

Changing Climate

Environmental Cycles

High School Guide

REACH Up

Raising Educational Achievement
through Cultural Heritage Up

Changing Climate

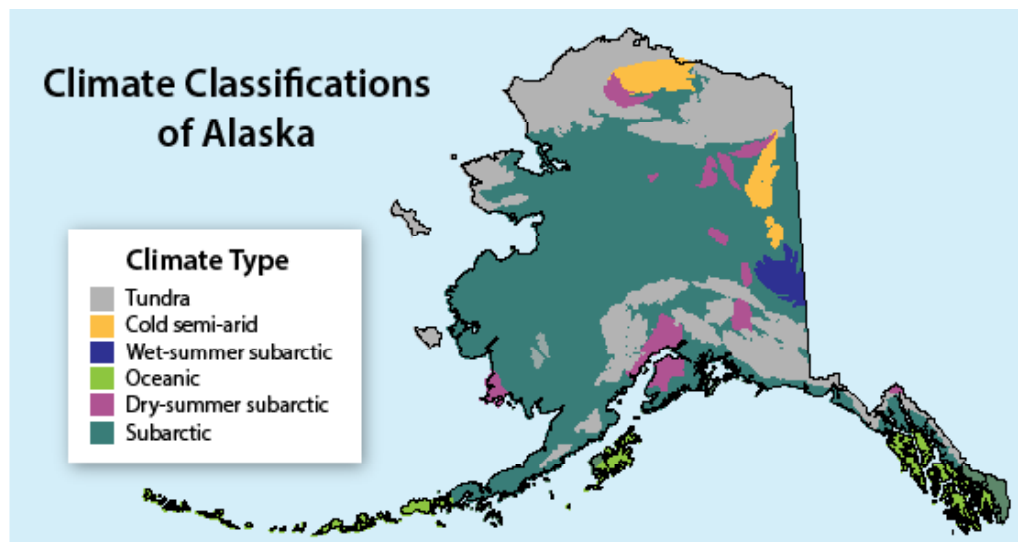
What is Climate?

Climate is the long-term average of weather conditions that occur in a particular region. The Bering Strait region of Alaska includes subarctic and tundra climates. Subarctic climates are characterized as having their coldest months average below 0°C (32°F) and at least one month that averages above 10°C (50°F). Much of Alaska has a subarctic climate in which there is no significant difference in the amount of precipitation between seasons. Some areas get most of their precipitation in winter (dry summer subarctic), while other areas receive most of their precipitation in summer (wet summer subarctic.) The tundra climate is characterized by temperatures that average below 10°C (50°F) in the warmest months. The tundra climate is a subcategory of polar and alpine climates; the other subcategory of polar climate is an ice cap climate, where all twelve months of the year average below 0°C (32°F). Which climate classification describes your community?

Residents across the Bering Strait region report changes to the local climate. Scientists, both local and distant, are working to understand this climate change. The changes have been so extensive and persistent that a New Arctic is emerging.

The New Arctic is warmer, with less sea

ice and shorter winters. In the New Arctic, permafrost is thawing and glaciers are shrinking. Measuring and understanding climate change requires collecting data about the weather and environmental conditions in the area over a long period of time. Both qualitative data (the use of words to describe what is observed) and quantitative data (the use of numbers to describe what is observed) are used in climate science. Qualitative data might include descriptions of visual environmental observations, oral histories of extreme weather events, and photographs of sea ice conditions. Quantitative data about weather, such as temperature, wind speed, and snow depth can be gathered using instruments. What qualitative and quantitative environmental observations do you make? When and why do you observe weather?



Map based on Wikimedia map "Köppen Climate Types of Alaska." Source: WorldClim.org.

