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Introduction

Thank you for using this Raising Educational Achievement through Cultural Heritage Up (REACH Up) unit in your classroom! The lessons are designed to address the Alaska Science Standards and Grade Level Expectations, Alaska Cultural Standards and the Bering Strait School District Scope and Sequence goals. All of the activities focus on infrastructure and related changes from Alaska Native cultural, physical and earth science perspectives. This supplemental unit addresses the place-based question: How is climate change affecting infrastructure in our area and why are these changes important to our community?

The REACH Up Environmental Cycles unit consists of four activities. Each activity will require a 45-minute class period; discussion could easily be extended into multiple class periods. You may also want to repeat sections of an activity during subsequent class meetings, such as reviewing the Environmental Cycles video or having your students practice the vocabulary card games multiple times. If you are utilizing the entire Environmental Cycles unit, you should introduce the activities in the order they are presented. However, if time is short, any of the activities could be presented independently.

The accompanying student guide is intended for use with multiple groups of students and you should not allow students to write in them. You can either have students record their work on a separate sheet of paper, or create copies of the corresponding worksheets that are included in this teacher's guide.

Whole Picture

Residents across the Bering Strait region are witnessing changes to their local climate and environment. A lot of those changes are due to the greenhouse effect, or a warming of Earth's surface and troposphere (the lowest layer of the atmosphere).

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 (GHGs), including water vapor (H2O), carbon dioxide (CO2), methane (CH4), ozone (O3), nitrous oxide (N2O) and some industrial chemicals such as chlorofluorocarbons (CFCs).

The absorbed energy warms the atmosphere and the surface of the Earth by trapping longwave radiation, which would otherwise radiate heat away from the Earth. This process makes it possible for life on Earth to survive.

An excess presence of GHGs, however, causes warming of the Earth. Among the main factors that influence the greenhouse effect (the total energy influx from the sun, the chemical composition of the atmosphere—what gasses are present and in what concentration, and albedo–how much light that hits the Earth's surface is reflected back into space), the chemical composition of the atmosphere is the only factor that has significantly changed in the past 200 years.

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 the dominant cause of the observed warming of the Earth, according to the Fourth National Climate Assessment, Vol. 1, Climate Science Special Report.

Possible consequences of warming climate are multi-fold. An example is an ongoing reduction in the pH in the ocean water, known as ocean acidification. As part of the carbon cycle, the ocean takes up CO2 from the atmosphere, but too much carbon can accelerate acidification of the 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.

Research has shown an increasing trend of rising ocean temperatures in the Arctic. For example, the National Oceanic and Atmospheric Administration's Arctic Report Card 2017, a peer-reviewed annual update of environmental conditions in the Arctic, describes that the surface sea temperatures in the Arctic are rising at a speed incomparable in at least the past 2,000 years. It is becoming well known that summer sea ice is predicted to disappear in the Chukchi Sea by 2050, and winter sea ice could decrease by 50% in the Bering and Chukchi Seas by the end of the 21st century.

Climate change also has potential health impacts as a newly published report by the Alaska Department of Health and Social Services states, ranging from increased accidents and injuries, poorer mental health and wellbeing, to compromised access to water and sanitation and decreased food security.

Alaska is warming at a rate two to three times faster than the mainland United States. Environmental changes are increasingly forcing communities to adapt more quickly than expected. Thriving communities in Alaska will benefit from young people who can help adapt to rapid climate change by learning about effects of greenhouse gasses such as CO2 on the environment locally and globally. Their innovative thinking of how to reduce the amount of CO2 release as individuals and as a community will be a tremendous asset to solving these problems associated with global warming.

References

Fourth National Climate Assessment, Vol. 1, Climate Science Special Report
https://science2017.globalchange.gov

Assessment of the Potential Health Impacts of Climate Change in Alaska. 2018. Alaska Department of Health and Social Services.
http://www.epi.alaska.gov/bulletins/docs/rr2018_01.pdf

Arctic Report Card 2017, National Oceanic and Atmospheric Administration.
http://www.arctic.noaa.gov/Report-Card

Unit Vocabulary

Science Terms to Define	
albedo	the proportion of the incident light or radiation that is reflected by a surface of a planet -- commonly refers to the "whiteness" of a surface, with 0 meaning black and 1 meaning white.
greenhouse effect	an increase in the average temperature of the Earth, due to certain gasses absorbing infrared heat that would normally be radiated into space
greenhouse gasses	gasses that contributes to the greenhouse effect by absorbing infrared radiation, such as water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), and ozone (O_3)
ocean acidification	a reduction in the pH of the ocean over an extended period of time, caused primarily by uptake of carbon dioxide (CO_2) from the atmosphere
pH	a figure expressing the acidity or alkalinity of a solution on a scale on which 7 is neutral, lower values are more acid, and higher values are more alkaline
troposphere	the lowest layer of Earth's atmosphere

Terms for Incorporating Local Indigenous Language				
English	**Iñupiaq**	**Yup'ik**	**Siberian Yupik**	**Local Translation**
atmosphere	sila	cella	aklighyaget (highest level) aghtuneq (lowest level)	
clam	abyaq (blue mussels)	aliruaq (razor)	imanaq	
climate	sila simiktuq	ella	eslavut	
coal	itniwium uquqsautaq	qetek	puyuq	
cold water	imiq alapaaqtuq	kumlaq	nengleketeghllak	
fuel oil	uqsruq	uqurkaq	mesiiq	
natural gas	igliktuat uqsruat	uquq	mesiiq	
sun	masaq	ak'erta	siqineq	
warm water	uqquqtuq imiq	puqla	negh'liimaq meq	

Activity HS.2.1: Ask an Expert

Overview

In this activity, students will interview an Elder or cultural knowledge bearer.

Objectives

On successful completion of the lesson, students will be able to:

- demonstrate effective interviewing techniques
- interpret qualitative data from interviews
- describe how harvesting practice, heating materials, and means of transportation changed over the years
- explain how climate change is affecting the environment in the local community

Alaska Standards

Alaska Science Standards / Grade Level Expectations

SA1: The student demonstrates an understanding of the processes of science by

[9] **SA1.1** asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring and communicating

[10] **SA1.1** asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring and communicating

[11] **SA1.1** asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring and communicating

SC3: The student demonstrates an understanding that all organisms are linked to each other and their physical environments through the transfer and transformation of matter and energy by

[11] **SC3.2** analyzing the potential impacts of changes (e.g., climate change, habitat loss/gain, cataclysms, human activities) within an ecosystem

Alaska Cultural Standards

[**B**] Culturally-knowledgeable students are able to build on the knowledge and skills of the local cultural community as a foundation from which to achieve personal and academic success throughout life. Students who meet this cultural standard are able to:

[**B.2**] Make effective use of the knowledge, skills, and ways of knowing from their own cultural traditions to learn about the larger world in which they live.

[D] Culturally-knowledgeable students are able to engage effectively in learning activities that are based on traditional ways of knowing and learning. Students who meet this cultural standard are able to:

[D.4] gather oral and written history information from the local community and provide an appropriate interpretation of its cultural meaning and significance.

[E] Culturally-knowledgeable students demonstrate an awareness and appreciation of the relationships and processes of interaction of all elements in the world around them. Students who meet this cultural standard are able to:

[E.4] determine how ideas and concepts from one knowledge system relate to those derived from other knowledge systems.

