

## Lesson 5: Ice in Action

Created by Montana State University Extended University  
and Montana NSF EPSCoR

<http://www.montana.edu/everest>

### Lesson Overview:

Explore glaciers and how they have shaped landscapes around them. Watch glaciers in Montana and those near Mount Everest change over several years through photographs and time-lapse images. Identify parts of a glacier and compare the decline of Himalayan and American glaciers. See how Mount Everest has been shaped by ice in action in the past and how the possible absence of glaciers in the future could change this mountain and those living in its shadows forever.

### Objectives:

Students will be able to:

1. Explain what a glacier is and how glacial movement affects the surrounding landscape.
2. Compare and analyze photographs of Himalayan and Rocky Mountain glaciers to evaluate melting and recession.
3. Explain factors that contribute to glacial ice melt.

### Vocabulary:

**albedo (al-BEE-do)** - the amount of light reflected by an object

**alpine (valley) glacier** - a glacier confined to a mountain valley

**climate change** - a significant change in the Earth's climate including temperature, precipitation and wind, as recorded over an extended period of time.

**continental glacier** - very large glaciers that hide the topography underneath them (also called ice sheets)

**crevasse (kruh-VAS)** - a crack in the glacier's surface that can be very deep and covered by snow

**glacier** - a massive river of ice that moves slowly downward from the high mountains

### Background Information:

Glaciers are large masses of ice that form from the accumulation of snowfall over a long period of time. Glaciers can be found in cool year-round climates including regions near the poles (continental glaciers) and on high mountains (alpine (valley) glaciers) where summer temperatures will not melt all the snow. Glaciers move like slow rivers of ice.

The Himalayan Mountains, including Mount Everest, are known as the "Water Towers of Asia." These mountains are the source of many of the world's largest river systems and have the most glaciers outside the polar region. More than a billion people in India and China rely on the fresh water stored in the Himalayan Mountains for their survival. Glacial water feeds agriculture and power generation, and supplies the area's drinking water. Glaciers are important not only to the Himalayas, but the whole world. Glaciers contain one-third of the world's fresh water and are considered earth's air conditioners.

Glaciers carved and shaped the rugged mountain landscape of the Himalayan Mountains. As the glaciers move, they erode the mountains and carry debris away from the peaks, creating steep slopes and deep valleys. Glaciers form on top of rocks and dirt but also pick up more as they move; these can be rock fragments from valley walls or new rocks from the ground that freeze into the ice. These rocks produce glacial grooves and scratches in bedrock that show patterns of glacial movement.

Glaciers, especially alpine (valley) glaciers, are sensitive to **climate change** and several studies have shown that glaciers are melting worldwide as a result of increasing temperature. Glaciers in the Himalayas have been shrinking over at least the past 150 years. The Himalayan region's temperature is increasing annually and accelerating the rate of glaciers melting significantly. Climbers are witnessing this recession first hand through the Khumbu (pronounced *KOOM-boo*) Glacier, which has receded over 3 miles (5 km) since the first climb of Mount Everest in 1953. Smaller glaciers break apart and melt faster than the bigger ones, so the chance of glaciers disappearing once they become small is very high.

### **Activity 1: What is a Glacier?**

Lesson Length: 10 minutes

Materials:

- *MSU Science Zone #28 "What is a Glacier?" worksheet (one per student)*  
<http://eu.montana.edu/pdf/outreach/msuscizone28.pdf>
1. Ask your students if they have ever heard of the word "**glacier**" or have seen a glacier before. Tell your class that Mount Everest and the Himalayan Mountains are home to thousands of glaciers that are important not only to the mountains and the people that live there, but everyone on earth.
  2. Have your students read the "What is a Glacier?" MSU ScienceZone. (Vocabulary included in this reading includes **glacier**, **continental glacier**, **alpine (valley) glacier** and **crevasse**.) Your students will be examining more photographs of glaciers and will do the "Try This!" activity during this lesson.
  3. Have your students watch the following short videos of Dr. Dave Lageson:
    - How a Glacier Forms  
<http://youtu.be/ZX-UGhTWvDI>
    - The Glaciers of Mount Everest  
<http://youtu.be/jy1T7qjO32Q>
    - The Shape of Mount Everest  
<http://youtu.be/iVENk4As1J8>
    - What is the Khumbu Icefall  
<http://youtu.be/ovCi6PrK4is>
    - How the Khumbu Glacier is receding  
[http://youtu.be/KtFM\\_cvwEQU](http://youtu.be/KtFM_cvwEQU)

