



Where Have All the Glaciers Gone?

Unit: Little Ice Age
Lesson: 4

Materials & Preparation

Time:

- Preparation: 20 minutes
- Teaching: 45 minutes

Materials for the Teacher:

- Overhead projector
- Overhead Transparencies of page 4 and 5 of this lesson and Venn diagram (Student Page 2)
- Examples of glacial till or striated rocks to show students (optional)

Materials for Student Pairs:

- Student Page 1
- Student Page 2 (Venn Diagram)
- Pencil

Materials for Individual Students:

- Student Page 3 (optional assignment)

National Science Standards

- Science as Inquiry: Content Standard A
- Earth and Space Science: Content Standard D
- Science in Personal and Social Perspectives: Content Standard F

Colorado Science Standards

- Science: 1, 4.2b, 4.4c, 5d, 6c

Learning Goals

Students will

- Understand that scientists examine evidence from around the world in order to understand global climate change.
- Understand that records of climate change exist.
- Describe photographs, interpreting changes in glaciers over time.
- Explain changes in climate over time based on interpretations of data and photographs.

What Students Do in this Lesson

In this lesson, students examine images of alpine glaciers to develop an understanding of how glaciers respond to climate change. They record, discuss, and interpret their observations. They consider explanations for changes in the size and position of glaciers from around the world. They develop an understanding that the melting (retreat) of glaciers is occurring simultaneously on different continents around the world, and, thus, they represent evidence of global climate change.

Key Concepts

- The position and size of alpine glaciers changes over time.
- 100 years ago the Rhone Glacier (and most others) were much larger.
- Natural and human made landmarks allow one to judge the change in size and extent of the glaciers over time.
- By comparing historical and present-day images, we can better understand climate change.
- Glaciers around the world are melting, indicating that Earth's climate is warming.



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Advanced Preparation

- Read and review the lesson plan and the science background information.
- Copy overheads onto transparencies (Page 4 and 5, and Venn Diagram from Student Page 2)
- Make copies of student pages, one per student.
- Gather additional images of glaciers or bookmark appropriate Internet sites such as the National Snow and Ice Data Center (<http://nsidc.org>).

Introducing the Lesson

- Begin the lesson by explaining the characteristics of an alpine or mountain glacier (See Background Information, page 3).
- Ask students how they would predict glaciers would be affected by climate change (i.e., warming climate causes glaciers to melt and cooling climate causes glaciers to grow).
- Based on their prediction, ask students if they can think of a way to use glaciers to understand if climate has changed over the past 100 years. Tell students that in this lesson they will compare photographs of glaciers from the past century.

Facilitating the Lesson

- Show students Overhead #1 (page 4) and introduce students to a map of Switzerland and the small mountain town of Gletsch, below the Furka Pass. Explain to students that if they were to visit Gletsch, Switzerland, they would see very steep mountains, a small rural town, and a narrow winding road through the mountains. If possible, search online for a current aerial photo of the area.
- Explain that students will receive two images of the Rhone Glacier, which sits above Gletsch, one from 1906 and one from 2003.
- Ask students to make careful observations of each image. Model how to use the Venn diagram to compare and contrast the images.
- Pair students and distribute to each team a set of images of the Rhone glacier and Venn diagram.
- Allow students time to examine the images and complete the Venn diagram, recording similarities and difference between the past and present images of the glacier.

Summarizing and Reflecting

- Have each team share one or more observation they made about the two images of the Rhone Glacier.
- Record team observations on an overhead copy of the Venn diagram.
- Ask students to identify one or two of the most likely reasons for changes in the size and position of the glacier (i.e., glaciers respond to long term changes in climate and current warming has caused melting).
- Ask students how they know that the retreating Rhone Glacier is due to climate change. What additional evidence might they need? (I.e., evidence from other glaciers in other places worldwide).
- Display Overhead #2 (page 5) to show retreat of glaciers of the world as evidence.