Bering Strait School District Scope & Sequence

9.9H Analyze the potential impacts of changes (climate change, habitat loss/gain, cataclysms, human activities) within an ecosystem. (SC3.2)

9.9I Develop an understanding of the dynamic relationships among scientific, cultural, social, and personal perspectives (hunting, fishing). (SF)

10.5A Understand concepts related to Earth's atmosphere (SD3.1)

10.5D Describe causes, effects, preventions, and mitigations of human impact on climate (SD 3.1)

- Global warming/climate change

10.9A Recognize the importance of Earth's ocean as a component of Earth Science. (SD2)

10.9C Identify the composition of seawater.

- Temperature

10.9D Understand the diversity of sea life.

- Plankton

10.10E Identify which energy resources are fossil fuels.

11.7E Students develop an understanding of the dynamic relationships among scientific, cultural, social and personal perspectives. (SF)

Materials

- REACH Up High School Student Guide: Environmental Cycles
- Student Worksheet: Ask an Expert about Environmental Cycles
- Internet access and projector

Activity Preparations

1. Identify adults within your school who have lived year-round in the community for many years. This might include teachers, administrators, secretaries, teacher aides, lunchroom/kitchen staff, recess duties, maintenance and custodial staff, etc. Ask these local knowledge bearers if they would be willing to speak with a group of your students about environmental changes and how those changes have affected the community. Make sure that the volunteers you have identified will be available during the time that your class will be completing this activity.
2. Ask the volunteers if they speak an Alaska Native Language, and if so, which language(s) and dialect(s) they are familiar with. If applicable, have them translate the written words on the student worksheet, so you have an answer key. Also, ask them to teach you the pronunciation of the terms.

Activity Procedure

1. Distribute the REACH Up High School Student Guide: Environmental Cycles and ask students to work with a partner to read pages 1-4.
2. Show the video, Environmental Cycles, available at www.k12reach.org/videos.php. Videos are located under the Multimedia tab. Allow time for students to share comments and ask questions.
3. Explain that students will interview a community member about environmental changes. Separate students into small groups according to how many knowledge bearers are available to share information with your class. Explain if the appointed interviewees speak an Alaska Native Language, so students know whether or not they should pursue that portion of the interview.
4. Review expectations for student behavior while conducting the interview, including introductions and thanking the interviewee at the end of the interview. Discuss suggestions for effective interviewing techniques, such as allowing ample time for the interviewee to answer, and asking follow-up questions.
5. Distribute one Student Worksheet: Ask an Expert about Environmental Cycles to each group and assign each group one local knowledge bearer to interview. Provide 15-20 minutes for students to locate and interview the knowledge bearer.
6. Reconvene in the classroom and ask groups to share their findings. How has the shellfish harvesting practice changed? Have the materials used for heating changed? Has the means of transportation changed? What kinds of environmental changes have been experienced? What impacts might the changes have on local lifestyles? If your students learned local indigenous words for the vocabulary terms, compare their translations with the translations found on page 5.

STUDENT WORKSHEET: ***Ask an Expert about Environmental Cycles***

Names of Group Members: ____

Interview a long-term community member to learn more about environmental changes in your area. Take notes about what you learn.

Who did you interview? ____

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?

Could you tell me about changes you have noticed in the environment over the years?

For example:

- the ocean (sea ice conditions, waves)
- weather (more or less snow/rain/wind in different seasons)
- vegetation (types and area of vegetation, height of trees, amount of shrubs)

Have people in our community made any changes to their lifestyles due to the environmental changes you have described?

Other notes:

For Alaska Native Language Speakers:

What language(s) do you speak? ____

What dialect(s)?__________________________________

Could you translate the following words?

atmosphere: ____

climate: ____

coal: ____

cold water: ____

fuel oil: ____

natural gas: ____

sun: ____

warm water: _______________________________________

Activity HS.2.2: Environmental Cycles Vocabulary

What terminology do we need to know to discuss environmental cycles?

Overview

In this activity, students will learn key environmental cycle terminology in English and their local Alaska Native language by playing vocabulary games with peers.

Objectives

On successful completion of this lesson, students will be able to:

- read and speak indigenous terms related to climate and environmental cycles
- illustrate and define terms related to environmental cycles.

Alaska Standards:

Alaska Cultural Standards

[A] Culturally-knowledgeable students are well grounded in the cultural heritage and traditions of their community. Students who meet this cultural standard are able to:

[A.1] assume responsibilities for their role in relation to the well-being of the cultural community and their lifelong obligations as a community member.

[B] Culturally-knowledgeable students are able to build on the knowledge and skills of the local cultural community as a foundation from which to achieve personal and academic success throughout life. Students who meet this cultural standard are able to:

[B.2] make effective use of the knowledge, skills, and ways of knowing from their own cultural traditions to learn about the larger world in which they live.

[D] Culturally-knowledgeable students are able to engage effectively in learning activities that are based on traditional ways of knowing and learning. Students who meet this cultural standard are able to:

[D.5] identify and utilize appropriate sources of cultural knowledge to find solutions to everyday problems.

Bering Strait School District Scope & Sequence:

9.9A Understand the interaction of living and nonliving parts of an ecosystem.

9.9H Analyze the potential impacts of changes (climate change, habitat loss/gain, cataclysms, human activities) within an ecosystem.

9.10E Understand, describe and diagram the biogeochemical cycle in an ecosystem including:

- Water
- Nitrogen

10.2C Identify the interrelationships and different stages of the water, carbon and nitrogen cycles.

10.5D Describe causes, effects, preventions, and mitigations of human impact on climate.

11.7E Students develop an understanding of the dynamic relationships among scientific, cultural, social and personal perspectives.

Materials

- REACH Up High School Student Guide: *Environmental Cycles*
- Vocabulary card sets (1 per group of 4-6 students)
- Student Information Sheet: *Word Games Instructions* (1 per group)
- Student Worksheet: *Environmental Cycles Vocabulary*
- Dry Erase Markers (1 per group)
- Timers (optional)

Activity Preparations

1. If your students completed Activity HS.2.1 Ask an Expert, refer to their completed worksheets for the terms you will have them use for the vocabulary word card games.
2. If your students did not conduct interviews with Native language speakers, consult with a local knowledge bearer or language expert to determine which language/dialect translation provided on page 5 of the Student Guide would be most appropriate for your students to practice. The following chart is provided for reference.

