

## Outcome

Learners will evaluate oceanographic and other evidence of climate change inclusive of a Mi'kmaw perspective.

## Indicator

Measure climatic indicators using probeware. (CT/T)

## Guiding Question

*How can evidence be used to determine that the earth's climate is changing?*

## Before Beginning this Learning Experience

The greenhouse kit should be set up in advance and a plant should be placed inside. A step-by-step guide to prepare the greenhouse for this investigation can be [found here](#). Additional information for this and other investigations, can be found at [Ayva.ca](http://Ayva.ca).

## Background Knowledge

The Nova Scotia Department of Environment and Climate Change highlights significant impacts in [Weathering What's Ahead: Climate Change Risk and Nova Scotia's Well-being \(2022\)](#). This publication outlines how climate scientists use models to explore different possible climate futures. They base these models on amounts of greenhouse gas emissions. With continued high global emissions, Nova Scotia can expect these climate changes:

- Temperatures will continue to rise.
- We will have less snow and more rain.
- The rain will be more intense.
- Storms will be more frequent and intense.
- The sea level will continue to rise.
- Ocean temperatures, oxygen, and acidity levels will change.

## Introduction to the learning experience

In this learning experience, learners will use the Pasco greenhouse to model and learn about climate change. Learners will explore the research question, "*How does increasing the concentration of carbon dioxide affect the temperature inside the greenhouse?*" They will extend their learning by developing their own testable question(s), gathering information, and communicating their findings.

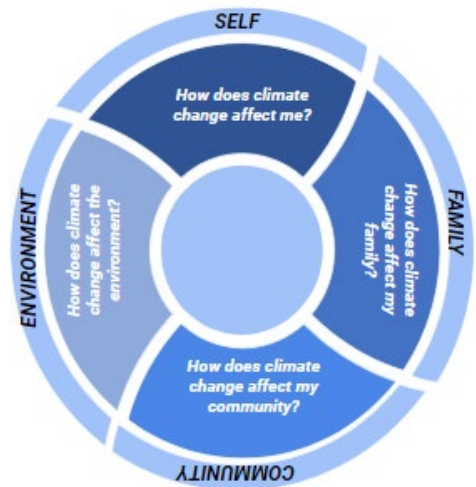
## Inquiring

Teachers may engage learners by facilitating a discussion about climate change specific to Nova Scotia. To support discussion, the infographics found at Climate Change Nova Scotia - Government of Nova Scotia may be useful resources to prompt learners either as a whole class or in small groups.

Teachers can facilitate a discussion about the potential impacts of climate change and the importance of understanding how the climate is changing. Learners could consider the interconnective impacts of climate change by considering direct impacts on self, family, community, and environment.

Questions to guide discussion may include:

- What do we know about climate change? What do we wonder?
- What is contributing to climate change now?
- How would a warming environment impact us, our families, our community, and the environment?
- How/where could water access/flow in our area change over time? How would this impact the biodiversity in our community?
- What changes may happen with increased light intensity?
- How do warming temperatures impact humidity?
- How does humidity change our environment (air, soil, water)?



## Introduction to Data Collection Using the Greenhouse

Teachers can model how to use the PASCO greenhouse to monitor how temperature changes over time after carbon dioxide is added to the greenhouse. This is a good opportunity to reinforce student understanding of *independent, dependent, and controlled variables*.

The teacher and learners should discuss how to collect data to ensure accuracy and reliability. Learners may require explicit instruction and support to code the program to operate the greenhouse.

Teachers can discuss with learners how the greenhouse uses sensors to collect, measure, and record data. They can prompt learners to think about data collection with questions such as:

- How often should we collect the data?
- How do we want to display the data?

For this investigation, learners will explore the impact of increasing the amount of carbon dioxide inside the greenhouse. This can be modeled in several ways (e.g. add carbonated water or other sources of carbon dioxide to the greenhouse). In this example, Alka Seltzer tablets added to water will provide the source of carbon dioxide. This is intended to model increased global CO<sub>2</sub> emissions. It may be worthwhile to allow students to investigate how carbon dioxide levels change using the CO<sub>2</sub> sensor before beginning the rest of this investigation. Learners should then be asked to predict what will happen to the temperature when carbon dioxide is added to the greenhouse.

