**LAB MODULE 17: GLACIAL LANDSCAPES**

**Note:** Please refer to the GETTING STARTEDmodule to learn how to maneuver through, and how to answer the lab questions, in the Google Earth () component.



**KEY TERMS**

You should know and understand the following terms:

|  |  |  |
| --- | --- | --- |
| Alpine glaciers | Equilibrium | Kettle |
| Arête | Esker | Moraine (lateral, medial, terminal) |
| Cirque | Fjords | Paternoster Lake |
| Continental glaciers | Freeze-on | Tarn |
| Crevasses | Glacial Mass Balance | Zone of Accumulation |
| Drumlin | Kame | Zone of Ablation |

**LAB LEARNING OBJECTIVES**

After successfully completing this module, you should be able to do the following tasks:

* Identify continental and alpine glaciers
* Identify erosional processes and features created by glaciers
* Identify depositional processes and features created by glaciers
* Examine the processes that create glaciers and glacial landforms
* Practice interpreting glacial features on aerial imagery and topographic maps
* Explain the concept of using ice cores to reconstruct climate history

**INTRODUCTION**

This module examines glacial processes and features. Topics include continental and alpine glaciation, ablation and accumulation, cirques, drumlins, kettles, kames and moraine. While these topics may appear to be disparate, you will learn how they are inherently related. The modules start with five opening topics, or vignettes, which are found in the accompanying Google Earth file. These vignettes introduce basic concepts of the glacial processes and landforms. Some of the vignettes have animations, videos, or short articles that will provide another perspective or visual explanation for the topic at hand. After reading the vignette and associated links, answer the following questions. Please note that some links might take a while to download based on your Internet speed.

Expandthe **INTRODUCTION** folder and then check **Topic 1: Introduction**.



Read **Topic 1: Introduction**.



**Question 1**: What are some uses of freshwater from glaciers?

Read **Topic 2: Types of Glaciers**.



**Question 2:** What is the semi-circular feature at the far left of the image?

Read **Topic 3: History within Glacial Ice**.



**Question 3:** Within the snow, colder temperatures result in higher or lower concentrations of light oxygen (16O)?

Read **Topic 4: The Global Retreat and Advance of Glaciers**.



**Question 4:** What happened to the Peterman Glacier on Aug 5, 2010?

Read **Topic 5: Human Reliance on Glaciers for Water**.



**Question 5:** What was the peak discharge on August 14, 2002?

Collapse and uncheck **INTRODUCTIONGLOBAL PERSPECTIVE**



Expand **GLOBAL PERSPECTIVE** and then double-click and select **Major World Glaciers**.



This map shows the location of major glaciers (in blue) throughout the world. At present, glaciers cover approximately 10 to 11 percent of the surface of the Earth. Many cities depend on glaciers as their source of water.

Double‑click **Question 6**. When you arrive at your destination, find the information to fill in the blanks below. Repeat this for Questions 7 and 8:



**Question 6:**

City:

Population:

Glacier(s) located (north, west, east or south of city):

**Question 7:**

City:

Population:

Glacier(s) located (north, west, east or south of city):

**Question 8:**

Glacier:

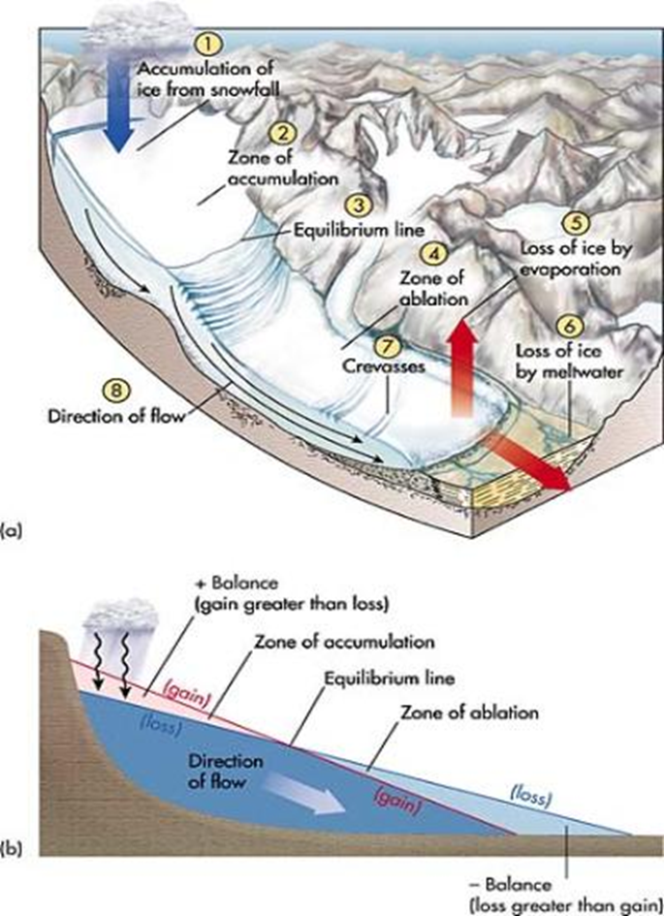
Latitude and Longitude (degrees only): \_\_\_\_\_ °N \_\_\_\_\_° E