Unit Vocabulary

Alaska Native Languages in the Bering Strait Region				
Language	**Dialect Group**	**Dialect**	**Subdialect**	**Community**
Iñupiaq	Seward Peninsula Inupiaq	Bering Strait		Brevig Mission
			Diomede	Little Diomede
				Shishmaref
			Wales (Kinikmiu)	Wales
		Qawariaq	Teller	Teller
				Unalakleet
				Shaktoolik
			Fish River	Golovin*
				White Mountain
	Northern Alaskan Iñupiaq	Malimiut		Koyuk
Siberian Yupik		St. Lawrence Island Yupik		Gambell
				Savoonga
Yup'ik		Norton Sound (Unaliq-Pastuliq)	Unaliq	Elim
				Golovin*
				St. Michael
		General Central Yup'ik	Nelson Island and Stebbins	Stebbins

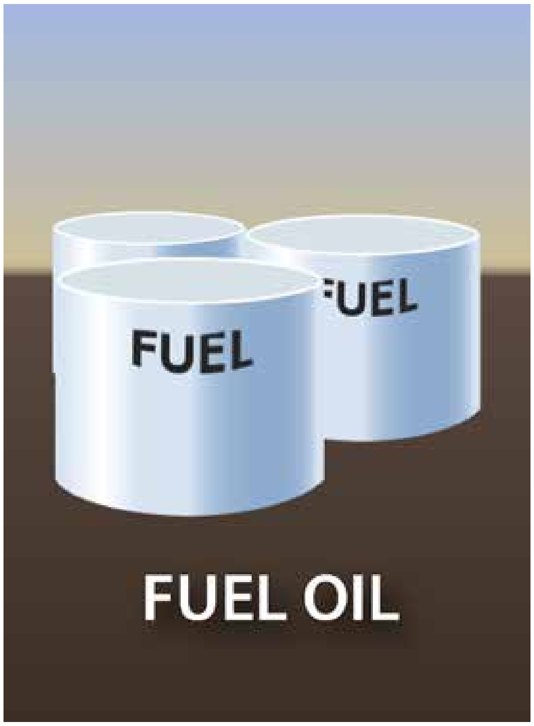
* It is very common for more than one language/dialect, or a combination of dialects, to be spoken in a community. It should also be noted that Inupiaq-Yup'ik bilingualism was common throughout the 1900s in the Norton Sound villages of White Mountain, Golovin, Elim, and Unalakleet. Golovin is listed twice on our chart because specific subdialects were cited in the research found on the Alaska Native Language Center website: http://www.uaf.edu/anlc/languages/.

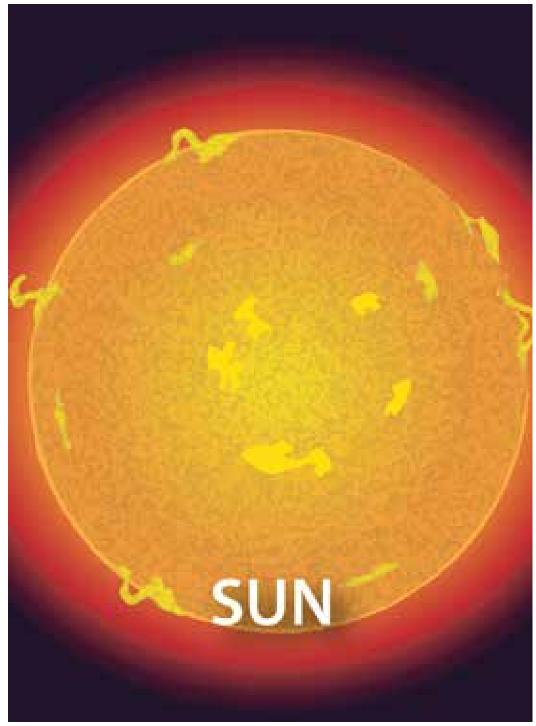
3. Keep in mind that different individuals may translate certain terms differently. It's fine to have different student groups working with various translations, or you can choose a set list of words for your whole class to practice. Highlight the diversity and do not attempt to offer an authoritative translation; the goal is to practice an Alaska Native language while discussing climate change topics.
4. If using the Vocabulary Cards provided by REACH Up, label a sample set of cards with local indigenous words using a dry erase marker. If needed, create your own sets of the vocabulary cards from the template provided.
5. Make copies of the Word Games Instruction Sheet (one per group) and the Environmental Cycles Vocabulary worksheet (one per student).

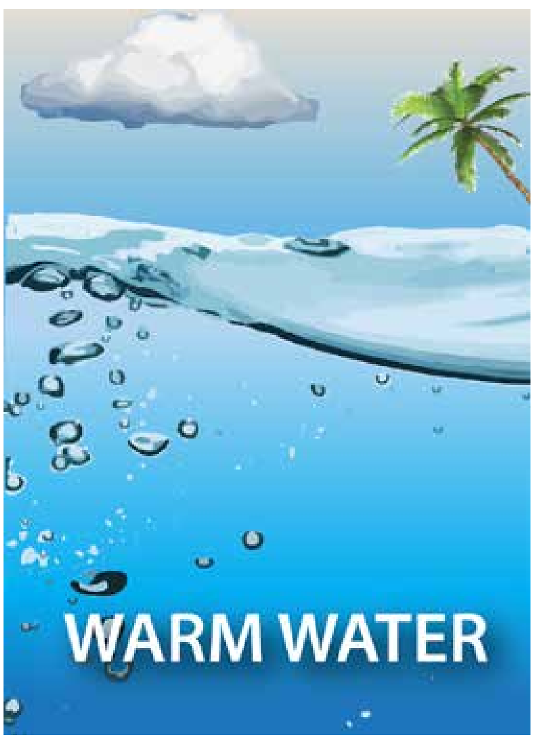
Activity Procedure:

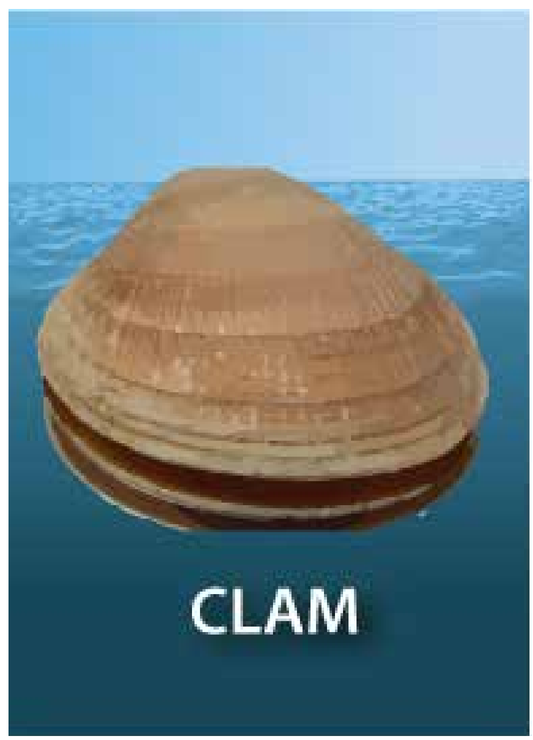
1. Distribute the REACH Up High School Student Guide: *Environmental Cycles* and review pages 1-5.
2. Show students the vocabulary cards. Hold up each card. Discuss what each card depicts. How do these terms relate to environmental cycles in their region?
3. Say the English and local Alaska Native Language word for the illustration depicted on the card. Ask students to repeat the words. Repeat this once or twice, then ask students to call out the correct words as you hold up each card.
4. Divide the class into four groups.
5. Provide each group with the Word Games Instruction sheet, a set of Vocabulary Cards, dry erase marker, and a timer (optional).
6. Instruct students to label their cards with the local indigenous words. Groups can select one student from the group for this task, or take turns.
7. Direct students' attention to the Word Games Instruction sheet. Students can commit to one game for a period of time or mix and match.
8. Encourage students to play the vocabulary games and practice the vocabulary words during free time throughout the duration of the Environmental Cycles unit. If possible, schedule 10-15 minutes twice per week to practice the vocabulary terms.
9. Write the following terms on the board: albedo, greenhouse effect, greenhouse gasses, ocean acidification, pH, troposphere. Ask students to share definitions for these terms. Refer back to the REACH Up High School Student Guide: Environmental Cycles as necessary. (Ocean Acidification will be introduced on Page 9 of the Student Guide and in Activity HS.2.4).
10. Distribute the Environmental Cycles Vocabulary Worksheet and ask students to complete it.

