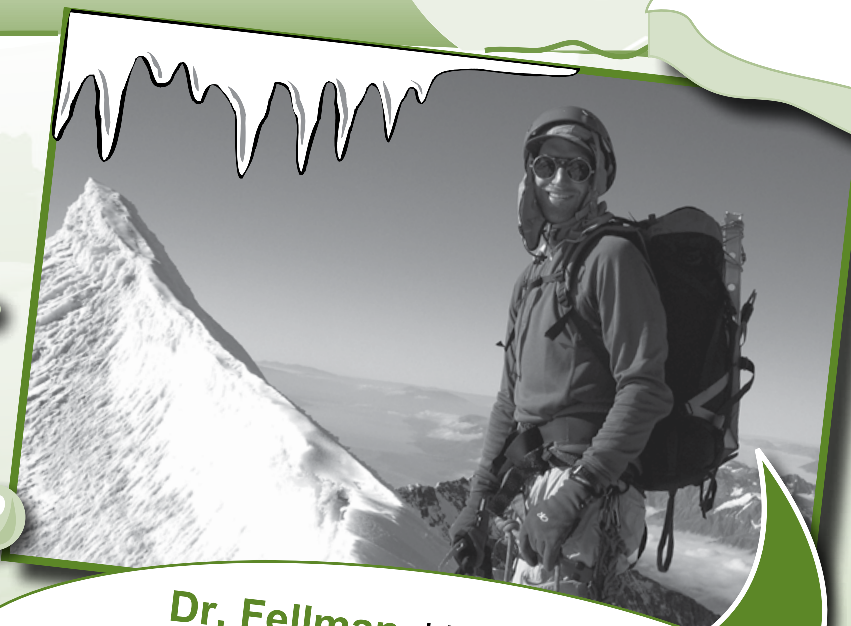
Frozen Food:

How Glaciers Provide Food for Animals That Live in the Ocean

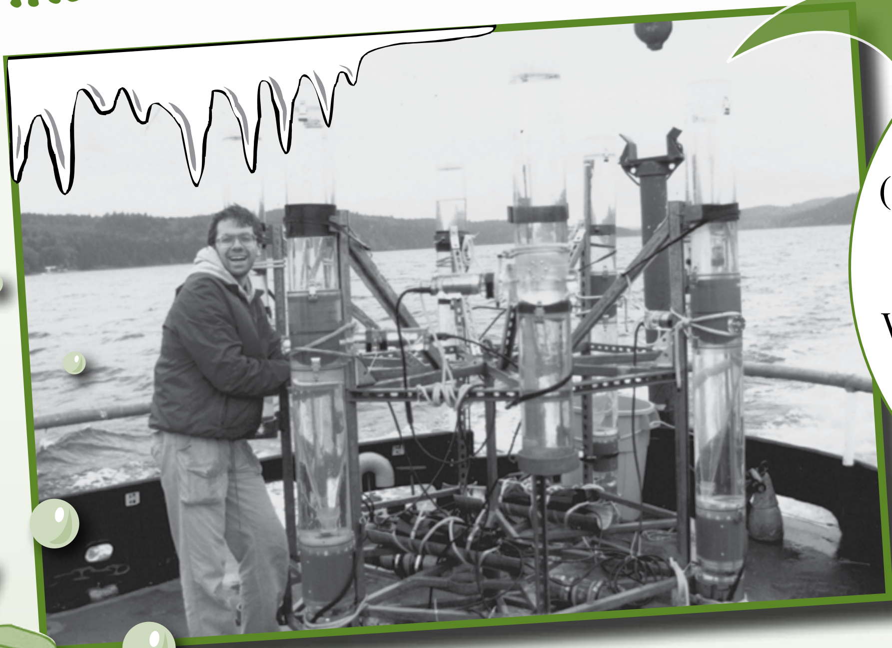
Meet the Scientists!



Dr. Fellman, biogeochemist:
My favorite science experience is going out to one of my field sites and finding several chewed salmon carcasses and bear footprints as big as my head!