Collapse and uncheck **GLOBAL PERSPECTIVE** **ALPINE GLACIATION**



Alpine glaciers are found in many of the world’s major mountain ranges. These glaciers are dynamic and flow downhill under the force of gravity. In many places, alpine glaciers are retreating as the snowpack decreases in winter months and mean temperatures increase during the spring and summer months.

Figure 1. Glacier mass budget. (Arbogast 2nd Ed.).



Expand the **ALPINE GLACIATION** folder. Double-click and select **Mass Balance**.



This is the Klinaklini glacier in British Columbia, Canada. Along an alpine glacier there are two major zones, accumulation and ablation. The *zone of accumulation* (Figure 1) is located at higher elevations where temperatures remain cold enough such that snowfall exceeds melting over the course of a year. Conversely, the *zone of ablation* is located at lower elevations where melting exceeds snowfall. The red line in the middle represents the *equilibrium line*, where snowfall and melting are equal over the course of a year. Farther down in the zone of ablation, and loss of ice by meltwater is evident.

**Question 9:** Where do we find the deep fissures in the glacier known as crevasses– in the zone of accumulation or the zone of ablation?

Keep **Mass Balance** selected, and then double‑click **Direction of Flow**.

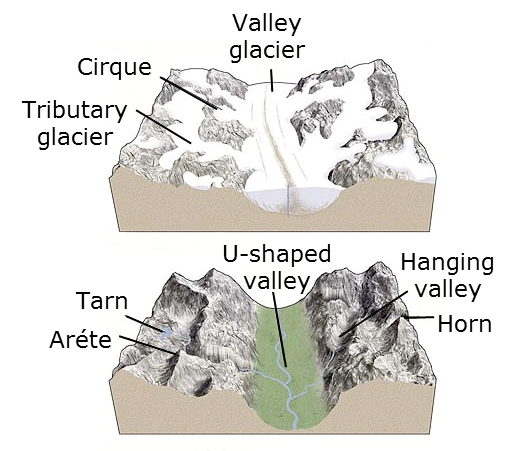


**Question 10:** Explain the direction of flow of glacial ice, from the zone of accumulation to the loss of ice by meltwater.

**Erosional Features**

A *cirque* (or *corrie*) is a bowl‑shaped erosional feature created by complex glacial ice flow that that plucks material from a hollow on a slope and promotes the creation of a depression. Cirque glaciers are typically the head of U shaped valley glaciers. After glaciation, many cirques contain *tarn lakes* (Figure 2) while in the glacial valleys, chains of *paternoster lakes* are formed, commonly connected by a single stream system.

Figure 2. Glaciation (17.16 Arbogast 2nd Ed.)

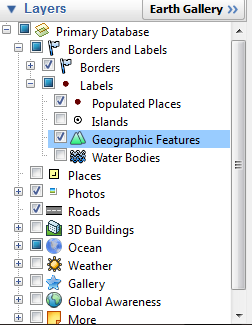


Expand **Erosional Features** and then double‑click and select **Mt. Rainier**.



Mount Rainier, with its 25 glaciers covering 90 square km (35 square mile), has more glaciers than any other peak in the continental US.