Vocabulary Cards

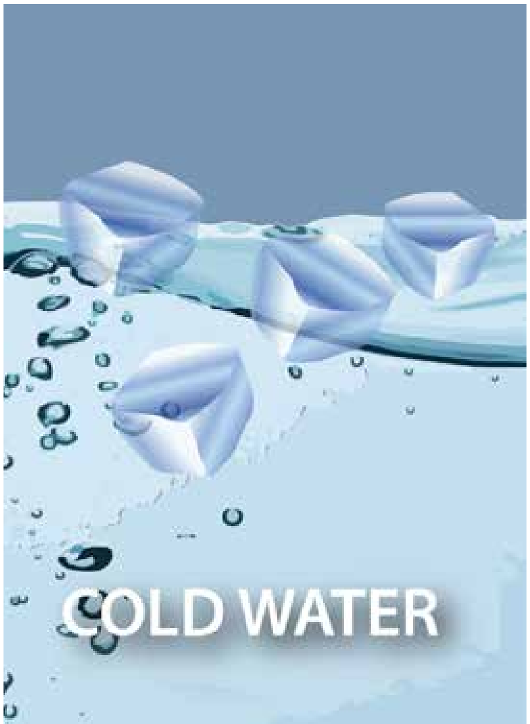


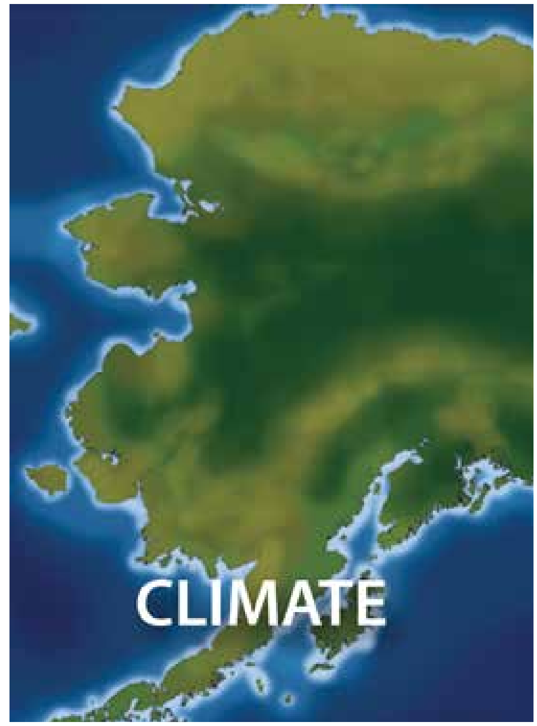


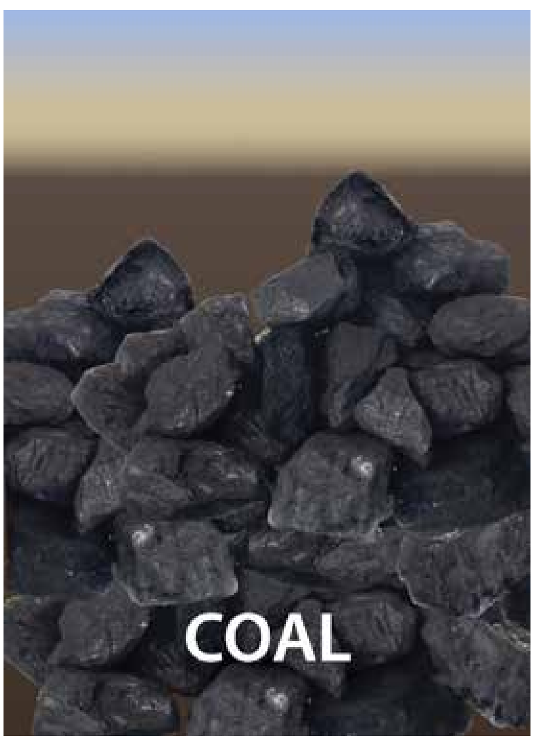




Vocabulary Cards







Vocabulary Cards

Local Indigenous Word

Local Indigenous Word

Local Indigenous Word

Local Indigenous Word

STUDENT INFORMATION SHEET: ***Word Games Instructions***

VOCABULARY SWAP:

1. Distribute one card to each person.
2. Practice the word on your card, then find a classmate. Teach them the word on your card and learn the word on their card. Trade cards.
3. Find another classmate and repeat.

FIND THE CARD:

1. Divide into small groups. Each group will need a set of vocabulary cards. Spread the cards in front of you so that everyone in your group can see the pictures.
2. Listen as your teacher says a word aloud from one of the cards.
3. Work with your group to find and hold up the correct card.

VOCABULARY SLAP:

1. Select one student to serve as the "caller" for this game. That student should make a list of the vocabulary words on a separate sheet of paper. The words can be found on the back of the cards.
2. Place the cards in a circle, picture-side-up, in the middle of the playing area.
3. The caller should call out a word from their list. Everyone else should quickly place their hand on the picture that they believe represents that word.
4. Turn over the card or cards that students selected to see who chose correctly. Each student who placed his or her hand on the correct card earns a point.
5. Put the card(s) back in the circle and play again.
6. Play for a designated period of time. At the end of the time, the person with the most points wins.

TEAMWORK:

1. Divide your group into two teams. Each team will need a pencil and paper.
2. Shuffle the vocabulary cards and stack them picture-side up in the middle of the table.
3. Work with your team to write down the local Alaska Native Language terms for the picture on the card.
4. After both teams have written answers for the top card, turn the card over to check. Teams get 1 point for the correct Alaska Native Language word.
5. Repeat until all cards are gone. The team with the most points wins.

STUDENT WORKSHEET: ***Environmental Cycles Vocabulary***

Name: ____

1. Find the definition of each word on the left from the right and write its letter next to the word.

Albedo ______

Greenhouse effect ______

Greenhouse gasses ______

Ocean acidification ______

pH ______

Troposphere ______

A. a figure expressing the acidity or alkalinity of a solution on a scale on which 7 is neutral, lower values are more acid, and higher values are more alkaline
B. the lowest layer of Earth's atmosphere
C. an increase in the average temperature of the Earth, due to certain gasses absorbing infrared heat that would normally be radiated into space
D. a reduction in the pH of the ocean over an extended period of time, caused primarily by uptake of carbon dioxide (CO_2) from the atmosphere
E. the proportion of the incident light or radiation that is reflected by a surface of a planet -- commonly refers to the "whiteness" of a surface, with 0 meaning black and 1 meaning white.
F. gasses that contributes to the greenhouse effect by absorbing infrared radiation, such as water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), and ozone (O_3)

2) Complete the chart by writing the local Alaska Native Language terminology and illustrating the missing terms.