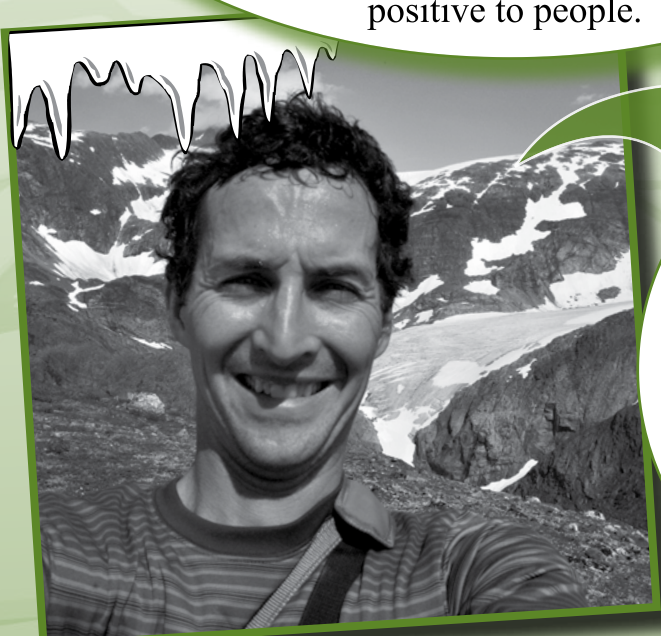
Dr. Hood, biogeochemist
(**bī** ō **jē** ō **kə** mist):
My favorite science experience is being able to climb around on the glaciers in the Juneau (Alaska) Icefield as part of my research.

Dr. Spencer, biogeochemist:
My favorite science experience was witnessing the spring thaw on the Yukon River in Alaska. This is called an "ice-out." When the ice melts, it is like a river of ice. You can see it in the photo.



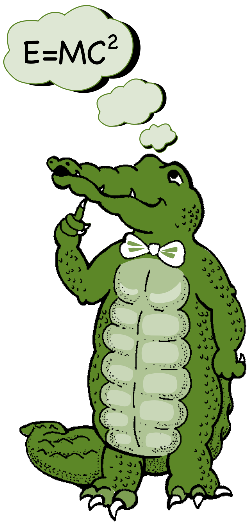
Dr. Hernes,
aqueous organic geochemist
(**aw** kwē us ôr **gə** nik **jē** ō **kə** mist):
My favorite science experience is seeing our research published. When a research paper is published, I know that it will influence how other scientists think for years to come.

Dr. Edwards,
ecologist (ē **käl** ō jist):
I've had so many wonderful experiences as a scientist I can't pick a favorite. From seeing koalas (kō **ow** las) in trees in Australia, to watching a grizzly bear catch salmon in Alaska, my research has allowed me to see things I never thought I'd see. Aside from the beautiful places, I am happy to know that I have discovered things that no one knew before. This has given me the feeling that I have contributed something positive to people.



Dr. Scott,
biological systems engineer:
One of my favorite science experiences was standing in the middle of a Rocky Mountain stream at 2 a.m. watching the Perseid (**pər** sē əd) meteor shower. The Perseid meteor shower occurs every August.

Thinking About Science



Have you ever wondered how scientists can tell the age of something very old? Often they use the element **carbon** to help them. Carbon is present in all living and once-living things. There are three types of carbon in living things. They are called carbon 12, carbon 13, and carbon 14. Living things contain very little carbon 14. They contain a lot of carbon 12. The amount of carbon 14 compared to the amount of carbon 12 is the same in all living things.

When living things die, the carbon 14 in them begins to decay. The carbon 12 does not decay. Scientists know exactly how fast carbon 14 decays. They can measure how much carbon 14 is present in something and compare that with how much carbon 12 is present. From this, they can estimate the object's age up to about 50,000 years old.

What Kind of Scientist?

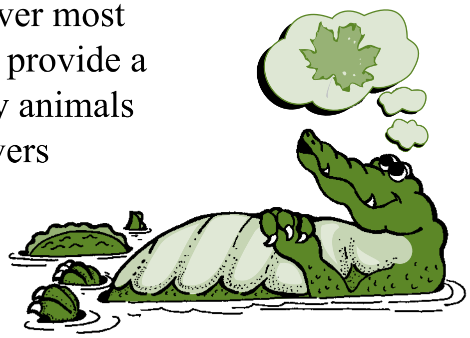
What is a biogeochemist? This kind of scientist studies the movement of chemical elements, such as carbon and nitrogen. These scientists also study how chemical elements relate to and become a part of living things over time.