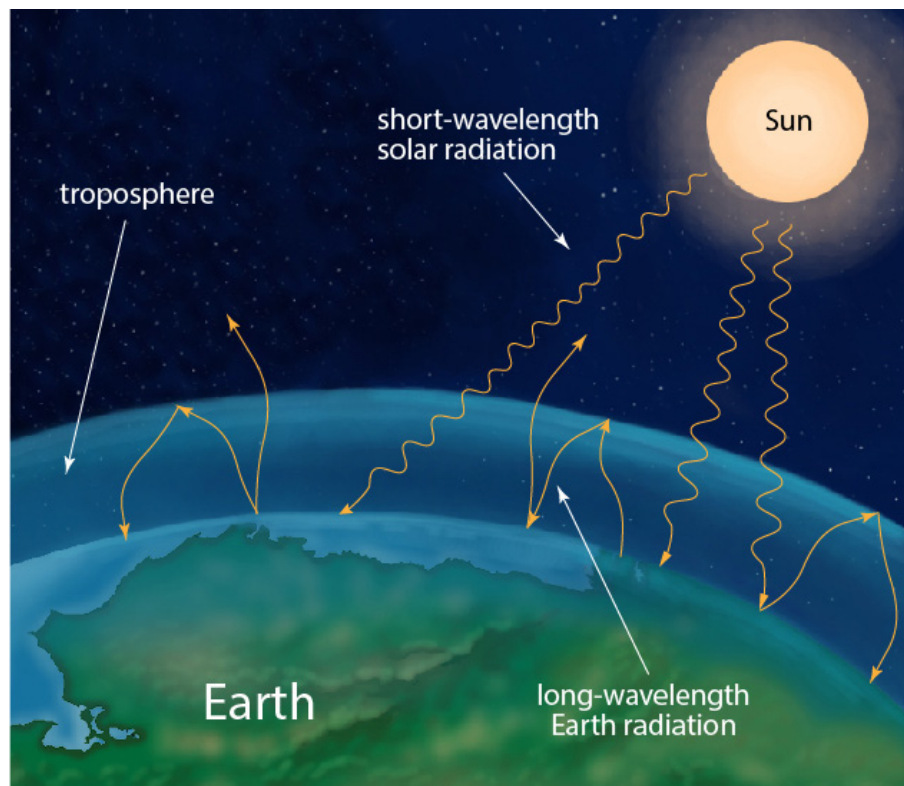


The Greenhouse Effect

Greenhouse effect is a warming of Earth's surface and the lowest layer of the atmosphere, called **troposphere**. When the Sun's energy reaches Earth's atmosphere, some of it is reflected back to space while the rest is absorbed and reabsorbed by **greenhouse gasses**.

Greenhouse gasses (GHGs) include water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), ozone (O_3), nitrous oxide (N_2O), and some industrial chemicals such as chlorofluorocarbons (CFCs).

The absorbed energy warms the atmosphere and the surface of the Earth. This process maintains the Earth's temperature at around $14^{\circ}C$ ($57^{\circ}F$). Without an atmosphere and GHGs, the Earth's temperature would be around $-19^{\circ}C$ ($-2^{\circ}F$). The atmosphere and GHGs ensure favorable conditions for life on Earth.