My Community: ______________________________

English Word	*Local Alaska Native Language Word*	*Illustration*
atmosphere		
climate		
coal		
cold water		
fuel oil		
natural gas		
sun		
warm water		

ANSWER KEY: *Environmental Cycles Vocabulary*

Name: ____

1. Find the definition of each word on the left from the right and write its letter next to the word.

Albedo __E___

Greenhouse effect __C__

Greenhouse gasses __F__

Ocean acidification __D__

pH __A__

Troposphere __B__

A. a figure expressing the acidity or alkalinity of a solution on a scale on which 7 is neutral, lower values are more acid, and higher values are more alkaline
B. the lowest layer of Earth's atmosphere
C. an increase in the average temperature of the Earth, due to certain gasses absorbing infrared heat that would normally be radiated into space
D. a reduction in the pH of the ocean over an extended period of time, caused primarily by uptake of carbon dioxide (CO_2) from the atmosphere
E. the proportion of the incident light or radiation that is reflected by a surface of a planet -- commonly refers to the "whiteness" of a surface, with 0 meaning black and 1 meaning white.
F. gasses that contributes to the greenhouse effect by absorbing infrared radiation, such as water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), and ozone (O_3)

2) Complete the chart by writing the local Alaska Native Language terminology and illustrating the missing terms.

My Community: ____________________

English Word	*Local Alaska Native Language Word*	*Illustration*
atmosphere	Answers will vary depending on language and dialect spoken in this community.	Sketch should illustrate word at left.
climate	Answers will vary depending on language and dialect spoken in this community.	Sketch should illustrate word at left.
coal	Answers will vary depending on language and dialect spoken in this community.	Sketch should illustrate word at left.
cold water	Answers will vary depending on language and dialect spoken in this community.	Sketch should illustrate word at left.
fuel oil	Answers will vary depending on language and dialect spoken in this community.	Sketch should illustrate word at left.
natural gas	Answers will vary depending on language and dialect spoken in this community.	Sketch should illustrate word at left.
sun	Answers will vary depending on language and dialect spoken in this community.	Sketch should illustrate word at left.
warm water	Answers will vary depending on language and dialect spoken in this community.	Sketch should illustrate word at left.

Activity HS.2.3: The Greenhouse Effect

Overview

In this lesson students will test how the presence of increased levels of CO2 affects the temperature inside a bottle when exposed to heat and learn how increased levels of CO2 in the atmosphere affect the temperature on the globe.

Objectives

On successful completion of this lesson, students will be able to:

- collect data, graph results, and assess temperature change
- explain the effect of CO2 on temperature
- identify CO2 as a greenhouse gas
- consider implications of increased levels of CO2 in the atmosphere and the Earth's temperature from scientific, cultural and personal perspectives

Next Generation Science Standards

Standards by Disciplinary Core Ideas: Earth's Systems

Standards by Topic: Earth's Systems

Performance Expectations

The activity is just one step toward reaching the performance expectations listed below:

HS-ESS2-2: Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.

HS-ESS2-6: Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

Dimention:

Science & Engineering Practices

Analyzing and Interpreting Data
Developing and Using Models

Disciplinary Core Ideas

ESS2.D: Weather and Climate

- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-2)

- Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6)

Crosscutting Concepts

Stability and Change
Energy and Matter

Alaska Standards:

Alaska Science Standards and Grade Level Expectations

SA1: The student demonstrates an understanding of the processes of science by

[9] SA1.1 asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring and communicating

[10] SA1.1 asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring and communicating

[11] SA1.1 asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring and communicating

[9] SA1.2 hypothesizing, designing a controlled experiment, making qualitative and quantitative observations, interpreting data, and using this information to communicate conclusions

[10] SA1.2 reviewing pertinent literature, hypothesizing, making qualitative and quantitative observations, controlling experimental variables, analyzing data statistically (i.e., mean, median, mode), and using this information to draw conclusions, compare results to others, suggest further experimentation, and apply student's conclusions to other problems

[11] SA1.2 recognizing and analyzing multiple explanations and models, using this information to revise students' own explanation or model if necessary

SB3: The student demonstrates an understanding of the interactions between matter and energy and effects of the interactions on systems by

[9] SB3.1 recognizing that a chemical reaction has taken place

[9] SB3.3 recognizing that atoms emit and absorb electromagnetic radiation

Bering Strait School District Scope and Sequence

9.2E Recognize molecular structures imperative to life (e.g., O2, CO2, C6H12O6, DNA strand, proteins).

9.2F Use scientific processes and inquiry to directly support concepts of the chemistry of life.

9.9H Analyze the potential impacts of changes (climate change, habitat loss/gain, cataclysms, human activities) within an ecosystem. (SC3.2)

9.9I Develop an understanding of the dynamic relationships among scientific, cultural, social, and personal perspectives (hunting, fishing). (SF)

9.10E Understand, describe and diagram the biogeochemical cycle in an ecosystem including:

- Water
- Carbon – relating the carbon cycle to the global climate change (SC3.1)

10.2C Identify the interrelationships and different stages of the water, carbon, and nitrogen cycles. (SD1.2)

10.5A Understand concepts related to Earth's atmosphere (SD3.1)

10.5B Understand characteristics of the atmosphere. (SD3.2)

- Identify atmospheric layers

10.5D Describe causes, effects, preventions, and mitigations of human impact on climate (SD 3.1)

- Global warming/climate change

10.10E Identify which energy resources are fossil fuels.

11.7E Students develop an understanding of the dynamic relationships among scientific, cultural, social and personal perspectives. (SF)

Materials

- REACH Up High School Student Guide: Environmental Cycles
- Student Worksheet: The Greenhouse Effect
- Two clear 2L plastic bottles
- Ruler
- 150W light fixture
- 150W incandescent light bulb
- 250ml beaker (to measure water)
- Water (200ml for each bottle)
- Effervescent tablets
- Aluminum foil
- Data logger and two temperature sensors (or thermometers)
- Timer

Activity Preparations

1. Check to make sure that the data loggers (such as LabQuest 2s) are fully charged. Recharge them if they need more battery power. Check the temperature reading setting of the data logger so ºC is chosen. As students will be reading temperature in ºC, review the ºC and ºF conversion with them before they begin their experiment, if you find it necessary. Note: It is possible to do this activity with regular thermometers, but you would have to make sure the thermometers fit into the bottleneck and have a way to secure them in place.
2. Have enough water ready (each bottle needs 200 ml water). Each group will need two bottles: a control bottle and an experimental bottle.
3. Make copies of the Student Worksheet: The Greenhouse Effect for your students.
4. Students will need to work as a team to conduct this experiment.

Activity Procedure

1. Review the activity procedure with your students. Once an effervescent tablet is placed, students will need to handle the experiment quickly and efficiently in order to obtain accurate reading of temperatures (#7, 8, 9, and setting the timer in #10 below). You may wish to demonstrate the experiment set up before students start the activity so the experiment will go smoothly.
2. When an effervescent tablet is placed in water, the bubbles that come up is CO2. Explain to the class that the water-only bottle is the control and their experimental bottle has water and CO2.
3. Follow the steps as listed in the Student Guide:
   a. Turn on the data logger.
   b. Connect two temperature sensors to the data logger.
   c. Add 200 ml of water to each bottle.
   d. 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.
   e. 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.
   f. 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.
   g. 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.

h. Quickly read the temperature of both control and experimental bottles and record it in the table on the worksheet, next to "0 minutes."
i. 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.
j. Set the timer. Have one teammate watch the timer. Record the temperature in both bottles every two minutes for the next ten minutes.
k. Turn off the lamp. Clean up your station.
l. 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.

