GREAT LAKES LEARNING

LESSONS & ACTIVITIES BASED ON THE MONTHLY GREAT LAKES NOW PROGRAM

EPISODE 2303 | CITIZEN SCIENCE

HOW IS OUR CLIMATE CHANGING?

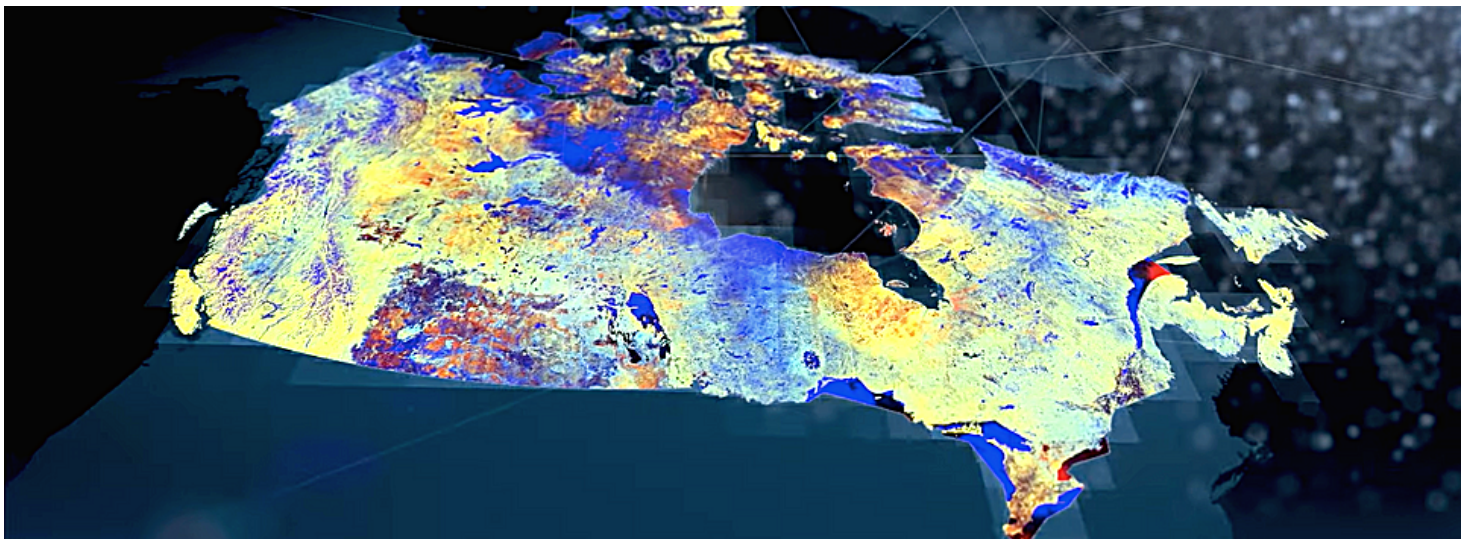


Image Credit: Great Lakes Now

OVERVIEW

This lesson will explore the phenomenon of **disappearing ice** in the Great Lakes and the impact this has on ice fishing as a result of climate change. Students will explore the global averages temperatures over time, model the greenhouse effect, conduct an experiment to model ocean acidification, and create an infographic to communicate the issue of climate change and how the impacts of human activites on the natural system can be reduced.

LESSON OBJECTIVES

- **Know** about the rise in global average temperatures since the industrial revolution
- **Understand** how human activities impact the natural system of the world including climate change
- **Be able to** model ocean acidification and global warming

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 go into depth with the fundamental principles behind climate change, namely that climate is different than weather, greenhouse gases contribute to climate change, and human activities impact the climate.

Using increases in global average temperatures for more than the past century, students will investigate the factors, which impact climate change, that we can most control—carbon emissions.

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
- Weather patterns and forecasts
- Basic chemistry concepts like atoms, molecules, compounds, ions, and names of common elements
- States of matter
- pH, acid and base
- Open and closed systems
- Particle diagrams
- Chemical reactions

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: Disappearing Ice

- ESS2.D
- LS2.C
- ESS3.D
- ETS1.B
- SEPs 1-8

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

- Class discussion to elicit and activate prior knowledge about **climate change**
- Teacher notes on climate change
- Close reading a video
- Watch a GreatLakes Now segment on climate change
- Class discussion to debrief the video
- Conduct an experiment to model global warming
- Conduct an experiment to model ocean acidification
- Read about the chemistry of ocean acidification
- Read about climate change
- Create a climate change infographic

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.*

The terms weather and climate are often used interchangeably; however, they are very different. Weather refers to the natural conditions in the atmosphere we experience on a day-to-day basis. It's things like temperature, wind, rain, and sunshine. For example, if it's hot and sunny outside today, that's the weather we're having today. But the next, or previous, day could have totally different weather. So while weather indicates daily conditions, how do we characterize the weather overall for a particular region? That's where climate comes in handy.