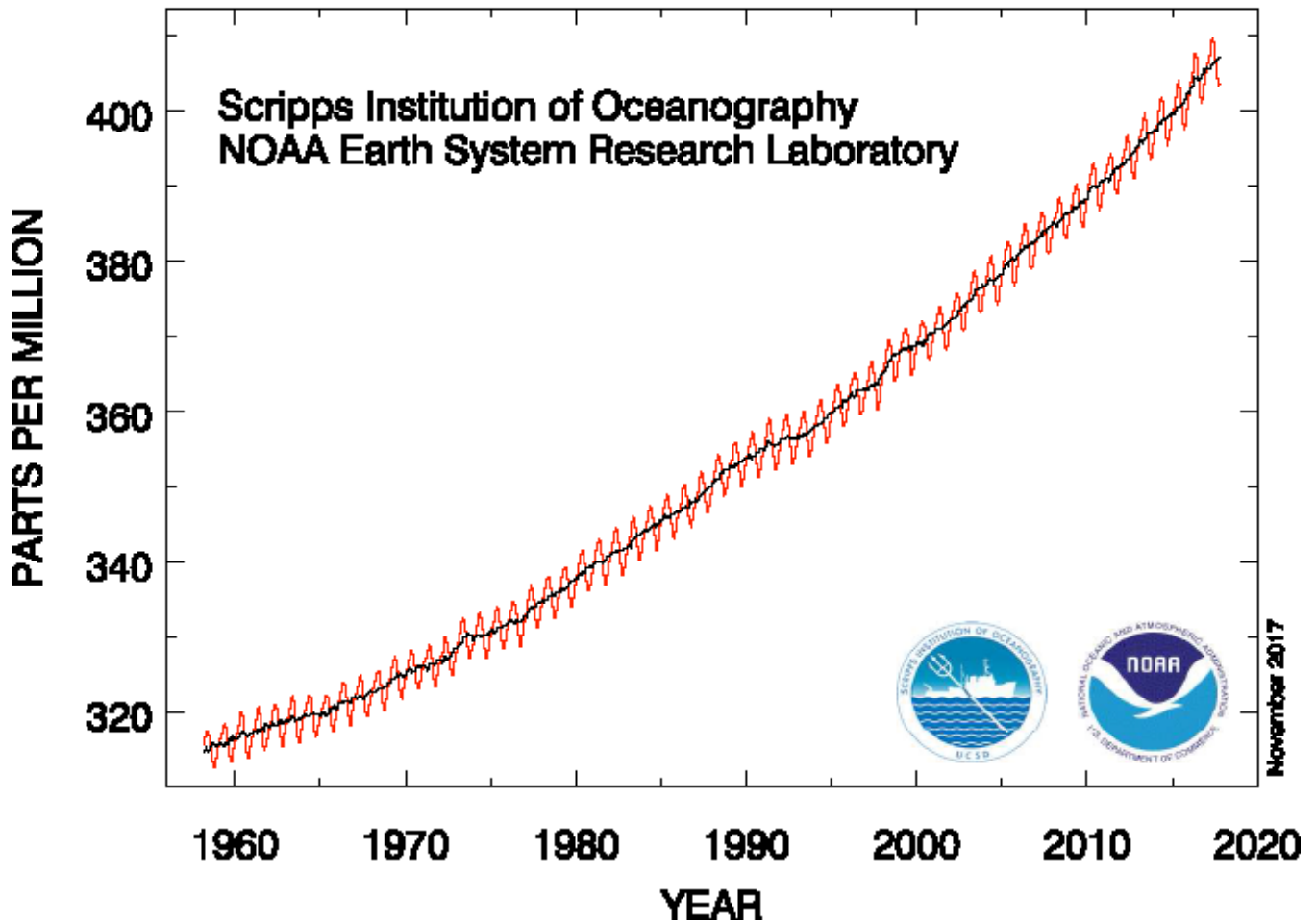


Three main factors that influence the greenhouse effect include: 1) the total energy influx from the sun, 2) the chemical composition of the atmosphere (what gasses are present and in what concentrations), and 3) **albedo**, or how much light that hits the Earth's surface is reflected back into space.

The only factor that has significantly changed in the past 200 years is the chemical composition of the atmosphere, due to human activities. Human activities, particularly burning fossil fuels (coal, oil, natural gas), agriculture, and land clearing, are increasing the concentration of GHGs. This enhanced greenhouse effect is contributing to warming of the Earth.



Atmospheric CO₂ at Mauna Loa Observatory



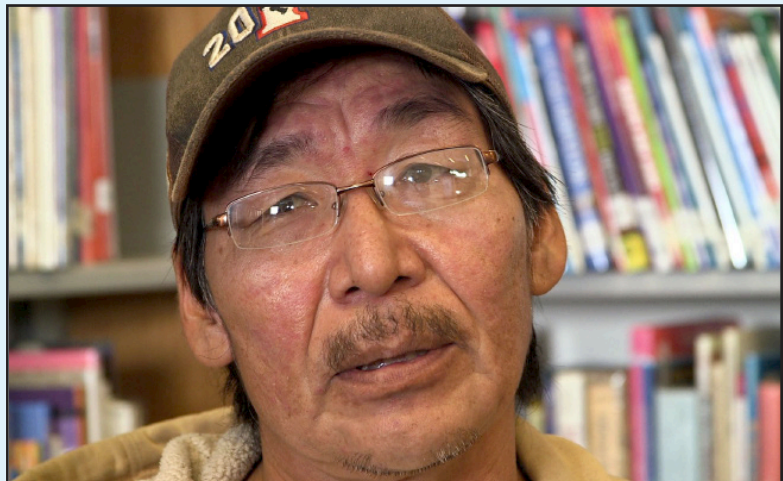
The graph shows the steady increase in atmospheric carbon dioxide measured at Mauna Loa Observatory in Hawaii between 1958 and 2017. The red curve represents the carbon dioxide data and the black curve represents the seasonally corrected data. Source: NOAA Earth System Research Laboratory, Global Monitoring Division.



Ask an Expert

1. Watch the video *Environmental Cycles* available at www.k12reach.org/videos.php.
2. Interview elders or cultural knowledge bearers in your community. Some questions you may want to ask:
 - Do you harvest clams and other shellfish? Have you witnessed any changes such as the amount, types, and locations of shellfish available over the years? Could you describe the changes?
 - How do you heat your home? Have materials used for heating changed over the years? Could you describe the changes? How did people heat their homes in the past?
 - What do you use for transportation when hunting or shipping goods? Has the means of transportation changed over the years? Could you describe the changes?
3. If the person you interview speaks an Alaska Native language, ask them what language and dialect they are familiar with. Ask them to please translate the following words:

- atmosphere
- climate
- coal
- cold water
- fuel oil
- natural gas
- sun
- warm water



Sean Komonaseak, from the community of Wales, discusses methane and ocean acidification in the *Environmental Cycles* video. Photo: Kelsey Skonberg, REACH Up.