What is an aqueous organic geochemist? This kind of scientist studies the impacts that organisms living in water (or ice) have on Earth.

What is a biological systems engineer? This kind of scientist seeks to design and implement systems. These systems are meant to act like or use life processes for conservation and restoration of the natural environment.

What is an ecologist? This kind of scientist studies the relationships of living things with each other and with the nonliving environment.

Thinking About the Environment



Oceans cover most of Earth. They provide a home for many animals and plants. Rivers and bays close to the coast also provide a home for animals and plants. Rivers carry **nutrients** that were washed into the rivers and bays from the surrounding land. These nutrients become available to the animals living in the water. This also happens in areas where there are glaciers. As glaciers melt, whatever was frozen in or beneath them runs into coastal rivers and bays **(figure 1)**.

Introduction

From studies of rivers with forests along their banks, scientists know that some plant material gets washed into rivers and bays. Plant material, like all living things, contains carbon. The carbon is used by some animals living in the rivers and bays. These studies

Photo courtesy of Durelle Scott

Figure 1. As this glacier melts, its **freshwater** goes into the bay.

have found that as the carbon in the plant material ages, it is less useful to animals living in the water.

In this study, the scientists studied glaciers and their nearby rivers in Alaska **(figures 2 and 3)**. The water coming from glaciers can be quite old. This water might contain nutrients such as carbon. This carbon could be at least 5,000 years old. The scientists wondered about the glacier water running into coastal rivers and bays. They wondered if the carbon in the water was too old to be useful to animals living in the rivers and bays.

Figure 2. The areas studied by the scientists.

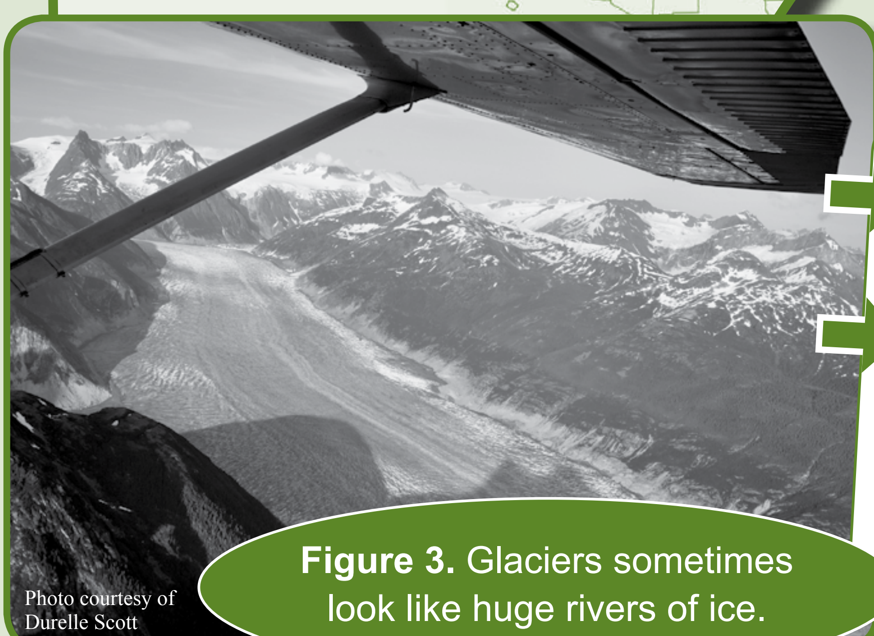
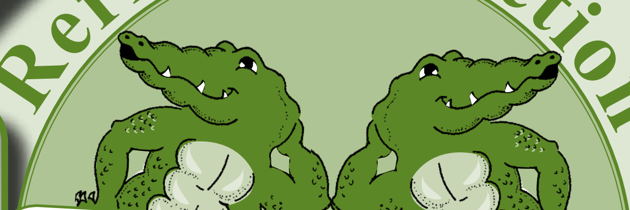


Photo courtesy of Durelle Scott

Figure 3. Glaciers sometimes look like huge rivers of ice.

Reflection Section



- State what the scientists wanted to study in the form of a question.
- Why did the scientists think the carbon might be too old to be useful to animals living in the rivers and bays? (Hint: Reread the last sentence in the first paragraph of the "Introduction.")