## Modeling the Effects of Carbon Dioxide on Temperature

Teachers can model the effects of carbon dioxide on temperature by following this procedure:

1. [Setup the greenhouse](#) to monitor temperature.
2. Have the class reflect on their hypotheses:
  - What do we think will happen?
  - How quickly do you expect the temperature to change, if at all?
  - How much change in temperature do you expect?
3. Add the Alka-Seltzer tablet (CO<sub>2</sub> source) to a beaker of water inside the Greenhouse.
4. Hit "Start" to begin collecting data (the lights should turn on).

### Resources to support the operation of the greenhouse

- [Step-by-step guide](#)
- [Nova Scotia Greenhouses – AYVA Educational Solutions.](#)

5. As a class, monitor the temperature change after the addition of CO<sub>2</sub>.

Teachers may wish to discuss the results with guiding questions such as:

- Do the results support your hypothesis?
- How did the temperature change?
- What do these results tell us about the impact of carbon dioxide levels on temperature?
- How does this model represent what is happening in the environment, and in what ways does it differ?

## Finding Evidence

After discussing the results of the greenhouse demonstration, teachers can have students think about the implications of temperature changes through the following question:

- How could increasing temperatures have implications for other environmental variables such as soil moisture, oxygen levels, carbon dioxide levels, light intensity and relative humidity?

Based on their conversations, learners will be asked to generate their own testable questions that can be answered through the design and running of an experiment. This may be investigated in small groups, pairs, or independently.

Learners may require explicit instruction to develop a testable question that is open-ended and identifies both the independent and dependent variables.

The teacher can facilitate a brainstorming session to generate questions that will allow learners to use the greenhouse to model and measure climate change. This may reflect the conditions in their local area and take into consideration the uniqueness of their communities. Teachers could consider using two greenhouses to compare results over a longer time frame, such as comparing the oxygen levels between greenhouses with different numbers of plants (few plants vs several plants). Some examples may include:

### How does (independent variable) affect (dependent variable)?

Independent variable	Dependent variable
<ul style="list-style-type: none"> <li>▪ CO<sub>2</sub> level</li> <li>▪ Soil moisture</li> <li>▪ Light intensity</li> <li>▪ Wavelength (coloured lights - red, blue or purple)</li> <li>▪ Temperature</li> <li>▪ Plant types (local vs. tropical)</li> <li>▪ Germination (types of seeds)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Temperature</li> <li>▪ Soil moisture</li> <li>▪ Oxygen levels</li> <li>▪ CO<sub>2</sub> levels</li> <li>▪ Light intensity</li> <li>▪ Relative humidity</li> </ul>

As learners refine their questions, the teacher should provide feedback that will guide learners towards developing a question to measure the impact of climate change.

Learners can devise a method to carry out their experiments and gather information. Alternatively, learners may be placed into groups to discuss the various experimental designs and one design can be chosen to be conducted. Another option is to refine the experimental designs as a group to include elements from several members of the group into one design. The refined design can then be carried out. A graphic organizer (sample provided at the end of this learning experience) could be used to guide students through the process of designing and carrying out an experiment. The graphic organizer can provide evidence of learning to help the teacher determine how they can support students for greater success.

## Communicating

Learners will communicate their findings in a variety of ways. Learners may be asked to reflect on how they have grown their understanding. This may be achieved in various ways (e.g. visual displays and data analysis, presentation, recordings of observations, and journal reflections). Learners may communicate their findings by exploring the following questions:

- Based on the measurements that you collected using the greenhouse, what can you conclude?
- How do your measurements compare to, support, or refute those of your classmates?
- How is your conclusion supported by scientific evidence regarding climate change?
- What additional questions about climate change could be answered by measuring variables in the greenhouse?

## Assessment

Teachers can gather evidence of learning in a variety of ways. Formative assessment can occur at various stages of the process as the teacher engages in conversations and observes learners. Summative assessment may take place as learners communicate the results of their investigations. This could be in the form of observations, conversations, and/or products.

## Next steps

Learners may wish to extend their learning by exploring impacts of climate change outside of the greenhouse in their communities. This may include ways to mitigate and adapt to the effects of climate change due to human activity.

## Additional Resources

- [Classroom Use Presentation](#)

### Websites

- [Climate Atlas of Canada](#)

### Articles

- [Interpreting Climate Data](#)
- [High vs Low Carbon | Climate Atlas of Canada](#)
- [Netukulimk](#)

## Greenhouse Learning Experience Sample Graphic Organizer

Testable Question :		
Independent Variable:	Dependent Variable:	Control Variables:
Hypothesis:		
Materials:	Location:	
Observations:	Data Gathered:	
Summary of Findings:		