Compare your words with the translations on the Environmental Cycles Vocabulary page in this guide. Are any of the terms the same or similar?



Environmental Cycles Vocabulary

Would you like to know Alaska Native language terms related to environmental cycles?

Work with your classmates to practice environmental cycle vocabulary words in English and the indigenous language of your community. Your teacher will give you vocabulary cards with the English word and an illustration on one side. Write the corresponding indigenous term on the blank line on the back of each card. Use the words that you learned from a local elder or cultural knowledge bearer, or choose the translation below that is closest to your community.

Miriam Toolie - Siberian Yupik
St. Lawrence Island Yupik dialect
Savoonga, AK

atmosphere - **aklighyaget**
climate - **eslavut**
coal - **puyuq**
cold water - **nengleketeghllak**
fuel oil - **mesiiq**
natural gas - **mesiiq**
sun - **siqineq**
warm water - **negh'liimaq meq**

Becky Atchak - Yup'ik
Northwest dialect
Stebbins, AK

atmosphere - **cella**
climate - **ella**
coal - **qetek**
cold water - **kumlaq**
fuel oil - **uquq**
natural gas - **uquq**
sun - **ak'erta**
warm water - **puqla**

Jolene Nanouk - Iñupiaq
Qawiaraq dialect
Unalakleet, AK

atmosphere - **sila**
climate - **sila simaktuq**
coal - **itniwium uquqsautaq**
cold water - **imiq alapaaqtuq**
fuel oil - **uqsruq**
natural gas - **igliktuat uqsruat**
sun - **masaq**
warm water - **uqquqtuq imiq**



The Greenhouse Effect

As we learned earlier in this student guide, human activities have significantly changed the chemical composition of the atmosphere over the past 200 years. Burning fossil fuels, land clearing, and agriculture have increased CO₂ levels in the atmosphere, which contributes to warming of the Earth.

In the experiment below, we will test how increased levels of CO₂ affect the temperature inside a bottle when exposed to heat.

Materials

- Two clear 2L plastic bottles
- Ruler
- 150W light fixture
- 150W incandescent light bulb
- 250ml beaker (to measure water)
- Water (200ml for each bottle)
- Effervescent tablet
- Aluminum foil
- Data logger and two temperature sensors (or thermometers)
- Timer

Procedure

You will need to work as a team to conduct this experiment. You will have two water samples: a control bottle and an experimental bottle.

1. Turn on the data logger.
2. Connect two temperature sensors to the data logger.
3. Add 200 ml of water to each bottle.
4. Screw the light bulb in the light fixture. Set up the lamp on the table so it will face away from the rest of the class. Do **NOT** turn it on yet.



Activity

5. Place the bottles next to each other side by side (very close but not touching each other), about 15cm (6 inches) away from the lamp. Both bottles need to be exactly the same distance from the lamp.
6. Carefully put a temperature sensor in one of the bottles. The sensor should **NOT** touch the water or the side of the bottle. Use aluminum foil to seal the bottle and also hold up the temperature sensor. Make sure that the foil closes the bottle opening completely but does not cover the body of the bottle. This is your *control* bottle.



7. Break an effervescent tablet in half and place both pieces in the second bottle. Immediately place the second temperature sensor into the bottle, making sure that the sensor is not touching the water or the side of the bottle, and close the top with aluminum foil as with the first bottle. This is your *experimental* bottle.
8. Quickly read the temperature of both control and experimental bottles and record it in the table on the worksheet, next to "0 minutes."
9. Turn on the lamp. **Note:** Be careful with the lamp, as it can get very hot. Make sure it shines on both bottles evenly. Do **NOT** move the bottles or lamp during the experiment.



10. Set the timer. Have one teammate watch the timer. Record the temperature in both bottles every two minutes for the next ten minutes.
11. Turn off the lamp. Clean up your station.
12. Graph your results: use the data in the table on the worksheet to make a graph showing the temperatures in the control and experimental bottles.