Extensions or Homework

- Introduce the Boulder Glacier images as an additional class assignment or as homework. Boulder Glacier is in Glacier National Park, MT (<http://www.nps.gov/glac/>). Have students apply their knowledge and experience with the Rhone Glacier to their study of the Boulder Glacier.



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- Map the recession of a specific glacier. Use aerial photographs and topographic maps to delineate the present and past positions of glaciers.

Background Information

What is an alpine glacier?

Glaciers are large masses of ice. The ice forms from snowfall that accumulates over long periods of time (many years). Most glaciers form where snowfall is high and temperatures are cool, even in summer. Thus, glaciers tend to be found either near the poles or at high altitudes on the slopes of high mountains. Glaciers in mountains are the focus of this lesson. They are called alpine glaciers.

How do glaciers respond to changes in the climate?

Alpine glaciers are particularly susceptible to shifts in climate. Glaciers respond to long term changes in the Earth's climate. Global temperature is determined by Earth's energy budget, that is, the amount of solar energy received and retained by our planet. The amount of this energy controls the average global temperature. If the average temperature on Earth increases, alpine glaciers melt. They appear to move to higher altitudes up the valley (see example below). The opposite is true as well. Small decreases in the average annual temperature cause glaciers to increase in size as increased snowfall at high altitude causes glacial ice to flow downhill. In the last several hundred years, most glaciers in the world have retreated, resulting from an increase in average annual global temperature.

How do we know alpine glaciers move?

One identifying characteristic of glaciers is that their ice flows slowly over time. The ice is able to flow because it is under considerable pressure from the immense weight of overlying ice. Glaciers move slowly down a valley over time as more ice is added to their upslope end. As a glacier melts, or retreats, piles of rock called moraines, eskers, drumlins are left behind in the valley.



Additional Resources

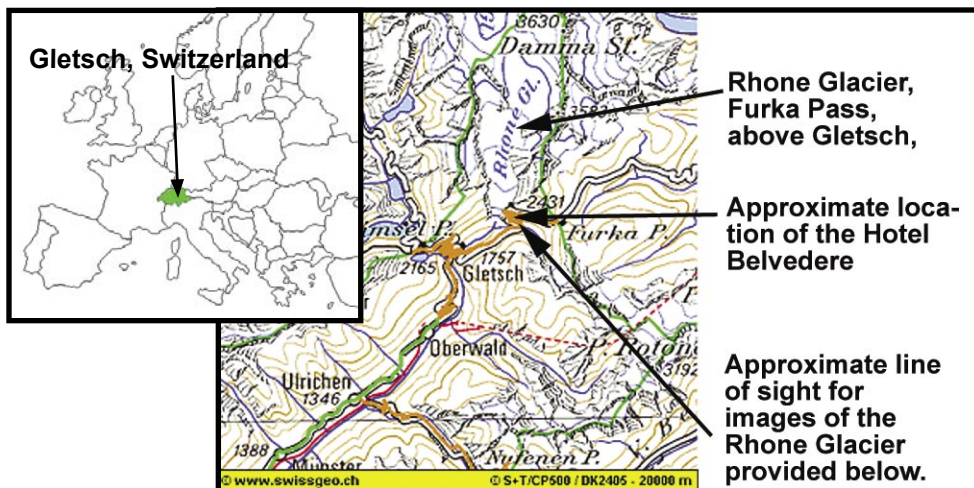
- The National Snow and Ice Data Center <http://nsidc.org>
- Glacier National Park <http://www.nps.gov/glac/>