4. When the experiment is complete, lead a discussion, using the "Discuss" section of the Student Guide, page 8.

This experiment uses effervescent tablets but baking soda and vinegar can make CO_2 as well. If time allows, expand your students' knowledge of chemistry by explaining or having students figure out the chemical process of how vinegar and baking soda react:

- Vinegar is acetic acid: CH_3COOH
- Baking soda is sodium bicarbonate: $NaHCO_3$
- Mixing the two is simply an acid/base reaction:
  $CH_3COOH + NaHCO_3$ » $CH_3COONa + H_2CO_3$
- The last product (H_2CO_3) is carbonic acid which quickly decomposes into water and carbon dioxide:
  H_2CO_3 » $H_2O + CO_2$
- The carbon dioxide (CO_2) is what you see fizzing and bubbling in this reaction.

It is important for students to collect data and graph results, but you can also have them set up the data logger for interval and run time, to have the data logger perform the graphing, if you like.

Student Worksheet: *The Greenhouse Effect*

Name: ____

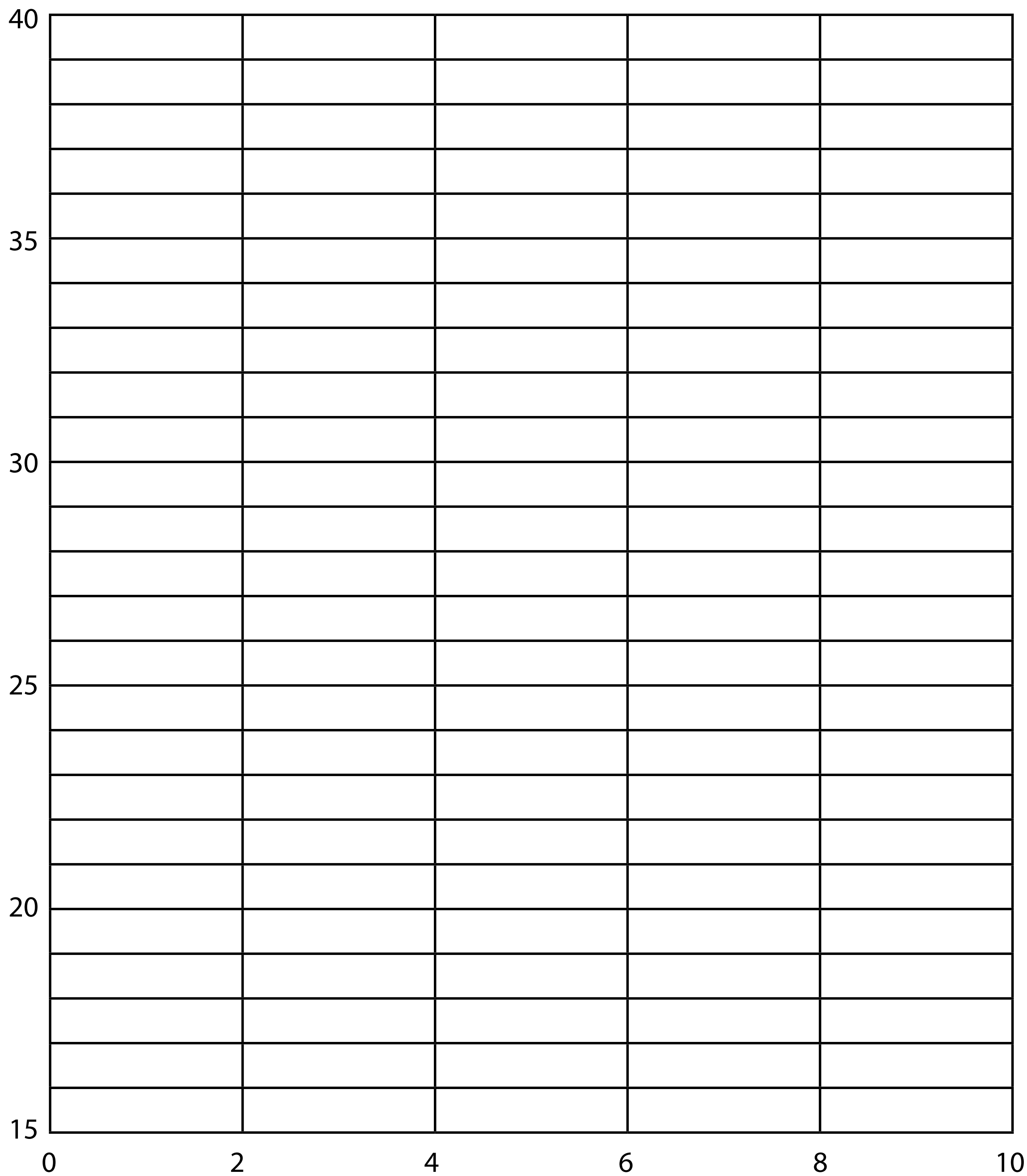
Once your experiment is set up, begin recording the temperatures in the control and experimental bottles on thea table below.

Time (minutes)	**Temperature (°C)**	
	Control (Water only)	**Experimental (Water + CO_2)**
0		
2		
4		
6		
8		
10		

Graph your results

1. Use the data in the table to make a graph showing the temperatures in the control and experimental bottles.
   a. The "Time (minutes)" will be the x axis on your graph.
   b. The y axis will be the "Temperature (°C)."
2. Label each axis and plot each data point. Use a dotted line for the control and solid line for the experimental. Alternatively, you can use straight lines in different colors for control and experimental temperatures.

Air Temperature in the Bottles



Key

☐ Control Bottle

☐ Experimental Bottle

Discuss

1. What was the same in the control and experimental bottles? What was different?
2. Did the temperature in the control bottle go up? How about the temperature in the bottle that contained the CO_2?
3. Did you observe any difference between the temperatures in the bottles? If yes, describe the difference and explain why.
4. What is a possible implication of this experiment to increased levels of CO_2 in the atmosphere and the Earth's temperature?

ANSWER KEY: *The Greenhouse Effect*

Name: ____

Once your experiment is set up, begin recording the temperatures in the control and experimental bottles on thea table below.

Time (minutes)	**Temperature (ºC)**	
	Control (Water only)	**Experimental (Water + CO_2)**
0	Answers will vary	Answers will vary
2	Answers will vary	Answers will vary
4	Answers will vary	Answers will vary
6	Answers will vary	Answers will vary
8	Answers will vary	Answers will vary
10	Answers will vary	Answers will vary

Graph your results

1. Use the data in the table to make a graph showing the temperatures in the control and experimental bottles.
   a. The "Time (minutes)" will be the x axis on your graph.
   b. The y axis will be the "Temperature (ºC)."
2. Label each axis and plot each data point. Use a dotted line for the control and solid line for the experimental. Alternatively, you can use straight lines in different colors for control and experimental temperatures.

Activity HS.2.4: Water Temperature and CO_2 Solubility

Overview

In this lesson students will test whether differences in water temperature affect solubility of CO_2, whether and how CO_2 changes the pH level of water, and learn how increased levels of CO_2 affect the ocean and marine life.