Discuss

- What was the same in the control and experimental bottles? What was different?
- Did the temperature in the control bottle go up? How about the temperature in the bottle that contained the CO₂?
- Did you observe any difference between the temperatures in the bottles? If yes, describe the difference and explain why.
- What is a possible implication of this experiment to increased levels of CO₂ in the atmosphere and the Earth's temperature?



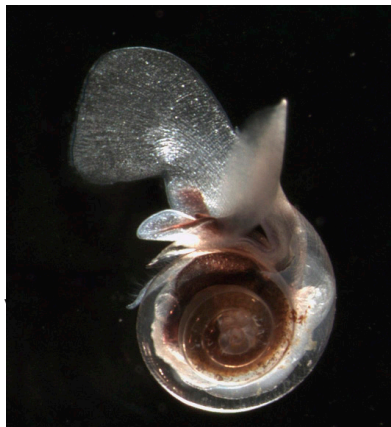
Ocean Acidification

Carbon Dioxide and Ocean Acidification

Among the greenhouse gasses, water vapor has the largest warming effect. Scientists have found, however, that the amount of carbon dioxide (CO₂) has increased exponentially due to human activities over the past two centuries.

CO₂ in the atmosphere acts like a blanket over the Earth by trapping longwave radiation, which would otherwise radiate heat away from the Earth. As CO₂ increases, so will its warming effect. As part of the carbon cycle, the ocean takes up CO₂ from the atmosphere. When CO₂ is absorbed by ocean water, chemical reactions called **ocean acidification** occur. One of the reactions includes the reduction of ocean water **pH**, making the water more acidic. Too much carbon can accelerate acidification of ocean water, which can have adverse effects on small organisms that fish and marine mammals feed on.

The ocean is crucial to weather and climate as it dominates the carbon cycle of the Earth. The ocean has a significant influence on climate change by absorbing, storing, and moving heat, carbon, and water. A slight change in the pH level, therefore, can have a major impact on the environment.



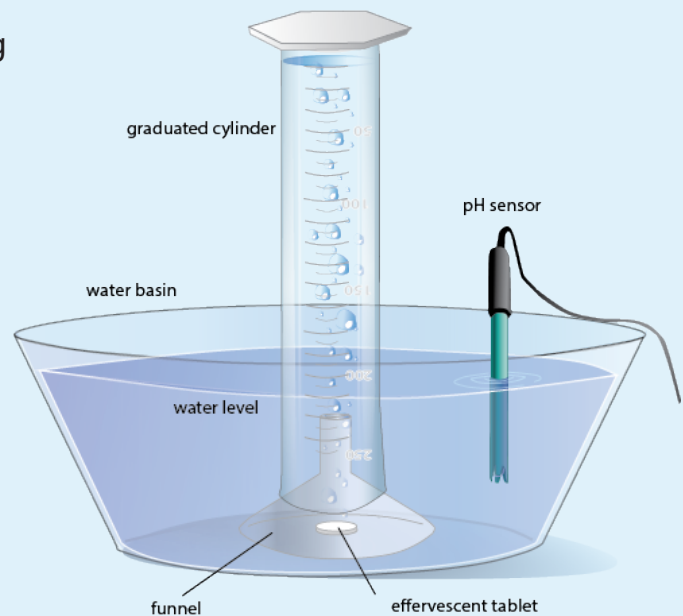
Pteropods (Left and middle: *Limacina helicina*, commonly known as “sea butterfly.” Right: *Clione limacina limacina* or “sea angel.”). The pteropod is a tiny, shell-building sea snail that serves as a staple food for plankton, fish, whales, and seabirds. Pteropods are an important component of the food web in Alaska’s seas and can make up an important part of the diet of young salmon. The pteropod is one of the marine organisms most threatened by ocean acidification. Photos: Russ Hopcroft, UAF College of Fisheries and Ocean Sciences Institute of Marine Science.



Water Temperature and CO₂ Solubility

Materials

- Clear basin
- Pitcher
- Temperature sensor (or thermometer)
- 250ml graduated cylinder, approx. 4-cm (1 ½-inch) opening
- Funnel, approx. 6-cm (2 ¼-inch) opening
- Cold water and ice cubes
- Warm water
- Index cards
- Effervescent tablets
- Data logger
- pH sensor
- Dry erase marker
- Worksheet (or notebook)



Predict!

1. When water absorbs CO₂, will the water become more acidic or more basic, or have no change at all?
2. Which can hold a higher concentration of CO₂, warm water or cold water?

Procedure

You will need to work as a team to conduct this experiment. You will have two water samples: cold water and warm water.