Method

The scientists collected water from 11 areas over 3 days in July 2008 **(figure 4)**. All of the water came from rivers containing melting glacier water. These rivers were not affected by ocean tides. This helped the scientists to be sure that the water was not affected by salt water in the ocean.

The scientists measured the amount of carbon in each container of collected water. They identified whether or not the carbon came from once-living plants or animals that are very old. They used carbon 14 dating to determine the age of the carbon. The pieces of material in the water were so small they could not be seen by the naked eye.

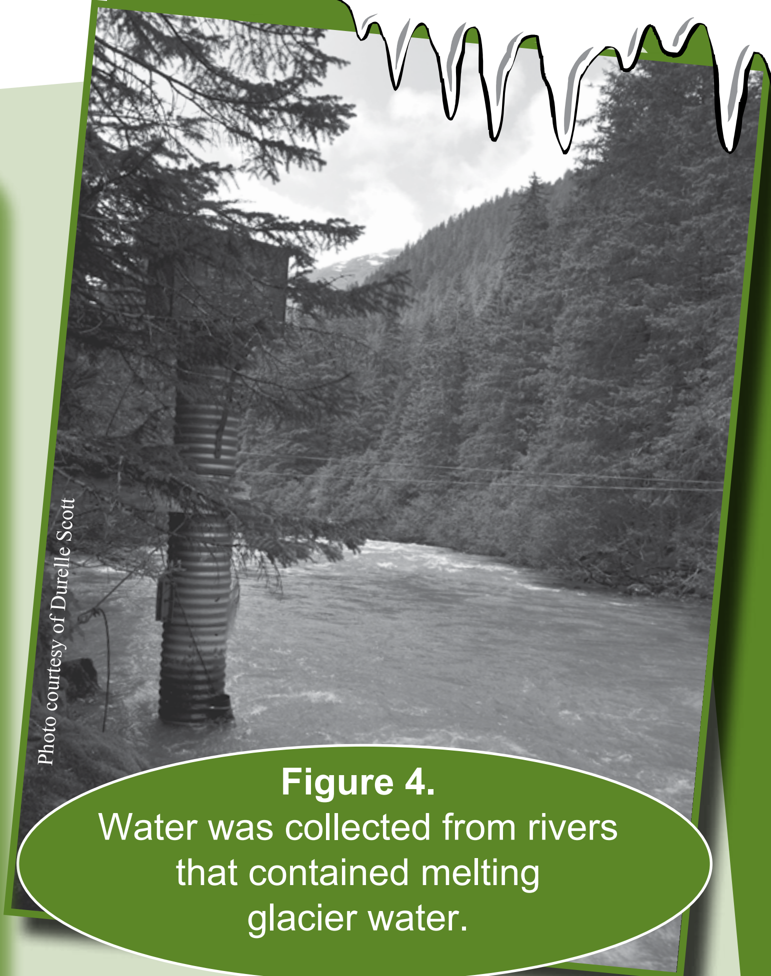


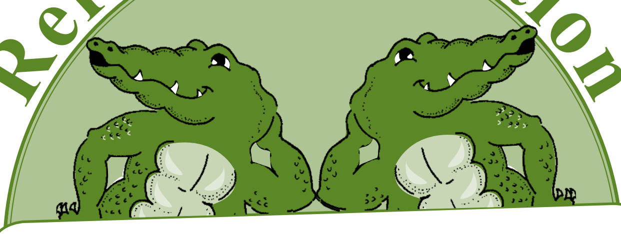
Figure 4.
Water was collected from rivers that contained melting glacier water.

Findings

The scientists knew that the glaciers covered ancient forests. The scientists found, however, that glacier water contained little material from ancient forests. They found that most of the glaciers' carbon came from microbes. Microbes are too small to be seen by the naked eye. They include **bacteria**, **fungi**, and **algae**.

Some kinds of bacteria can live in glaciers. The scientists believe that bacteria living in the glaciers have been eating old plant material for thousands of years. The old plant material came from the ancient forests. The carbon that is coming from glaciers today is made up of the remains of bacteria.