Objectives

On successful completion of this lesson, students will be able to:

- describe how water temperature affects solubility of CO_2
- describe how CO_2 affects the pH level of water
- consider the implications of warming oceans

Next Generation Science Standards

Standards by Disciplinary Core Ideas: Earth and Human Activity

Standards by Topic: Human Sustainability

Performance Expectations

The activity is just one step toward reaching the performance expectations listed below:
HS-ESS3-6: Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Dimention:

Science & Engineering Practices
Using Mathematics and Computational Thinking

Disciplinary Core Ideas
ESS2.D: Weather and Climate

- Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (secondary to HS-ESS3-6)

ESS3.D: Global Climate Change

- Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (HS-ESS3-6)

Crosscutting Concepts

Systems and System Models

Alaska Standards:

Alaska Science Standards and Grade Level Expectations

SA1: The student demonstrates an understanding of the processes of science by

[9] SA1.1 asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring and communicating

[10] SA1.1 asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring and communicating

[11] SA1.1 asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring and communicating

[9] SA1.2 hypothesizing, designing a controlled experiment, making qualitative and quantitative observations, interpreting data, and using this information to communicate conclusions

[10] SA1.2 reviewing pertinent literature, hypothesizing, making qualitative and quantitative observations, controlling experimental variables, analyzing data statistically (i.e., mean, median, mode), and using this information to draw conclusions, compare results to others, suggest further experimentation, and apply student's conclusions to other problems

[11] SA1.2 recognizing and analyzing multiple explanations and models, using this information to revise students' own explanation or model if necessary

SC3: The student demonstrates an understanding that all organisms are linked to each other and their physical environments through the transfer and transformation of matter and energy by

[11] SC3.2 analyzing the potential impacts of changes (e.g., climate change, habitat loss/gain, cataclysms, human activities) within an ecosystem

Bering Strait School District Scope and Sequence

9.2E Recognize molecular structures imperative to life (e.g., O_2, CO_2, $C_6H_{12}O_6$, DNA strand, proteins).

9.2F Use scientific processes and inquiry to directly support concepts of the chemistry of life.

9.9A Understand the interaction of living and nonliving parts of an ecosystem. (SC3.2, SC3.3, SF)

9.9B Identify the needs that must be met by an organism's surroundings.

9.9D Identify dynamic factors (e.g., carrying capacity, limiting factors, biodiversity, and productivity) affecting population size. (SC3.3)

9.9E Describe levels of organization and major kinds of interactions within an ecosystem.

9.9H Analyze the potential impacts of changes (climate change, habitat loss/gain, cataclysms, human activities) within an ecosystem. (SC3.2)

9.9I Develop an understanding of the dynamic relationships among scientific, cultural, social, and personal perspectives (hunting, fishing). (SF)

9.10E Understand, describe and diagram the biogeochemical cycle in an ecosystem including:
- Water
- Carbon – relating the carbon cycle to the global climate change (SC3.1)

10.2C Identify the interrelationships and different stages of the water, carbon, and nitrogen cycles. (SD1.2)

10.5A Understand concepts related to Earth's atmosphere (SD3.1)

10.5D Describe causes, effects, preventions, and mitigations of human impact on climate (SD 3.1)
- Global warming/climate change

10.9A Recognize the importance of Earth's ocean as a component of Earth Science. (SD2)

10.9C Identify the composition of seawater.
- Temperature

10.9D Understand the diversity of sea life.
- Plankton

10.10E Identify which energy resources are fossil fuels.

11.7E Students develop an understanding of the dynamic relationships among scientific, cultural, social and personal perspectives. (SF)

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

Activity Preparations

1. Check to make sure that the data loggers (e.g., LabQuest 2s) are fully charged. Recharge them if they need more battery power.
2. Have enough water ready. Each group will need enough water to fill a water basin ¾ full twice and to fill a graduated cylinder to the brim twice during the activity, one time with cold water, the other time with warm water.
3. Make enough ice cubes (each group may need about a dozen ice cubes to keep the water in the basin cold during the activity).
4. Make copies of the *Student Worksheet: Water Temperature* and CO_2 Solubility for your students.
5. Plan how you will group students.
6. Students will need to work as a team to conduct this experiment. Minimum three students per group would be ideal—one who holds a pH sensor throughout the activity, one who keeps the upside-down graduated cylinder in place, and one who records observation in the worksheet.

Activity Procedure

1. Read Carbon Dioxide and Ocean Acidification (page 9 in the Student Guide) as a class.

Note: It is important that students understand the pH scale, with 7 being neutral, lower values being more acidic and higher values more alkaline. When CO_2 is absorbed, ocean water becomes more acidic, lowering the pH level. The pH of surface ocean waters has fallen by 0.1 pH units since the Industrial Revolution. As the pH scale is logarithmic (like the Richter scale), this change represents about a 30 percent increase in acidity.

2. Lead students with a discussion, using the "Predict" section of the Student Guide (page 10) before they start the investigation.
3. Review the activity procedure with your students. You may wish to demonstrate the experiment set up so the experiment will go smoothly, especially how to flip the

graduated cylinder with an index card carefully so there will be no spill of water and no air bubble will form in the cylinder.

