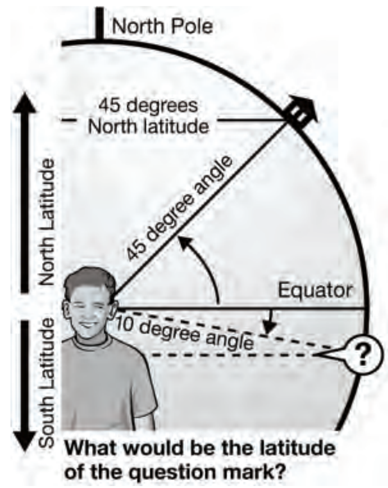
Name: ______________________ Date: ______________

SKILL and PRACTICE 8.1

Latitude and Longitude

READ

History: Latitude and longitude are part of a grid system that describes the location of any place on Earth. When formalized in the mid-18th century, the idea of a grid system was not a new one. More than 2000 years ago, ancient Greeks drew maps with grids that looked much like our maps today. Using mathematics and logic, they postulated that Earth could be mapped in degrees north and south of the Equator and east and west of a line of reference. From the ancient times, geographers and navigators used devices such as the cross-staff, astrolabe, sextant, and astronomical tables to determine latitude. But determining longitude required accurate timepieces, and they were not reliably designed until the 1700's.



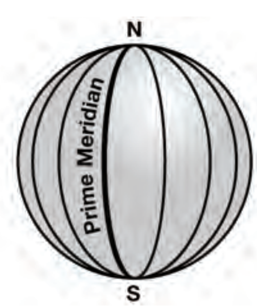
Latitude: Think of Earth as a transparent sphere, just as the ancient Greeks did. Now imagine yourself standing so that your eyes are at the center of that sphere. If you tip your head back and look straight up, you will see the North Pole above you. If you look straight down, you will see the South Pole below you. If you turn around while looking straight out at the middle of the sphere, your eyes will follow the Equator, the line around the middle of Earth. The ancient Greeks realized that they could describe the location of any place by using its angle from the Equator as measured from that imaginary place at the center of Earth.

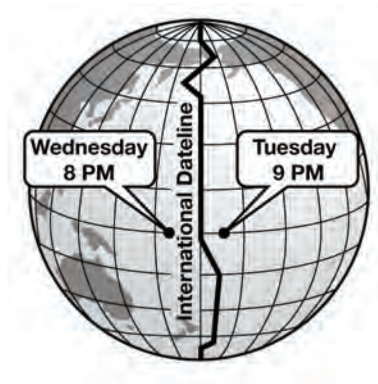
All latitude lines run parallel to the Equator, creating circles that get smaller and smaller until they encircle the Poles. Because latitude lines never intersect, latitude lines are sometimes referred to as *parallels*.

At first, you might be confused because when latitude lines are placed on a map. They appear to run from the left side of the page to the right. You might think they measure east and west, but they don't. The graphic at the right shows latitude lines. If you think of them as steps on a ladder, then you will see the lines are taking you “up” toward the north or “down” toward the south. (Of course, there is no real “up” or “down” on a map or globe, but the association of LAdder and LAtitude may help you.)

The Equator is designated as 0º. The North Latitude lines measure from the Equator (0º) to the North Pole (90ºN). The South Latitude lines measure from the Equator (0º) to the South Pole (90ºS). There are other special latitude lines to note. The Tropic of Cancer is at 23.5ºN latitude, and at 23.5ºS latitude is the Tropic of Capricorn. These lines represent the farthest north and farthest south where the sun can shine directly overhead at noon. Latitudes of 66.5º N and 66.5º S mark the Arctic and Antarctic Circles, respectively. Because of the tilt of the Earth, there are winter days when the Sun does not rise and summer days when the sun does not set at these locations.

Longitude: Now imagine yourself back in the transparent sphere. Look up at the North Pole and begin to draw a continuous line with your eyes along the outside of the sphere to the South Pole. Turn to face the opposite side of the sphere and draw a line from the South Pole to the North Pole. These lines, and all other longitude lines, are the same length because they start and end at the poles. Look at the graphic below and see that although longitude lines are drawn from north to south, they measure distance from east or west.





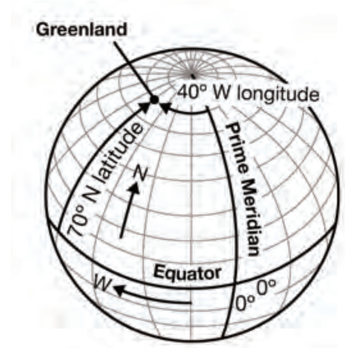
There are no special longitude lines, so geographers had to choose one from which to measure east and west. Longitude lines are also called *meridians*, so this special line is called the Prime Meridian and is labeled 0º. The ancient Greeks chose a *Prime Meridian* that passed through the Greek Island of Rhodes. In the 1700's, the French chose one that passed through Ferro, an island in the Canary Islands. There are maps that show that America even used Philadelphia as their special reference location. But in 1884, the International Meridian Conference met in Washington, DC. They chose to adopt a Prime Meridian that passes through an observatory in Greenwich, England. At the same conference, they also determined a point exactly opposite of the Prime Meridian. This second important longitude line is the 180º meridian. Longitude lines measure eastward and westward from the Prime Meridian (0º) to the180º meridian. Superimposed on the 180º meridian is the *International Dateline*. This special line does not follow the 180º meridian exactly. It zigzags a bit to stay in the ocean, which is an unpopulated area. International agreements dictate that the date changes on either side of the Dateline.