Figure 3. Geographic Features line item



Mt. Rainier is located south of Seattle, Washington. Google has a function that enables you to see more information about the mountain such as the elevation and the elevation profile, and to fly on a tour. Open the **Layers** pane, expand **Borders and Labels**, expand **Labels** and then check **Geographic Features** (Figure 3).

Double‑click **Mount Rainier Tour**



Double‑click and select the **A and B** folder.



**Question 11:** The ridgeline is what type of glacial feature?

Double‑click **Forbidden Peak Tour** to get a closer look



**Question 12:** What glacial feature (there are nearly 20 of them) is found on both sides of the ridgeline between A and B?

**Question 13:** Look at the lake below this ridgeline. This lake is what type of glacial feature?

Double‑click and select .



**Question 14:** What type of glacial feature is this lake?

Double-click select the **D** folder.



When 3 or more cirques back into each other they create a particular landform feature. However, this feature is somewhat difficult to see in the 2D perspective.

Double‑click . Double‑click and select **Mountain Tour**.



**Question 15:** What is the name of this glacial feature, to which the mountain is named (Hint: You can determine the name of the major summit by enabling **Geographic Features**)?

Close the simulation control panel:



Double-click **Valley** and then click **animation** in the pop-up window. Select the symbol.



This valley was originally created by a river system and substantially modified by a glacier that has since retreated.

**Question 16:** What type of valley is found at D?

Collapse and uncheck **Erosional Features**



**Transportation and Depositional Features**

Double-click **Transportation and Depositional Features**.



### This is the glacier d'Otemma in Switzerland. Within this alpine glacier, several depositional features are evident. Most notable are the various *moraines* found along (lateral), among or between (medial) and at the end (terminal) of the glacier. Morainesconsist of unsorted till (diamicton or sediment) that is deposited with glaciers; the location of the moraine determines the type. Three of the most well-known moraines are:

Double‑click and select letters **F**, **G** and **H** individually to identify the following features:



**Question 17:** Feature : \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_



**Question 18:** Feature : \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_



**Question 19:** Feature \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_



Collapse and uncheck **Transportation and Depositional Features**



**Continental Glaciation**

During glacial periods in the past, large portions of North America were cover by continental glaciers. Today, these glaciers are found predominantly in Greenland and the Antarctica. But remnants of continental glacier activity can be found across much of Canada, the northern continental US, northern Europe and Russia.

Double click **CONTINENTAL GLACIATION**. This animation depicts marginal landforms of continental glaciers.



As you can see, it is the depositional features of continental glaciations that remain on the landscape. These features include those that formed under or as a result of glacial lobes while other features are a result of glacial meltwater.

Expand **CONTINENTAL GLACIATION** and then expand **Depositional Features**.



Drumlins are created by continental glaciers that reshape previous deposited glacier material as they move over it (Figure 4). They tend to be elongated and orient in the direction of ice movement. The blunt end of a drumlin faces the direction from which the glacier was moving when it created the drumlin.

Double-click **Drumlin**.