Climate is the average weather pattern of a place over a long period of time, usually multiple decades of time. It's like a big picture view of what the weather is typically like in a certain location. For example, some places have a hot and dry climate most of the time, like Phoenix, AZ. That means that it's usually hot and doesn't rain much. Other locations have cooler wetter conditions most of the time, such as Seattle, WA.

While the climate indicates what is typical most of the time for a specific locale, it doesn't mean that place will always have the same weather. Seattle experiences frequent rain between October and May, but is generally dry and cool during the summer, whereas even the typically dry Phoenix valley gets periodic strong thunderstorms and heavy downpours, called monsoons, during the late summer.

So, whereas weather is what's happening outside right now, climate is what the weather is usually like over a long period of time in a certain place. And that is why scientists are more interested in how the climate of a region compares over time.

Climate change refers to the long-term changes in general temperature and weather patterns that can happen in one place or all around the world. For example, if Seattle's climate became more like the climate in Phoenix, that would be climate change; however, if it thunderstorms one additional day during one single year in Phoenix, that is not climate change.

Climate change has been happening naturally for millions of years. The Earth's climate has changed many times in the past, and this has been caused by things like changes in the sun's energy, volcanic eruptions, and shifts in the Earth's orbit. However, what we're seeing now is different.

The Earth's temperature is controlled by a delicate balance of energy from the sun that is absorbed by the Earth and energy that is radiated back into space. When this balance is disrupted, the Earth's temperature can rise or fall. The same thing could happen locally in one region of the planet; however, because of the movement of air in the atmosphere, these effects eventually can spread out and affect more than just a single area.

The science of climate change is based on data collected by scientists all over the world. They use things like temperature readings, ice core samples, and satellite images to study the Earth's climate over time. They have found that the Earth's average temperature is increasing overall, and the rate of increase is happening faster than it has in the past. This increase in temperature is causing a lot of changes on our planet, like melting ice caps, rising sea levels, and more frequent severe weather events.

One of the main impacts from human activity on the climate comes from an increase in greenhouse gases, such as carbon dioxide, methane, and nitrous oxide, in the Earth's atmosphere. Human activities, such as deforestation, cattle ranching, and burning fossil fuels (like coal, oil, and gas) for energy, have released large amounts of greenhouse gases into the atmosphere. Although human activity isn't the only source of such gases, the continuous addition of increasing amounts of these gases act like a blanket around the Earth, trapping heat and causing the planet to warm up. This has resulted in changes to the Earth's climate that are happening faster than they would naturally. So, while human activity did not start climate change, nor do our activities intentionally try to negatively impact the climate and planet, human activity is nonetheless continuing climate change.

The more we continue to release greenhouse gases into the atmosphere, the more severe the effects of climate change could become. To help take positive action against climate change, we need to reduce the amount of greenhouse gases we are putting into the atmosphere.

That's why it's important for all of us to take action to reduce our greenhouse gas emissions, like using cleaner sources of energy, such as solar or wind, driving less (and biking/walking more), reducing our use of single-use plastics, turning off lights and electronics when we're not using them, planting more trees, and even eating less meat.

LESSON LAUNCH

A. Warm Up

The warm up is intended to be structured as teacher-facilitated, whole-group student discussion activities. They help students begin thinking about the central topic of the lesson.

1. Ask students to list out on a piece of paper five things that come to mind when thinking of **climate change**.
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 **climate change** that they already know about or that came to mind during this exercise.