Part 1: Cold Water

1. Turn on the data logger.
2. Connect the pH sensor and temperature sensor to the data logger.
3. Fill a pitcher with cold water, add a few ice cubes, and stir. Check that the temperature of the water is 0-2°C (32-35°F).



Activity

- Fill the graduated cylinder to the brim with the cold water from the pitcher (do not allow any ice cubes to go into the cylinder). Fill the water basin 3/4 full with the cold water and ice cubes from the pitcher.
- Use a dry erase marker to mark the top level of water in the basin.
- Place an index card on the mouth of the graduated cylinder. Holding it in place with the palm of one hand, carefully flip the cylinder upside down with the other hand into the basin. Take care so that no air gets in the cylinder (or minimal air). Once the opening of the graduated cylinder is immersed in the water, remove the index card.
- Hold the upside-down cylinder steady by hand and place a funnel in the mouth of the graduated cylinder. Take care so there is no space between the funnel and the mouth of the graduated cylinder and that no air bubble forms inside of the graduated cylinder.
- Use a dry erase marker to mark the top level of the water in the inverted graduated cylinder. Record it in the chart on the worksheet, under "Initial water level" (#2).

	Initial water level (ml)	Final water level (ml)	Volume of CO ₂ gas in the cylinder (ml) (Final water level - Initial water level)
Cold Water	10	15	5
Warm Water	10	15	5

- Hold a pH sensor straight into the water and measure the pH level of the water in the basin. Make sure that the sensor's tip is not touching the bottom or side of the basin. When the reading steadies, record it in the chart on the worksheet, under "Initial pH level" (#3). Have one teammate keep the pH sensor steady in the water basin until the final reading (Step #12).

	Initial pH level	Final pH level	Change in the pH level (Initial pH level - Final pH level)
Cold Water	7	6	1
Warm Water	7	6	1



10. Place an effervescent tablet under the funnel. Make sure that your hand is dry when you touch the effervescent tablet so it won't dissolve in your hand and that you place the tablet quickly.
11. Observe how an air space develops on top of the upside-down graduated cylinder. The gas bubbles are CO_2 .
12. As soon as the tablet is dissolved, measure the pH level again. Record the result in the chart, under "Final pH level" (#3). You may remove the pH sensor from the water basin.
13. Use a dry erase marker to mark the top level of the water in the inverted cylinder. Record it on the chart, under "Final water level" (#2).
14. Record the volume of the CO_2 gas formed. Subtract the number you obtained at the first reading of the water level (#8) from the number at the final reading (#13). **Note:** If the cylinder is not graduated all the way to the bottom, use a ruler to calculate the volume of CO_2 .
15. Record the change in the pH level. Subtract the number you obtained at the final reading of the pH level (#12) from the number at the first reading (#9).
16. When all the data has been recorded, erase the water level marks on the cylinder. Leave the water level mark you made on the basin (you will need it at the next step). Rinse the tip of the pH sensor (do **NOT** touch the tip), cylinder, funnel, and inside of the basin, so you can use them again in Part 2 with warm water.

Part 2: Warm Water

1. Repeat steps 3 and 4 from Part 1; only this time, use warm water in the graduated cylinder and basin. Try to have the water temperature about 30-35°C (85-95°F). Make sure to use the same amount of warm water in the basin as the cold water you used earlier. Use the mark you made in Part 1 step #5 as a guide.
2. Repeat steps 6 through 15 from Part 1.
3. When all the data has been recorded, rinse the tip of the pH sensor (do **NOT** touch the tip), gently dab with paper towel or cloth to dry it, and place it carefully back into the storage solution bottle. Make sure that the tip of the pH sensor does not touch the bottom of the bottle. Clean up the station.



Discuss

Share the results with the class. As a class, pool your data for the cold and warm water samples separately and calculate an average for each water sample (#5 on the worksheet).

- Did you find any difference in the pH level after the tablet was dissolved (i.e., CO_2 was released into the water)? Did the water become more acidic or more basic? Which showed a greater change in the pH level, cold water or warm water?
- Did you find any difference in the volume of CO_2 gas formed in the graduated cylinder between cold water and warm water? Which produces a larger volume of gas inside the graduated cylinder, cold water or warm water? Which holds a higher concentration of CO_2 , cold water or warm water?
- What are the potential consequences of warming oceans?
- How will the role of oceans as a carbon sink change with warmer ocean water?







REACH Up, K-12 Outreach Office
School of Education, University of Alaska Fairbanks
P.O. Box 755400
Fairbanks, AK 99775
www.k12reach.org