Cold water

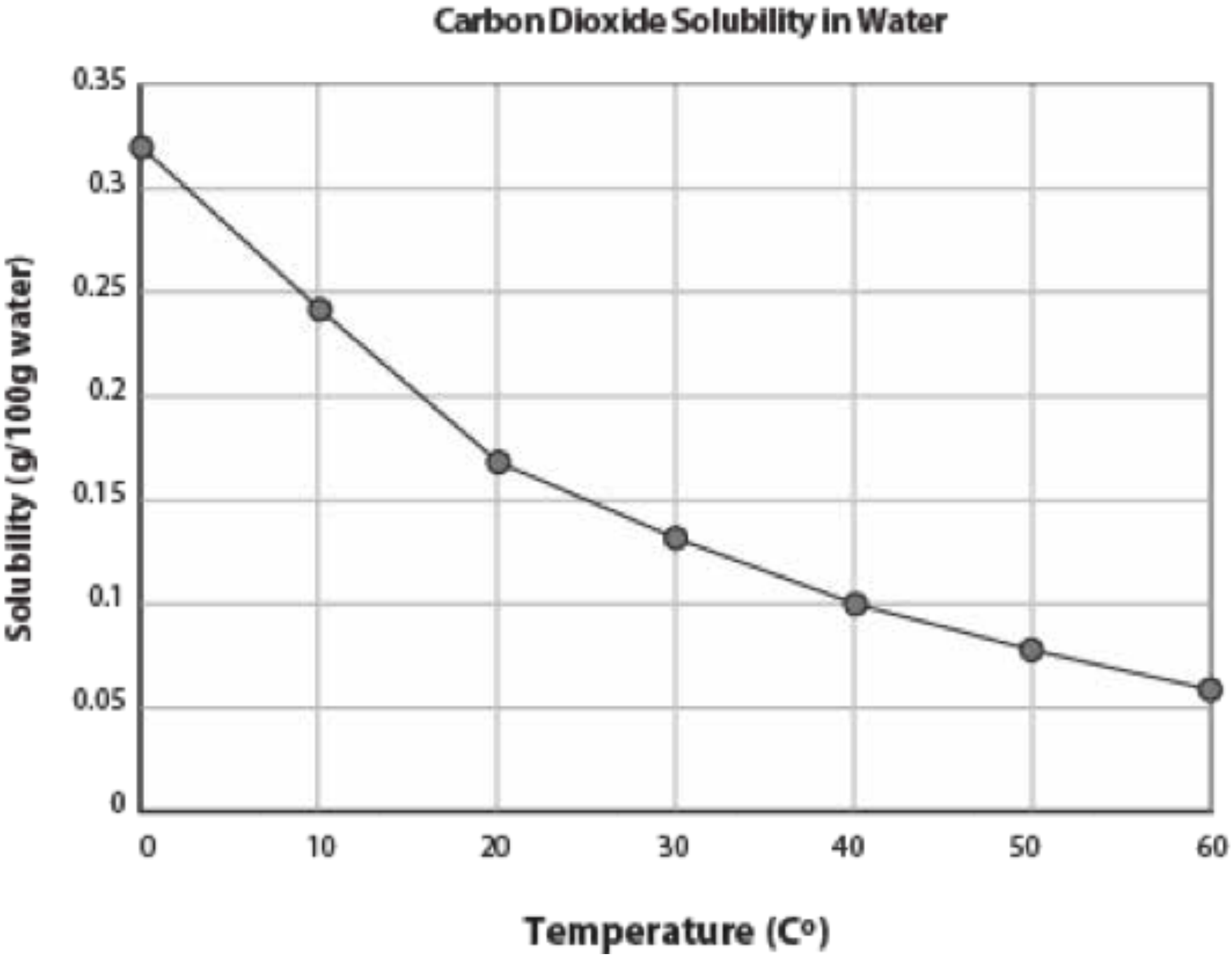
1. Turn on the data logger.
2. Connect the pH sensor to the data logger.
3. Fill a water basin 3/4 full with cold water. Add ice cubes to keep the water cold. With a dry erase marker, mark the top level of water in the basin.
4. Fill a graduated cylinder to the brim with cold water.
5. Place an index card on the mouth of the graduated cylinder. Holding it in place on 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.
6. 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.
7. Use a dry erase marker to mark the top level of the water in the inverted graduated cylinder. Record it on the top part of the worksheet, under "Initial water level."
8. 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 ("Initial pH level"). Have one teammate keep the pH sensor steady in the water basin until the final reading (#11 below).
9. 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.
10. Observe how an air space develops on top of the upside-down graduated cylinder. The gas bubbles are CO_2.
11. As soon as the tablet is dissolved, measure the pH level again. Record the result in the chart ("Final pH level"). You may remove the pH sensor from the water basin.
12. Mark with a dry erase marker the top level of the water in the inverted cylinder. Record it on the top part of the worksheet, under "Final water level."
13. Record the volume of the CO_2 gas formed. Subtract the number you obtained at the first reading of the water level (#7) from the number at the final reading (#12). Note: If the cylinder is not graduated all the way to the bottom, use a ruler and calculate the volume of CO_2.

14. Record the change in the pH level. Subtract the number you obtained at the final reading of the pH level (#11) from the number at the first reading (#8).
15. 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 at the next step with warm water.

Warm water

1. Repeat steps 3 and 4 above; only this time, use warm water in the graduated cylinder and basin. Make sure to use the same amount of warm water in the basin as the cold water you used earlier. Use the water mark you made as a guide.
2. Repeat steps 5 through 14 above.
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.

1. When the experiment is complete, lead a discussion, using the "Discuss" section of the Student Guide, page 13. In this experiment, the gas bubbles released by an effervescent tablet are CO_2.
   a. The volume of the air space formed in the graduated cylinder is equal to the volume of CO_2 that cannot be dissolved in water anymore. When the tablet is placed under the funnel, the CO_2 will first be dissolved in the water. When the water is saturated with CO_2, the CO_2 will escape into the air, displacing the water in the graduated cylinder. The solubility of CO_2 decreases with increasing temperature, i.e., colder water holds more CO_2 than warmer water, so less CO_2 will escape to the air with cold water. The air space inside the graduated cylinder with cold water, therefore, will be less compared to warm water.



The graph shows that less carbon dioxide dissolves as water temperature increases. *Source: middleschoolchemistry.com.*

STUDENT WORKSHEET: ***Water Temperature and CO_2 Solubility***

Name: ____

1. Predict!

Before you start the experiment, write below your predictions.

1) When water absorbs CO_2, will the water become more acidic or more basic, or have no change at all?

____

2) Which can hold a higher concentration of CO_2, warm water or cold water?

____

2. Water levels in the graduated cylinder

Indicate below the initial and the final water levels in the upside-down graduated cylinder. Obtain the volume of CO_2 gas formed in the cylinder by subtracting the *initial* reading of the water level (before an effervescent tablet was placed under the funnel) from the *final* reading of the water level (after the tablet dissolved). If the intervals are not indicated all the way to the top of the upside-down graduated cylinder, use a dry marker to mark the initial level and final level. You can determine the volume by using a ruler and comparing to the intervals indicated on the cylinder.

	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			
Warm water			

3. pH levels in the water basin

Indicate below the initial and the final pH levels in the water basin. Obtain the change in the pH level by subtracting the *final* reading of the pH level (as soon as the effervescent tablet is dissolved) from the *initial* reading of the pH level (before the tablet was placed under the funnel).

	Initial pH level	Final pH level	Change in the pH level (Initial pH level – Final pH level)
Cold water			
Warm water			

4. Copy CO_2 and pH

Copy the volume of CO_2 gas formed in the graduated cylinder you calculated above and the change in the pH level you obtained above to the chart below.

	Volume of $C0_2$ gas in the cylinder (ml)	Change in the pH level
Cold water		
Warm water		

5. Share the results with the class

Copy your data from #4 above under your group number below. Also copy other groups' data below. Have a discussion as a class, using the "Discuss" section of the Student Guide and data below.

		Group 1	Group 2	Group 3	Group 4	Group 5
Cold water	Volume of CO_2 gas in the cylinder (ml)					
	Change in the pH level					
Warm water	Volume of CO_2 gas in the cylinder (ml)					
	Change in the pH level					

6. Analyze data

Using the data you obtained (#5 above), write your thoughts on the questions below:

1) Did you find any difference in the pH level after CO2 was released into the water (i.e., after the tablet was dissolved)?

____

2) Did the water become more acidic or more basic?

____

3) Why did the pH change?

____

4) Which showed a greater change in the pH level, cold water or warm water?

____

5) Did you find any difference in the volume of CO_2 gas formed in the graduated cylinder between cold and warm water?

____

6) Which produced a larger volume of gas inside the graduated cylinder, cold water or warm water?

____

7) Which held a higher concentration of CO_2, cold water or warm water?

____

8) What are the potential consequences of warming oceans?

____

____

____

9) How will the role of oceans as a carbon sink change with warmer ocean water?

____

____

____

ANSWER KEY: ***Water Temperature and CO_2 Solubility***

Name: ______________________________

Answers will vary.

The result, however, should show that cold water holds a higher concentration of CO_2 than warm water because the solubility of gases decreases with increasing temperature. As a result, students will observe a lower level of pH (more acidic) in the cold water and a smaller volume of gas formed inside the graduated cylinder when cold water was used.

Rising temperatures accelerate melting sea ice, which increases the rate that ocean mixes, resulting in upwelling of CO_2-rich deep waters. When the water reaches the surface, it is warmed and leads to the degassing of CO_2.