B. Bridge to Learning

After the warm-up activity has concluded, help students prepare for the learning that is about to come by demonstrating how a system filled with carbon dioxide* gets warm:

**Note: while this isn't a perfect analogy for the atmosphere, the goal is to connect the two for students.*

Image Credit: Great Lakes Now

1. Ask them to discuss with a partner what happens when you breathe into a paper bag, such as is sometimes advised for someone to do when they are having an anxiety attack.
2. Elicit a couple of ideas from student volunteers. Be sure to try and guide everyone to focus on the fact that carbon dioxide is a gas that our lungs produce when we exhale.
3. Have students draw a particle diagram of what it would look like inside the paper bag after 1 breath, or 5, 10, and 20 breaths.
4. Have student volunteers describe their diagrams. Draw a consensus particle diagram for everyone to see.
5. Provide each student a paper bag to experiment with breathing into it. Note: give students who might be uncomfortable with this activity due to health reasons the option to partner up with someone else who wants to do it.
6. Instruct them to curl one hand around the mouth of the bag and to hold it to their mouth. Without letting go, have them take a few long slow breaths exhaling into the bag. The bags should inflate and deflate accordingly.
7. After a 3-5 breaths ask students to discuss with a partner what they observe happening with the bag. (Note: it should feel like the air inside is getting warmer)
8. Students can continue with a few additional breaths if they didn't notice anything in the first few. The goal is for them all to notice the connection between increased carbon dioxide and temperature inside of the bag.

C. Close Reading a Video

Inform students that they are about to view **a short video clip from NASA** that illustrates global average temperature changes over time. Their task is to pay close attention to what's going on in the video and to jot down notes with things they noticed and wondered from the video on the **Notice & Wonder Protocol** student handout. Then, elicit and discuss their ideas. Next, point out that this video was shown during the opening ceremonies of the 2016 Summer Olympics in Rio de Janeiro, Brazil. Last, discuss why they think it was shown then.

D. Background Information Notes

Explain that we are going to build on these ideas and learn more about climate change in this lesson. Then proceed to give the 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 *Great Lakes Now* segment discussing the winter recreational sport of ice fishing and the impact that climate change is having on it due to warmer winter temperatures. 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 2202 of *Great Lakes Now* called **Angling For Ice**.

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 **climate change.**

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 CLIMATE CHANGE IN THE GREAT LAKES

Climate change affects all seasons. The day to day weather in the Great Lakes region may continue to have its assortment of weather days filled with rain, snow, sleet, or hail—as well as heat and sunshine—on the regular, but the climate has seen larger scale changes in the region over time. Just what might that mean for the future? Drier summer days and wetter winters perhaps, but at present the threat of more severe storms and flooding is already a reality.

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 **Science Says What? Climate change, deluges and snow days** by *Great Lakes Now* contributor Sharon Oosthoek. 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.

Image Credit: Great Lakes Now

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:

In what ways does (or has) a continually-changing climate pose threats to our local community?

After giving the groups some time to discuss this question, invite conversation from the whole group to see what consensus can be reached. Be sure to encourage students to support their claims with evidence and reasoning as they discuss in the whole group.

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: MODELING GLOBAL WARMING

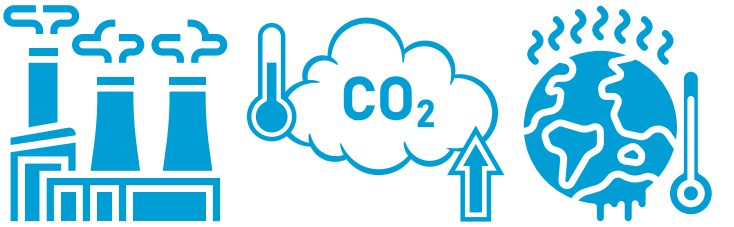


Image Credit: Gary Abud, Jr.

The purpose of this experiment* is for students to model the impact that increased levels of carbon dioxide have on temperatures in the atmosphere.

Materials:

- Two clear plastic containers (such as jars/cups)
- A thermometer
- A light source (such as a lamp or direct sunlight)
- A source of baking soda and vinegar OR instead, optionally, a block of dry ice (optional)

Note: this experiment takes several hours of light exposure in order to provide useful data. In a self-contained classroom setting, students can set the experiment up at the beginning of the day and take data at the end of the day. In a period-switching bell schedule, earlier classes can set up the experiment and later classes can take (and share) data.

First, inform students that they will be working with their groups to create a microsystem atmosphere to model the impact that increased levels of carbon dioxide have on temperatures. If they do not already have the concept of a system/surroundings construct for examining situations in science, discuss what a system (both closed and open). Draw particle diagrams (e.g., squares with dots inside and outside of the square) to illustrate. After reaching group understanding, distribute the materials for the experiment to groups.