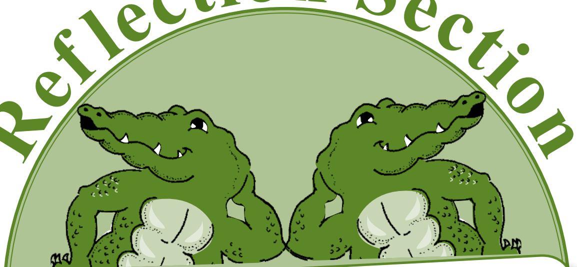
Reflection Section



- Why did the scientists avoid getting salt water in their samples?
- Think about the water coming out of the glaciers. Do you think the scientists found that the carbon was quite old? Why or why not?

The scientists discovered that the larger the glacier was, the older the carbon was in the glacier water. The scientists also found something different than what scientists before them found. These scientists found that the older the carbon in the glacier water was, the more useful it was to animals living in the rivers and bays. In earlier studies, scientists found the opposite to be true.

Reflection Section



- Are you surprised that the glacier water contained little material from ancient forests? Why or why not?
- What might happen to the flow of glacier water as the global climate changes?

Discussion

Glacier water is different than water flowing down rivers with forests along their banks. It is different in at least two ways. First, the carbon in the glacier water comes from microbes, not from grasses and trees. Second, the older the carbon in the glacier water is, the more useful it is to animals living in the rivers and bays.

As the climate changes, the temperature will rise in the northern regions of Earth **(figure 5)**. This will cause glaciers to melt faster. More carbon will be flowing into rivers and bays near the glaciers. Scientists do not know how this will change the **ecosystem** of the rivers and bays. They believe, however, that a greater amount of carbon will provide more nutrients to animals living in the rivers and bays.

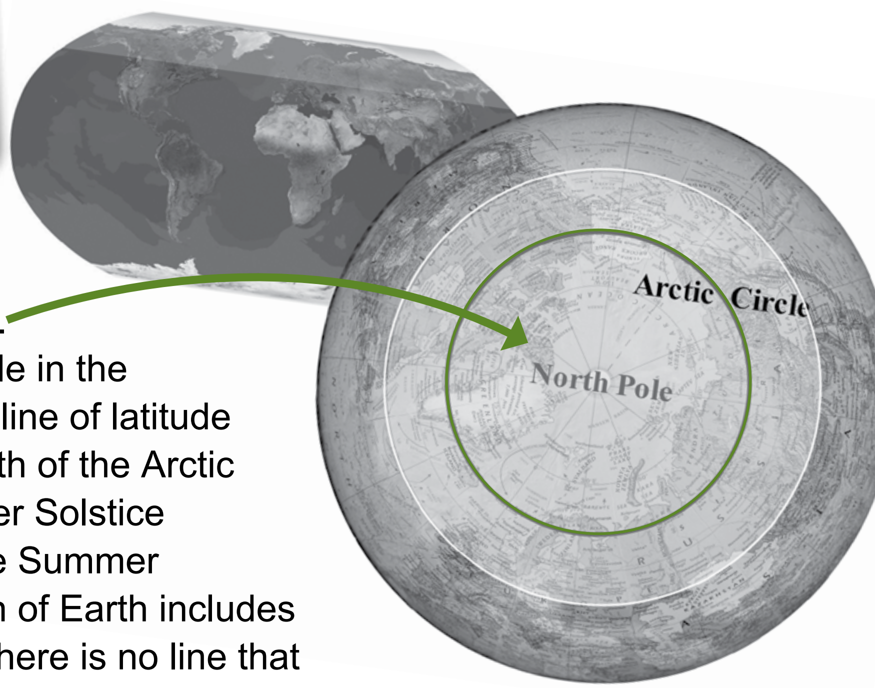
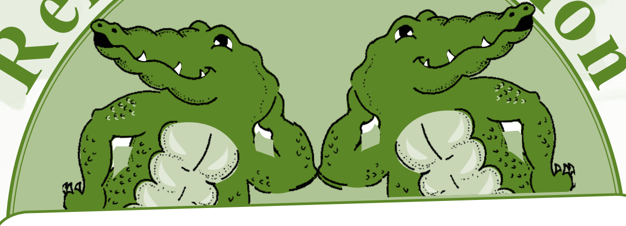


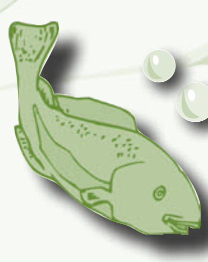
Figure 5. The northern region of Earth is shown lightly shaded in both images. On the right, you can see the North Pole in the center. The Arctic Circle is an invisible line of latitude on Earth's surface. Within the area north of the Arctic Circle, the sun never rises on the Winter Solstice (December 21) and it never sets on the Summer Solstice (June 21). The northern region of Earth includes an area south of the Arctic Circle, but there is no line that defines the exact area. Glaciers are found in Earth's northern region, including areas south of the Arctic Circle.