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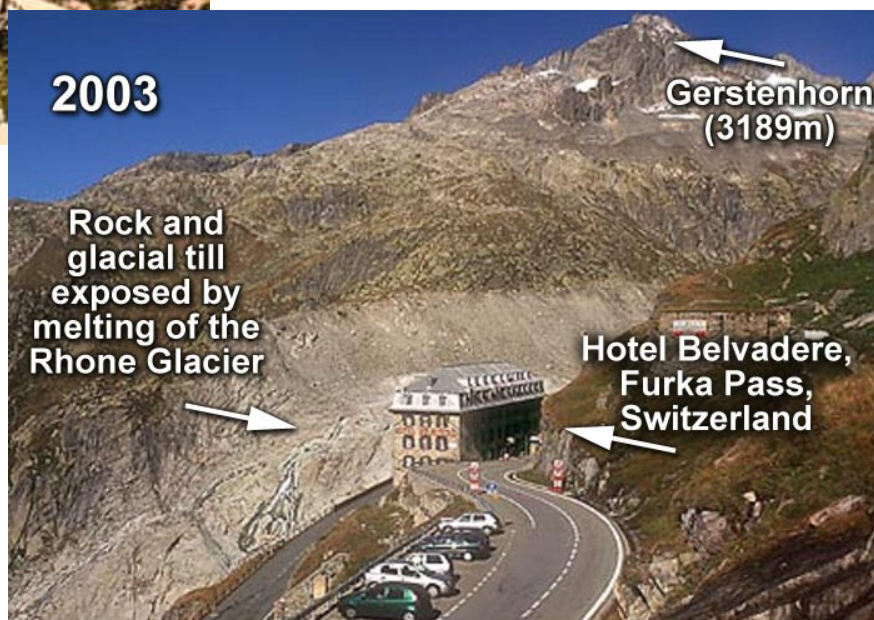
Overhead #1: Rhone Glacier Information

- Maps at right:
Topographic map of the region surrounding the Rhone Glacier and small map of location within Europe.



- Painting at left:
Date: Approximately 1906
Location: Furka Pass above Gletsch, Switzerland
Description: This image shows the Rhone glacier behind the Hotel Belvedere in about the year 1906. The glacier is located near the town of Gletsch and the Furka Pass in northeastern Switzerland. The glacier has experienced extensive melting over the past century.

- Photograph at right:
Date: 2003
Location: Furka Pass above Gletsch, Switzerland
Description: By 2003 the Rhone glacier has melted, exposing the valley floor scraped free of soil and carving the U-shaped valley formerly filled with ice. Recent increases in mean annual global temperature are responsible for the change.





Where Have All the Glaciers Gone?

Overhead #2: Images of Global Glacial Retreat

Pasterze Glacier, Austria
1900
2000

South Cascades, USA
1928
2000

Qori Kalis, Peru
1978
2000

Franz Joseph, New Zealand
1912
2000

The Melting Snows of Kilimanjaro
1912
2002

Mt. Kilimanjaro, Kenya
2002

Total Area of Ice
1950-2000
1950 1960 1970 1980 1990 2000
100 80 60 40 20 0
100 80 60 40 20 0
1950 1960 1970 1980 1990 2000
100 80 60 40 20 0
100 80 60 40 20 0

Source: Working Group on the Assessment of Glaciers (WGAG)



Page #1: Where Have
All the Glaciers Gone?

Name _____
Date _____ Class _____

Directions

- Compare and contrast the two images below.
- What features of the landscape remain unchanged?
- What changes occurred in the landscape between 1906 and 2003
- **Use the Venn diagram to record your observations.**