Next, have students execute the steps of the following procedure:

Procedure:

- Fill both containers with equal amounts of water.
- Place the thermometer in each container and record the starting air temperature.
- In one container, add a small amount of baking soda and vinegar to simulate increased CO2 levels. Be careful not to spill or overflow the container.
- Place both containers under the light source and let them sit for several hours.
- Record the air temperature of each container after the designated time(s).
- Optional: If you have access to dry ice, have some groups place a small amount in each container instead of using baking soda and vinegar, and observe the results as compared to the vinegar and baking soda combination. (Remember to use oven mitts or ski gloves when handling dry ice.)

Then, provide students with chart paper and markers, or large dry-erase boards and whiteboard markers, to summarize their group's data and experimental results. Be sure to have them include a particle diagram to show what is happening at the smallest possible level in the system at the beginning and ending times.

Last, engage the students in a "board meeting" where all students sit/stand in a circle facing one another with their chart paper or dry-erase boards facing inward for all to see to discuss their collective results. Facilitate this discussion by selecting and sequencing groups to share about their data and answer probing questions so that any of the following discussion goals are accomplished:

- How did the temperature of the two containers compare before and later?
- Note: if you had any groups use dry ice, also compare the results of dry ice vs. vinegar and baking soda
- Discuss the implications of this experiment. How did increased CO2 levels contribute to temperature change in the system? What do our particle diagrams illustrate is happening?
- How does this microsystem model what is happening at the scale of our planet with global warming?
- What is the main thing that needs to happen in order to combat climate change? Brainstorm some ways we can accomplish this in our everyday lives.

ACTIVITY 4: INVESTIGATING OCEAN ACIDIFICATION

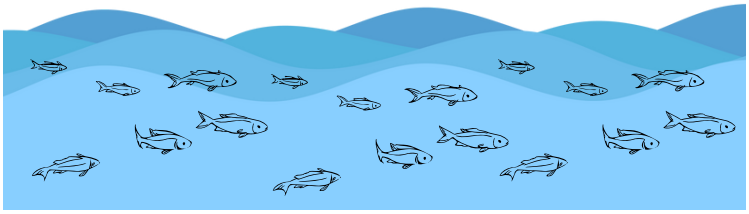


Image Credit: Gary Abud, Jr.

The purpose of this activity is for students to model the impact that increased levels of carbon dioxide have on ocean waters.

Materials:

- Clear plastic cups (or 500mL beakers)
- Plastic straws
- A block of dry ice (optional)
- Litmus paper (or a digital pH probe)
- Universal indicator solution
- Graduated cylinder or a 1 tsp spoon
- Ski gloves or oven mitts
- Distilled water

First, inform students that they will be working with their groups to model the impact that increased levels of carbon dioxide have on ocean acidity. If they do not already have the concept of a system/surroundings construct for examining situations in science, discuss what a system (both closed and open). Draw particle diagrams (e.g., squares with dots inside and outside of the square) to illustrate. After reaching group understanding, distribute the materials for the experiment to groups.

Some variations of this experiment can be done—either by the same group or by separate groups—to see their effects on the acidity:

- Exhaling through a straw into the water (can be done by one or more students)
- Dissolving dry ice (solid carbon dioxide) in the water

Next, have students execute the steps of the following procedure:

Procedure:

1. Fill two containers with equal amounts of water and add 5mL (e.g., 1tsp) of indicator
2. Take the pH of the water in both containers.
3. In one container, leave the water alone
4. Add carbon dioxide to the other container using dry ice or by blowing bubbles into it

Method 1: blow bubbles through the straw continuously for 3-5minutes. (Note: students may need to take a break so they don't get lightheaded)
Method 2: add 2-3 pebble sized pieces of dry ice to the water and let it bubble for 3-5 minutes

Finally, take the pH of both containers again and note any differences in appearance.

Then, provide students with chart paper and markers—or large dry-erase boards and whiteboard markers—to summarize their group's data and experimental results. Be sure to have them include a particle diagram to show what is happening at the smallest possible level in the system at the beginning and ending times.