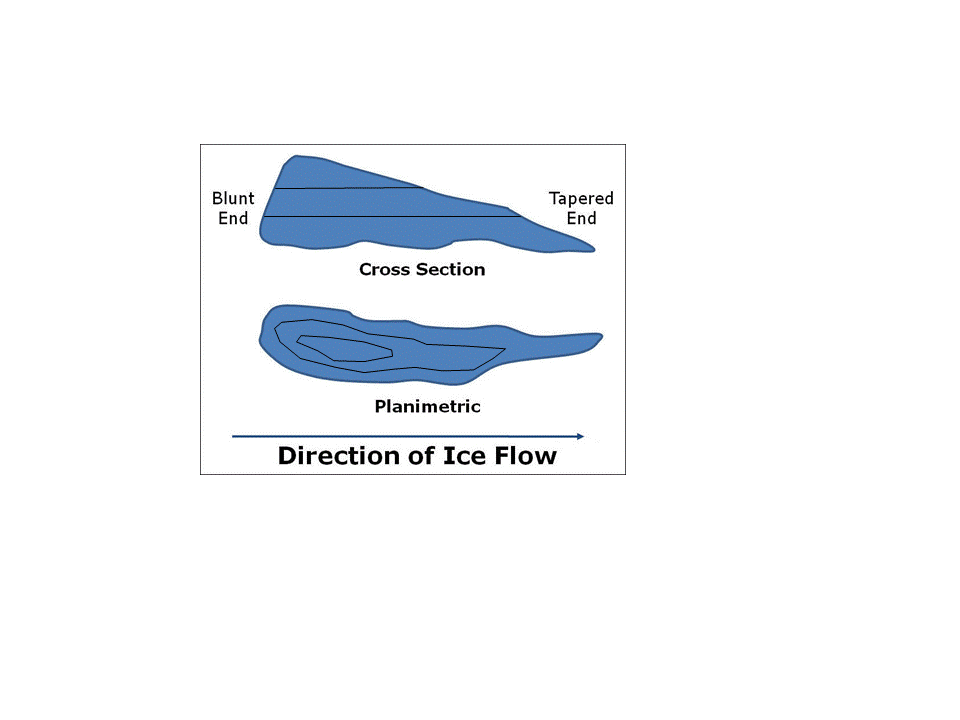


Figure 4. Topographic representation of a drumlin and its direction of glacial ice flow.



This is a landscape with several drumlins. From the air it is difficult to see them; however, it becomes more obvious when contour lines are added to show elevation changes.

Set the elevation exaggeration to 3.



Select **Drumlin Contour**.



Look for a series of contour lines forming an elongated shape similar to Figure 4. This feature is a *drumlin*.

Double-click and select **Drumlin Oblique View** to see an oblique view of the feature.



**Question 20**: According to the shapes of the drumlins, what (compass) direction do you think the ice was moving when it formed the drumlins?

Double-click and select **Kettle Lake**.



This large circular body of water is a kettle lake formed by a block of ice a retreating glacier falling off. Over time the block of ice is partially buried and then melts to create a depression. When filled with water, this depression is termed a kettle lake. Use the ruler tool and measure the distance across the lake from point H to point I.

**Question 21:** How wide, in miles, is the lake (from H to I)?

**Question 22:** Assuming the lake is circular, calculate the *area* of this lake (A=πr2) in square miles, where A is area, pi is 3.14, and r2 is the radius of the circle squared. (Hint: the kettle lake is approximately the size of 1,000 North American football fields).



Area is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_mi2

Double-click **Eskers**.



Eskers are long snake like ridges created by the deposition of sediment from melt water streams that flowed within or under glaciers. Gravel pits often mine eskers for sand and gravel.

This is the Ripley Esker in Minnesota. Notice how the trees delineate the esker.

Select **Belle Prairie**.



You can use the following Google Earth tools to make the esker easier to see on the topographic maps:

* Use the **Adjust Opacity** tool to see how the topographic map compares to the aerial photograph.



* Use the **Ruler** tool to compute the length of the esker.



**Question 23**: What is the length of the esker in miles? \_\_\_\_\_\_\_\_\_\_\_\_

**Question 24**: What are the two dominant economic activities found around the esker?

Double-click **Moraine**.



This landscape in Minnesota is dotted with a terminal moraine and kettle lakes. While the lakes are easy to see, the moraine is not.

Double-click **Moraine Perspective** to view the landscape from a 3-D perspective.



The moraine appears as a series of hills.

Double-click and select **Inspiration Peak** to view a topographic map of the landscape.



**Question 25**: What is the high point of the moraine in section 1 (Central eastern part of the Inspiration Peak map marked by the red number 1)?

**References**:

Alan Arbogast. 2011. *Discovering Physical Geography, 2nd edition.* John Wiley and Sons, Inc.

Robin E. Bell, Fausto Ferraccioli, Timothy T. Creyts, David Braaten, Hugh Corr, Indrani Das, Detlef Damaske, Nicholas Frearson, Thomas Jordan, Kathryn Rose, Michael Studinger, and Michael Wolovick. 2011. Widespread Persistent Thickening of the East Antarctic Ice Sheet by Freezing from the Base. *Science* 331 (6024), 1592-1595*.Published online 3 March 2011 [DOI:10.1126/science.1200109]*

**Extra Resource:**

North Cascades (Including Mt. Rainier): http://www.edugen.com:30120/geodiscoveries/resources/ch12/print/cascade\_range/index.htm