## **Activity 2: Make Your Own Glacier**

Lesson Length: 20 minutes

Materials:

- Ice cubes with dirt and rocks (1 per every 2 students, see Teacher Prep Notes)
- Play dough
- Small pan (1 per every 2 students)

*Teacher Prep Notes: One to two days before this lesson, make a mixture of dirt and rocks of different sizes. Add approximately one tablespoon of the mixture per ice cube and make enough ice cubes for your students to share one ice cube between two students. Fill the ice cube trays with water and then freeze them.*

1. Approximately 10 minutes before this activity (or when your students start the previous activity), take the model glacier ice cubes out of the freezer and leave them out at room temperature until they begin to melt a bit and the rocks at the bottom become exposed and loose.
2. Divide your class into pairs. Tell your students that to learn about glaciers, they will play with them.
3. Have each pair take a handful of play dough and smooth it out like a pancake. Ask one student from each pair to take a model glacier ice cube and drag it (rough end down) slowly, one way across the play dough while pushing down with medium pressure. (Pairs may do this twice so each student has the chance to participate.)
4. Have each pair of students look closely at their model glaciers and playdough landscapes and discuss the following questions together. Listen to student conversations and lead a group discussion of these questions as needed.
  - a. What kind of marks does the glacier make in the play dough?
  - b. Does the glacier leave anything behind (dirt, rocks)?
  - c. Are there interesting features on the surface of the glacier like **crevasses**?
  - d. How is the dirt and gravel distributed throughout (randomly)?
  - e. How was the play dough “landscape” affected by the sediment in the “glacier” (scratches, grooves, large boulders picked up and then deposited by glaciers)?
5. Now, have each pair of students put their model glacier into a pan and observe it melting. (This is more similar to a **continental glacier**, while the scraping activity represented an **alpine (valley) glacier**.) Have each pair of students look closely at their model glaciers and discuss the following questions together. Listen to student conversations and lead a group discussion of these questions as needed.
  - a. What do you notice about how the rocks and dirt are distributed by the melting ice (sediment is unsorted, piles are of mixed sizes)?
  - b. Can you think of areas you have visited that show evidence of glaciers?
  - c. Describe the areas and the clues the glaciers left behind.

### **Activity 3: Photograph Analysis**

Lesson Length: 20 minutes

Materials:

- Copies of Glacier National Park photographs from the Repeat Photograph Project (one per student or projected to view as a class)
    - You can go to <http://www.montana.edu/everest/multimedia/index.htm#glacier> to see a slide show of repeat photography in Glacier National Park or <http://nrmsc.usgs.gov/repeatphoto> if you want to print out just one of the slides
  - Copies of Mount Everest repeat photographs (one per student or projected to view as a class)
    - <http://www.eorc.jaxa.jp/en/imgdata/topics/2007/tp070718.html>
    - <http://www.telegraph.co.uk/earth/earthnews/7895611/Photos-show-dramatic-shrinking-of-Mount-Everest-glaciers.html>
    - <http://www.telegraph.co.uk/earth/earthpicturegalleries/6719563/Nepal-ministers-to-stage-the-worlds-highest-Cabinet-meeting-in-the-shadow-of-Mount-Everest.html?image=17>
    - <http://www.realclimate.org/index.php/archives/2010/01/the-ipcc-is-not-infallible-shock/>
1. Tell your students that glaciers in the Himalayan Mountains as well as glaciers in the United States including Montana are receding and melting. These changes are recorded through historic and modern day photographs.
  2. Examine each pair of the following photographs with your students. (Project each pair of photographs for your students to look at as a group or have each student look at the photographs on their own in front of them.) Compare and contrast the size of the glacier in each photo including its depth and area.
  3. Share the following information for each pair of photographs with your students. You can view photos of these places on the Glacier National Park Repeat Photography Slideshow at <http://www.montana.edu/everest/multimedia/index.htm#glacier>.
    - a. Boulder Glacier, ice cave (1932 - 1988)

This is one of the earliest photographs repeated from Glacier National Park that shows the disappearance of glacier ice and helped to start the current Repeat Photography Project. The 1932 photograph shows a guide, wearing chaps, and three clients next to the ice cave. This was one of the popular routes during the hey day of horseback trips through the park and underscores the charisma that glaciers had for early park visitors. The 1988 photo not only shows a completely ice-free view 56 years later, but shows how vegetation has moved in to the area vacated by the glacier. Boulder Glacier is now about 14 acres and too small to be considered a viable glacier.
    - b. Grinnell Glacier (circa 1940 - 2006)

This overlook is accessed by a spur trail off the Highline Trail in the vicinity of Granite Park Chalet and shows the degree to which Grinnell Glacier has receded. It also offers a view of Salamander Glacier (right foreground) and the miniature meltwater lake that has formed as a result of accelerated melting.