In the short term, more carbon and nitrogen might be helpful to animals living in the rivers and bays. In the long term, the scientists wonder what will happen after the glaciers have melted. There may no longer be very old carbon flowing into the rivers and bays.

Reflection Section



- Are you surprised that carbon that is thousands of years old is useful to animals living in nearby rivers and bays? Why or why not?
- As more glacier water runs into rivers and bays, will more or less nutrients be available to animals living there?
- In the long term, what might happen to the food source coming from glaciers?



Glossary

Algae (**al** jē): Simple, plantlike organism.

Bacteria (bak **tēr** ē uh): A large group of one-celled organisms, too small to be seen by the naked eye.

Carbon (**kar** bun): A chemical element present in all life forms.

Ecosystem (ē kō **sis** tem): Community of plant and animal species interacting with one another and with the nonliving environment.

Freshwater (fresh **wa** tur): Having to do with or living in water that is not salty.

Fungi (**fun** jī): Organisms without chlorophyll that reproduce by spores. Mushrooms, molds, mildews, and toadstools are examples.

Nutrients (**nu** trijənt**):** Any substance found in foods that are necessary for plants and animals.

Accented syllables are in **bold**.

This article was adapted from Hood, E.; Fellman, J.; Spencer, R.G.M.; Hernes, P.J.; Edwards, R.; D'Amore, D.; Scott, D. 2009. Glaciers as a source of ancient and labile organic matter to the marine environment. Nature. 462: 1044–1047.

Pronunciation Guide

ā	as in ape	ū	as in use
a	as in car	u	as in fur
ē	as in me	ü	as in tool
i	as in ice	ŋ	as in sing
ō	as in go	ə	as in about (both a and u)
oi	as in for		

Accented syllables are in **bold**.

FACTivity

Time required: 30 to 40 minutes

Materials needed:

• One page of lined paper and pencil for each student.

• A copy of page 49 for each student. (Optional: An unlined piece of paper, scissors, and glue for each student.)

The question students will answer in this FACTivity is:

What does photographic evidence appear to tell us about glaciers over the last century?

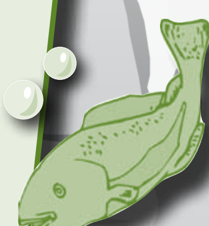
The process students will use to answer the question is as follows:

1. Students may work on page 49 in the journal, or may work from a sheet that was copied from this page. These are photographs of five glaciers in Alaska. The photographs on the left were taken in the early 1900s. The photographs on the right were taken in 2000.

2. Students will examine these photographs and do two main tasks.

- First, students will carefully observe the photographs and match the glacier photograph on the left with the glacier photograph on the right. Students may draw a line connecting the matching glacier photographs. If students are using a copy of the photographic sheet, they may cut the photos out and paste the pairs side-by-side on a separate sheet of paper.
- Each student will select two pairs of matching photographs to observe.

3. Students will study each pair of photographs for 10 seconds. From this, students should form an overall impression of the photographs and write down their impression on a sheet of paper. In the next 4 minutes, students should compare and contrast the early photographs with the more recent photographs. To assist with the observation, students may divide each photo into quadrants (four equal areas) and study each section to see what new details become visible.



4. Based on these observations, students should list three things they might conclude from the two pairs of photographs.

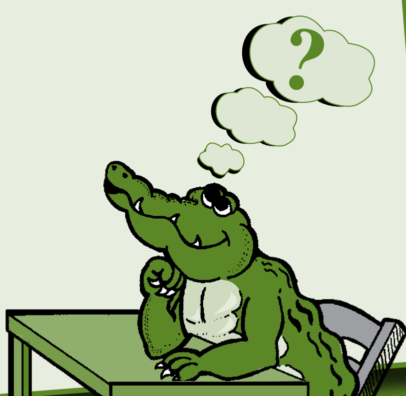
FACTivity continued

5. Hold a class discussion about the students' observations. What was the students' overall impression? What did students conclude about glaciers based on the photographs?