Last, engage the students in a "board meeting" where all students sit/stand in a circle facing one another with their chart paper or dry-erase boards facing inward for all to see to discuss their collective results. Facilitate this discussion by selecting and sequencing groups to share about their data and answer probing questions so that any of the following discussion goals are accomplished:

- How did the pH of the two containers compare before and later? The color?
- Note: if you had any groups use dry ice, also compare the results of dry ice vs. straws
- Discuss the implications of this experiment. How did increased carbon dioxide levels contribute to pH / color change in the system? What do our particle diagrams illustrate is happening?
- How does this microsystem model what is happening at the scale of our planet with increased carbon emissions?
- What are the potential consequences of carbon emissions on ocean acidification?
- What is the main thing that needs to happen in order to combat ocean acidification?

Extensions to this activity include: brainstorming ways to reduce carbon emissions, exploring in more detail the chemistry behind what's happening during ocean acidification, or discussing the article in Activity 5.

ACTIVITY 5: READ ABOUT OCEAN ACIDIFICATION

This content can be used as an article reading for students, or it could serve as discussion points to review chemistry content or teacher notes to provide new information to students. Depending on students' prior knowledge of chemistry, you can write chemical equations or stick with the names of the substances involved in the reactions.

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

First, have students partner up and distribute the article, which is available in the student handouts section of this lesson, entitled **How Does Carbon Dioxide Cause Ocean Acidification?** by *Great Lakes Now* contributor Gary Abud, Jr. 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.

Image Credit: Great Lakes Now

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:

In what ways does ocean acidification pose a threat to our local community? Regional? National? Global? And what can we do about it?

After giving the groups some time to discuss this question, invite conversation from the whole group to see what consensus can be reached. Be sure to encourage students to support their claims with evidence and reasoning as they discuss in the whole group.

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 6: CLIMATE CHANGE INFOGRAPHIC

The purpose of this activity is for students to summarize and communicate the most important details about the science of climate change using data, text, and other visuals.

For this activity, students will need a basic understanding of what an infographic is and how to use an infographic-creation tool such as Canva, Google Slides, or PowerPoint. Students do not have to create something from scratch (e.g., they can find and repurpose a template), but they can also choose to do something original as well.

First, inform students that they will be working with a group to create an infographic about climate change that will inform others about the basics of it, how it works, the data available to support it, and what can be done about it. Elicit suggestions from the whole group about what makes for a good infographic. Optionally, you can show some sample infographics (not about climate change) to help students select features that they think make for a good infographic. Generate a list of what they mention and then, through discussion, help them arrive at a consensus about what the key features are. That will serve as the success criteria for their projects to focus their thinking and efforts.

Next, through discussion, create a similar outline of what sorts of information about climate change need to be part of their infographics. The list may include things like:

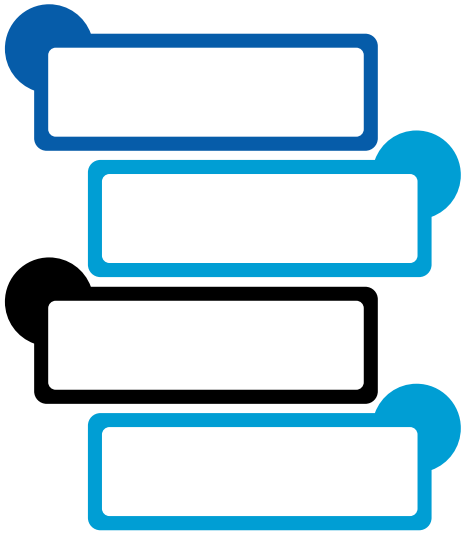
- What is climate change? How do climate/weather compare?
- The impact human activity has on climate change
- The mechanism by which climate change happens
- The effects of climate change
- Data about climate change
- Actions we can take to address climate change

Then, give students work time in class over one or more days to work on their infographics with their groups. Before using the digital tools, students should sketch out their plan for their infographic and get approval by their teacher (or peer feedback) to inform what they do. After receiving feedback, they can begin iterating on their plans using digital tools.

Last, give students the opportunity to share their infographics with others to get feedback and discuss their ideas. This can be accomplished in one of several ways:

1. Groups can present to each other
2. Groups can each present to the entire class
3. Groups can post their infographics in an online gallery to get feedback from their peers or an outside community (e.g., parents, other classes/teachers/peers outside their classroom)

Remember to make sure that any feedback provided to the groups on their infographics is in accordance with the success criteria defined together with them earlier in the activity. Note: you may wish to create a rubric for evaluators to give feedback on the infographics based on the criteria.



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

Image Credit: Great Lakes Now

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.

ARTICLE: HOW DOES CARBON DIOXIDE CAUSE OCEAN ACIDIFICATION?