- c. Jackson Glacier (1911- 2009)  
At the time this historic image was taken in 1911, Blackfoot Glacier encompassed the current Jackson Glacier. By 1939, Blackfoot Glacier's recession had resulted in two distinct glaciers, Jackson and Blackfoot. This photo pair shows glacial recession and successive vegetation establishment along Jackson Glacier's terminus.
4. Discuss with your students why and how glaciers are melting (including the glaciers they saw in these photographs). Ask your students what is causing glaciers around the world to melt (including those in Montana and the Himalayas)? Discuss with your students that warming temperatures and **climate change** are increasing the rate at which glaciers are melting. Tell your students that a glacier's white color reflects sunlight. This reflection, called **albedo**, helps keep temperatures cool. Have your students hypothesize what will happen to the Earth's temperature with fewer glaciers on Earth and less white frozen ice-reflecting sunlight. Tell your students that they will investigate these global changes in climate in a future lesson.

### **Tying it All Together:**

Use the following ongoing activities to check for student understanding of each lesson's concepts. Grade for completion, management of data collection, effort and participation throughout unit.

1. **"Mount Everest and Me" Worksheet**

[http://www.montana.edu/everest/resources/worksheets/Worksheet\\_EverestandMe.pdf](http://www.montana.edu/everest/resources/worksheets/Worksheet_EverestandMe.pdf)

This worksheet will be an ongoing activity for your students. In a table format, the "Mount Everest and Me" Worksheet compares Mount Everest, Granite Peak (the highest peak in Montana), and your hometown. Using comparisons, the worksheet reinforces the lesson's content while helping students put this knowledge into perspective by comparing their home state and hometown. Have your students fill in the correlating rows of the table after completing each lesson. This can be completed as a class or individually.

2. **Everest Education Expedition Vocabulary Crossword Puzzle**

[http://www.montana.edu/everest/resources/worksheets/Worksheet\\_Lesson4Crossword.pdf](http://www.montana.edu/everest/resources/worksheets/Worksheet_Lesson4Crossword.pdf)

This crossword puzzle reinforces vocabulary presented in each lesson. Have your students fill in the correlating vocabulary words for each lesson's puzzle after each lesson.

### **Taking it Further:**

It's a Cool Color: The Albedo Effect and Climate

Students do a hands-on activity to learn about the albedo effect. Understanding this phenomenon will help them learn how decreases in light-colored snow and ice could cause increases in temperatures.

[http://forces.si.edu/arctic/pdf/ACT%204\\_COOL%20COLOR.pdf](http://forces.si.edu/arctic/pdf/ACT%204_COOL%20COLOR.pdf)

They can also watch a short video of Dr. Dave Lageson explaining the albedo effect.

<http://youtu.be/dwjKxTmogU>

### Extreme Ice Survey Time-Lapse Videos

With your students, watch short time-lapse videos of glaciers on Mount Everest at <http://www.montana.edu/everest/multimedia/index.htm#glacier> and watch videos of glaciers in Alaska, Greenland, or Iceland to see glacier movement and retreat at [http://www.extremeicesurvey.org/index.php/new\\_gallery/](http://www.extremeicesurvey.org/index.php/new_gallery/).

### Photo Monitoring

Have your class take a photo of the same exact spot daily over a period of time. Note the changes your students see over time. Check out this activity at <http://www.montana.edu/everest/resources/pdf/GearActivity/RepeatPhoto.pdf>.

### Photograph Analysis of Glacier National Park

Examine more photographs of receding glaciers in a 19-page guide from the 2010 *Losing a Legacy: A photographic story of disappearing glaciers* exhibit.

[http://nrmsc.usgs.gov/files/norock/repeatphoto/Gallery\\_guide\\_general.pdf](http://nrmsc.usgs.gov/files/norock/repeatphoto/Gallery_guide_general.pdf)

Optional: Introduce the use of primary sources to gather historical information by using a photograph analysis worksheet.

[http://www.archives.gov/education/lessons/worksheets/photo\\_analysis\\_worksheet.pdf](http://www.archives.gov/education/lessons/worksheets/photo_analysis_worksheet.pdf)