6. Hold a class discussion about photographic evidence. Some questions to discuss are:

- Can photographic evidence be trusted? Why or why not?
- How do photographs provide information that words cannot?
- What might add to the photographic evidence presented by these photographs?

Now, answer the question posed at the beginning of this FACTivity.



This FACTivity was adapted from http://www.windows2universe.org/teacher_resources/glacier_then_now.pdf. The photographs were provided by the Glacier Photograph Collection. Boulder, Colorado USA: National Snow and Ice Data Center/World Data Center for Glaciology, http://nsidc.org/

National Science Education Standards addressed in this article:

Science as Inquiry: Abilities to do scientific inquiry, Understandings about scientific inquiry

Life Science: Reproduction and heredity, Regulation and behavior, Populations and ecosystems, Diversity and adaptation of organisms

Earth Science: Structure of the Earth system

Science in Personal and Social Perspectives: Natural hazards, Risks and benefits, Science and technology in society

Science and Technology: Understandings about science and technology

History and Nature of Science: Science as a human endeavor, Nature of science

If you are a Project WET-trained educator, you may use the activity "Old Water," page 171, as a supplemental activity.

Web Site Resources

http://www.fs.fed.us/r10/tongass/forest_facts/resources/geology/icefields.htm: Tongass National Forest, icefields and glaciers

http://www.pbs.org/wgbh/nova/vinson/glacier.html: The life cycle of a glacier. This slide show traces the journey of a snowflake onto a glacier and eventually reaching the sea.

http://ga.water.usgs.gov/edu/earthglacier.html: U.S. Geological Survey: glaciers and icecaps. Focuses on glaciers as a source of the world's freshwater.

The research reported in this article was funded in part by the Hydrologic Sciences Program of the U.S. National Science Foundation.

Holgate Glacier 1909. Photograph by Ulysses Sherman Grant

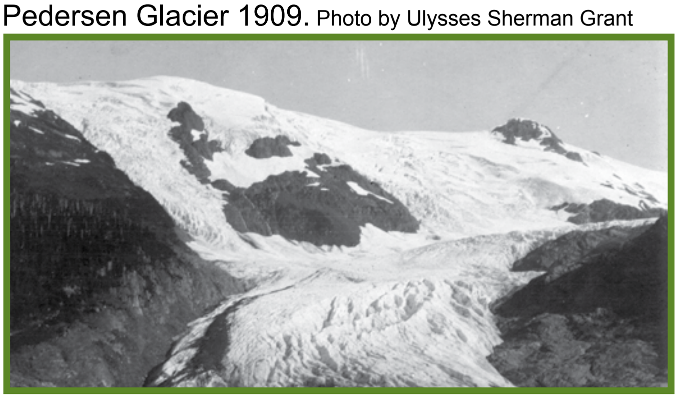
2000. Photo by Bruce F. Molina

McCarty Glacier 1909. Photograph by Ulysses Sherman Grant

2004. Photograph by Bruce F. Molina

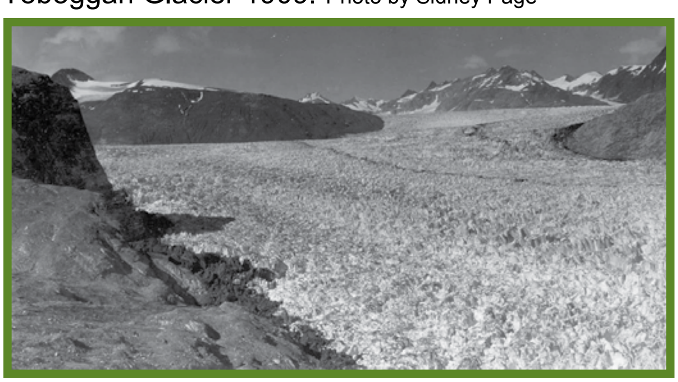
Pedersen Glacier 1909. Photo by Ulysses Sherman Grant

2004. Photograph courtesy of the U.S. Geological Survey



Toboggan Glacier 1909. Photo by Sidney Page

2004. Photo by Bruce F. Molina



Muir Glacier 1941. Photograph by William O. Field

2004. Photo by Bruce F. Molina