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

Image Credit: Great Lakes Now

Ocean acidification happens when the seawater around the world becomes more acidic. The organisms in the ocean are used to a certain pH, which is a measure of acidity, but what's more is that they need consistency with pH in order to survive. Even small changes in pH can threaten aquatic life.

The increased acidity of the seawater can make it more difficult for these organisms to build and maintain their shells, which can ultimately affect the entire marine food web. Additionally, ocean acidification can also impact other processes such as nutrient cycles that plants depend on.

The Chemistry of Ocean Acidification

Carbon dioxide and water can react to form carbonic acid. The chemical reaction that occurs when carbon dioxide dissolves in water is as follows:

$$CO_2 + H_2O \rightarrow H_2CO_3$$
$$H_2CO_3 \rightarrow H^+ + HCO_3^-$$

The oceans get acidified by carbon dioxide because when it dissolves in seawater, it reacts with water to form carbonic acid, which can then release hydrogen ions into the water. The "H" in pH stands for hydrogen ions, and pH is a measure of the amount of hydrogen ions in a solution such as seawater. On the pH scale—from 1 to 14—lower numbers indicate more hydrogen ions and more acidic conditions.

The hydrogen ions released from carbonic acid increase the acidity of the seawater, causing the pH of the seawater to decrease. This process is known as ocean acidification. It happens naturally from the carbon dioxide in the air as it meets the water, and it could happen in freshwater or seawater.

But since the oceans cover much more surface area around the earth, there is increased opportunity for ocean water to dissolve carbon dioxide as more carbon-filled air meets water over the oceans.

Once the carbon dioxide is dissolved in the ocean, it can react with the water to form carbonic acid, thus acidifying the ocean. Because we exhale carbon dioxide, and since dry ice is solid carbon dioxide, incorporating those two sources of carbon dioxide into the water in our experiment allowed us to model ocean acidification. Our microsystem illustrated this process by adding more carbon dioxide to the water—by exhaling through the straw or dissolving dry ice into the water—thus producing carbonic acid and acidifying the water more than normal conditions.

Overall, when there is more carbon dioxide present in the air the amount of carbonic acid produced in the oceans can increase. And the more carbonic acid in the water, the more acidic the water becomes. On a very small scale, this shows how emitting more carbon dioxide into the atmosphere can result in more dissolved carbon dioxide in the oceans, produce more carbonic acid, and cause greater ocean acidification—eventually threatening marine ecosystems. Beyond global warming and climate change, ocean acidification is another major concern of excess carbon emissions.

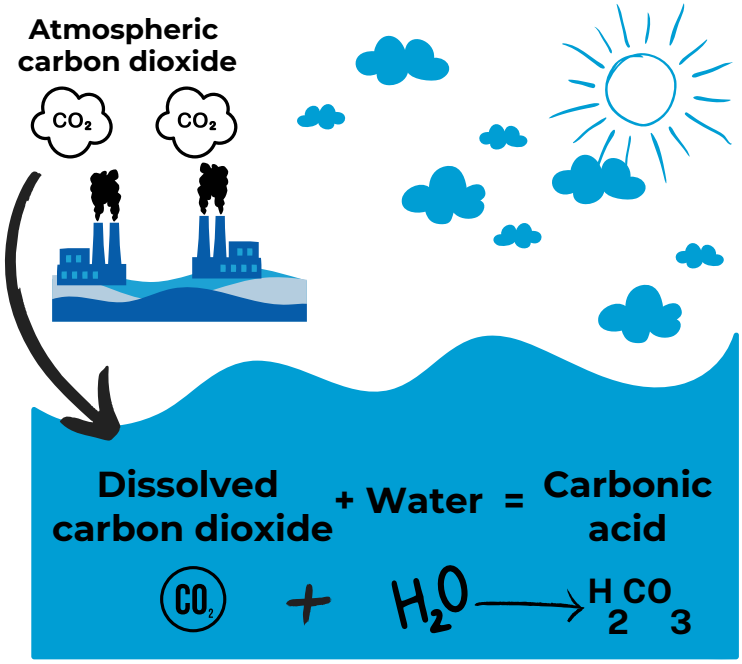


Image Credit: Gary Abud, Jr.

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

NAME: _____

Notice & Wonder Protocol

NOTICE	WONDER
Things that you noticed during the experience	*Things that you wondered after the experience*