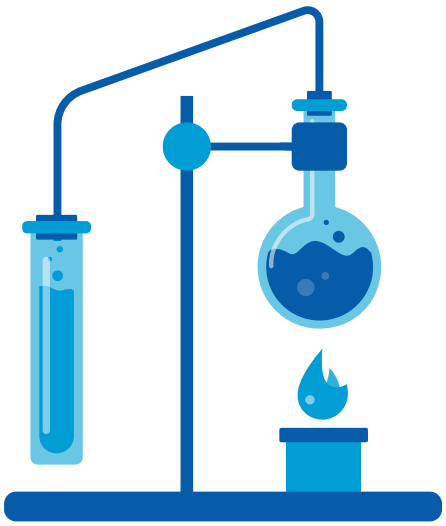
1. In the beaker or a small saucepan, combine the sugar and water.
2. Mix the solution until the sugar is mostly dissolved. It won't all dissolve.
3. Heat the mixture over medium heat, stirring occasionally, until the sugar is completely dissolved.
4. Bring the mixture to a boil and let it boil for 1 minute.
5. Remove from the heat and let it cool completely.
6. Once the simple syrup has cooled, it is ready to use.

It's important to consider what's happening at the smallest possible level here: heating the water transfers energy to the molecules, making the water molecules faster and move farther away from each other. With more space in between them, more sugar molecules can be dissolved than would happen at room temperature (e.g., a saturated solution). This addition of extra dissolved sugar by heating is called a super-saturated solution. As the temperature increases water begins to boil off, but the sugars also begin themselves to change. Larger sugar molecules like sucrose get broken down into smaller ones, such as fructose or glucose. The result is more sugar in less water, which gives a thicker sweeter-tasting solution that we call syrup.

Teaching Tip:

Celebrate the completion of this experiment by enjoying the simple syrup over a dessert like fresh fruit, angel food cake, or on sorbet.

ACTIVITY 5: DISTILLATION OF COLA



The purpose of this activity is for students to separate the components of a complex everyday solution—cola—using a distillation technique.

Materials:

- 100mL of regular cola*
- Heat source (such as a hot plate or burner)
- 250mL Flask
- Glass tubing (or a distillation apparatus)
- Cork with hole for glass rod/tubing
- 250mL Beaker or other container
- Thermometer
- Ice

First ask students what they think is in a can of cola? Without looking at the label, take some responses from them and list them out. After students have shared some ideas, consult the label and read it off to the group to compare. Inform them that most of the ingredients in cola, or most sodas, are added to water in the form of a special syrup. And using a process similar to how syrup is produced from sap, they will be using a process called **distillation** to separate the water and carbon dioxide from cola, leaving the cola syrup behind.

Then, demonstrate and explain the steps of the distillation process before allowing the groups to begin their experiment. Point out during the procedure that throughout this experiment, they can observe that distillation is a process used to separate the components of a mixture based on their boiling points. In the case of any solution being distilled, including cola, the components with the lowest boiling point—in this case carbon dioxide and water—will separate out first. And since we are capturing the steam in the distillation tubing and then cooling it, this experiment will allow us to condense the gaseous water back into its liquid state and collect the water in a separate container to compare the volume of water that was in the volume of cola distilled.

**Note: you could use a diet cola instead, but it has a lot less syrup since it contains no sugar. A variation of this experiment could be to have some groups distill regular cola and others diet cola, then compare the results and discuss them in terms of the syrup and composition of each kind of cola.*

Procedure:

1. Pour the cola into the flask.
2. Insert the glass tubing into the cork and then insert the cork into the mouth of the flask.
3. Place the beaker or container underneath the other end of the glass tubing.
4. Heat the flask gently using the heat source.
5. The cola will begin to boil and the vapor will travel through the glass tubing into the beaker.
6. Place a few ice cubes (or a flexible ice pack) on the glass tubing to cool the vapor.
7. The cooled vapor will condense into a liquid and collect in the beaker.
8. Monitor the production of water vapor as the cola boils further
9. Once water stops traveling through the tube, the distillation process is complete.
10. Measure the volume of water collected and the amount of syrup left in the original flask.

Next, allow student groups time to distill their cola and measure what volume of water they collected and what amount of syrup remained.

Last, have students summarize their findings, observations, and data. They can draw particle diagrams of the before, during, and after phases of the distillation experiment. They can also estimate a percentage of cola that is water by calculating the amount of water collected as compared with the starting volume of cola. They can present their findings to the class to discuss all of the groups' results with everyone; this is especially important if there were different types of soda used by different groups, e.g., diet vs. regular cola.

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.

A. Free Recall

Group students in pairs or triads (e.g., in groups of 2-3 partners) and distribute the **Free Recall Protocol handout**, Alternatively, you can have students do this in their notebooks. Set a 3-min timer and have students generate a list of everything they can remember learning about in this lesson related to the central topic of the lesson. This doesn't have to be in depth, just whatever each group can call to mind. Have them draw lines between any terms that relate to one another. After the timer finishes, give groups a chance to volunteer to share aloud 2-3 things from their free recall lists and any of the connections that they made with those. Jot down any ideas that come up multiple times during the shareout for the whole group to see.

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: _____

Free Recall Protocol

With 1-2 partners, generate a list of everything you can remember learning about in this lesson related to the central topic of the lesson. Draw lines between any terms that relate to one another.

NAME: _____

4 Notes Summary Protocol

OOOH!

Something that was interesting to you

AAAH!

Something that became clearer; an "ah-ha" moment

HMMM...

Something that left you wanting to learn more

HUH?

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

NAME: _____

Rose, Thorn, Bud Protocol

ROSE

Something that "blossomed" for you in your learning

THORN

Something that challenged your thinking or was difficult to understand

BUD

Something that's new and growing in your mind — a "budding" idea