The Rhone Glacier and the Hotel Belvedere in **1906**



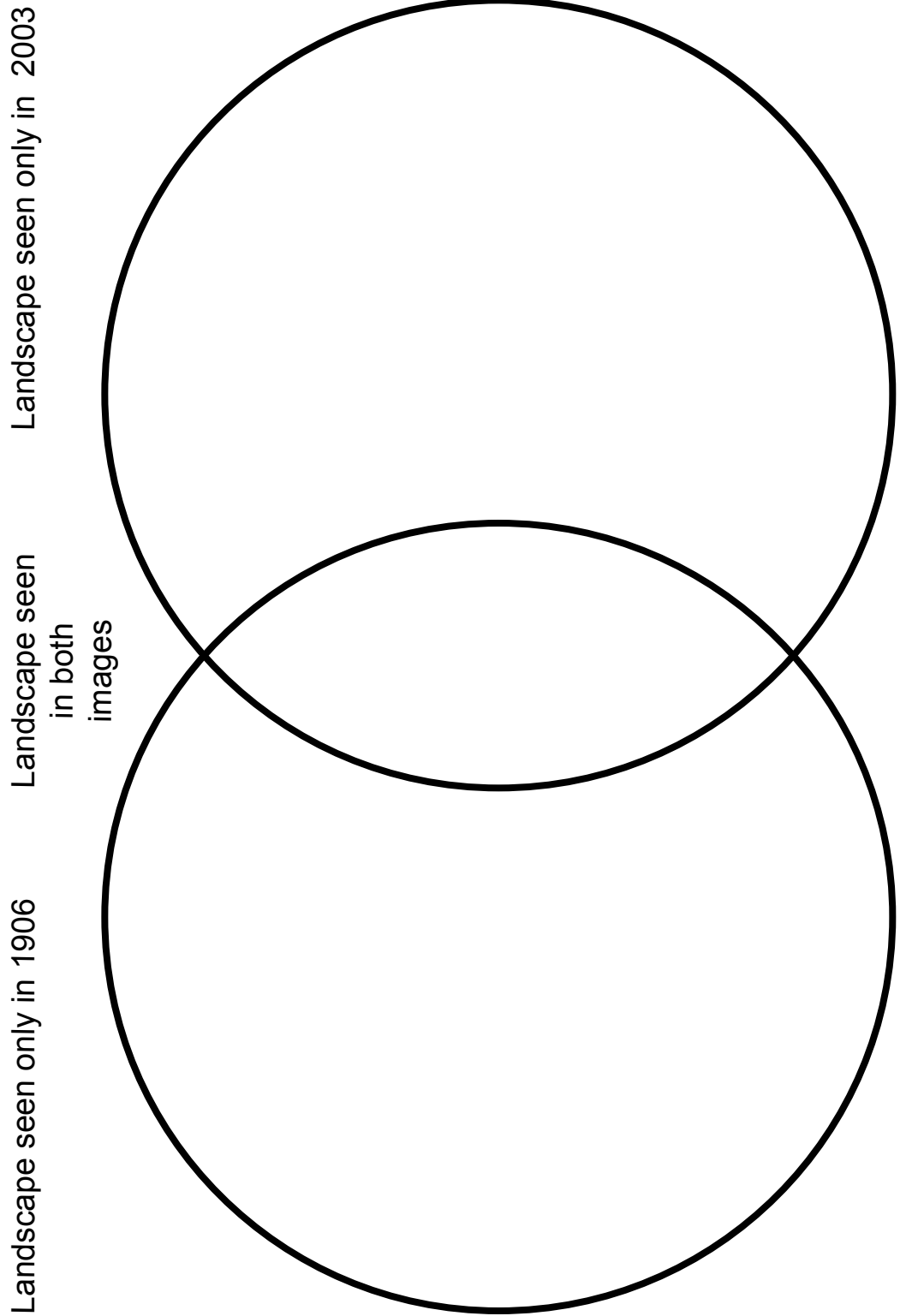
The Rhone Glacier and the Hotel Belvedere in **2003**



Page #2: *Where Have
All the Glaciers Gone?*

Name _____
Date _____ Class _____

- Directions**
- Use the 1906 and 2003 pictures of the Rhone Glacier to complete this Venn diagram.





Page #3: Where Have All the Glaciers Gone?

Name _____
Date _____ Class _____

The two photographs below were taken from the same position in Glacier National Park, Montana of the Boulder Glacier. The one on the left was taken in 1932 and the one on the right was taken in 1988.

Directions

- Compare and contrast the two images of the Boulder Glacier shown below.
- Create your own Venn diagram and use it to list the similarities and differences between the images.

Answer the following questions on a separate sheet of lined paper

- What evidence in the photographs indicates that the images are from the same location?
- How much time has passed between the taking of the first and the second photograph?
- What changes occurred to the landscape between 1932 and 1988? Be specific.
- Imagine that you took both of these photographs. You took the first while you were 10 years old and vacationing with your parents. You took the second picture when you retired and took a trip to the National Park. Write a postcard describing each visit to the area. What might you have done? What clothing or supplies did you bring?



1932



1988