GPS and decimal notations. In the past, latitude and longitude lines always had measurement labels of degrees (º), minutes ('), and seconds ("). The labels of "minutes" and "seconds" did not denote time in these cases. Instead they described places between whole degrees of longitude or latitude more exactly. For example, consider Sacramento, CA. Traditionally, its location was said to be at 38º 34' 54"N (38 degrees, 34 minutes, 54 seconds North) and 121º 29' 36"W (121 degrees 29 minutes, 36 seconds West). Now GPS (Global Positioning System), in decimal notation would say Sacramento is located at 38.58ºN and 121.49ºW. Note: As a matter of custom when giving locations, latitude is listed first and longitude second.

EXAMPLES ▶

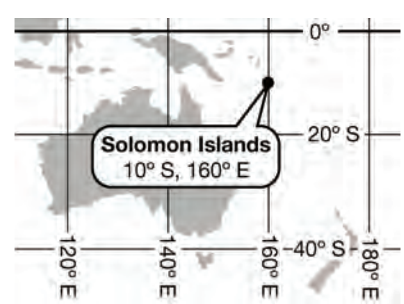
Finding a Location on a Globe

You can find any location by using latitude and longitude on a globe. See the example in the diagram. The position is 70ºN and 40ºW. First on the globe, you would find the latitude line 70ºN, seventy degrees north of the Equator. Next you would find the longitude line 40ºW, forty degrees west of the Prime Meridian. Trace the lines with your fingers. Where they intersect, you will find the location. In this case, you have located Greenland.



Finding a Location on a Map

You use the same procedure to find any location on a map. Look at the graphic below. The position is 10ºS and 160ºE. First you would find the latitude line 10ºS, ten degrees south of the Equator. Next you would find the longitude 160ºE, one hundred-sixty degrees east of the Prime Meridian. You have located the Solomon Islands.



PRACTICE 1

Use an atlas or globe to answer these practice questions.

1. What country will you find at the following latitude and longitude?
   a. 65ºN 20ºW
   b. 35ºN 5º E
   c. 50º S 70ºW
   d. 20ºS 140ºE
   e. 40ºS 175ºE
2. What body of water will you find at the following latitude and longitude?
   a. 20ºN 90ºW
   b. 40ºN 25ºE
   c. 20ºN 38º E
   d. 25ºN 95ºW
   e. 0ºN 60ºW

EXAMPLE

Converting Traditional Notation To Decimal Notation

Sometimes you need to convert the traditional notation of degrees, minutes, and seconds into decimal notation. First you must understand this traditional notation, which was a base-60 system.

One degree = 60 minutes One minute = 60 seconds One degree = 3,600 seconds (60 × 60)

Let's look at 34º 15' (thirty-four degrees 15 minutes).

Regardless of the system, the notation will begin with 34 degrees. To change the minutes into a decimal, you must divide 15 by 60, the number of minutes in one degree (15/60). The answer is 0.25. Therefore, the decimal notation would be 34.25º or thirty-four and twenty-five hundredths degrees.

Let's look at 12º 20' 38" (twelve degrees, twenty minutes, thirty-eight seconds). We know the notation will begin with 12 degrees. Next we have to convert the 20 minutes into seconds (20 × 60 = 1,200 seconds. Then we add the 38 seconds for a total of 1,238 seconds. There are 3,600 seconds in one degree, so you must divide 1,238 by 3,600. (1,238 / 3,600). The answer is 0.34. Therefore the decimal notation would be 12.34º or twelve and thirty-four hundredths degrees.

PRACTICE 2

3. Convert the following latitudes in traditional notation to decimal notation. (Round your answer to the nearest hundredth.)
   a. 30º 20' N
   b. 45º 45' N
   c. 20º 36' 40" S
   d. 60º 19' 38" S

4. Convert the following longitudes in traditional notation to decimal notation. (Round your answer to the nearest hundredth.)
   a. 25º 55' E
   b. 145º 15' E
   c. 130º 37' 10" W
   d. 85º 26' 8" W

Name: ______________________ Date: ______________

SKILL and PRACTICE 8.1

Map Scales

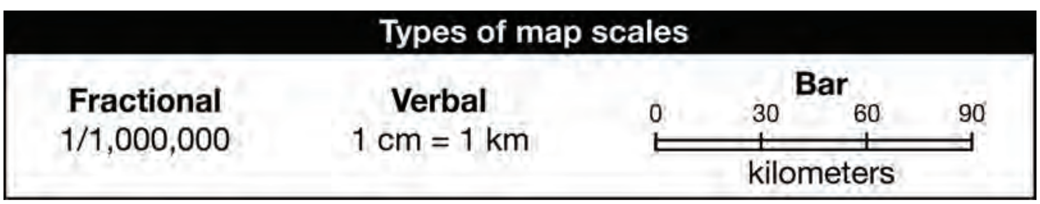
READ

Mapmakers have developed a tool that allows them to accurately draw the entire world on a single piece of paper. It's not magic—it's drawing to scale. To be useful, maps must be accurately drawn to scale. The mapmaker must also reveal the scale that was used so that a map-reader can appreciate the larger real-life distances. The scale is usually written in or near the map's legend or key.

There are thee kinds of map scales: fractional, verbal, and bar scales. A fractional scale shows the relationship of the map to actual distance in the form of a fraction. A scale of 1/100,000 means that one centimeter on the map represents 100,000 centimeters (or 1 kilometer) of real life distance.

A verbal scale expresses the relationship using words. For example, "1 centimeter equals 500 kilometers." This is a more usable scale, especially with large real-life distances. With a scale of 1cm = 500 km, you could make a scale drawing of North America on one piece of paper.

A bar scale is the most user-friendly scale tool of all. It is simply a bar drawn on the map with the size of the bar equal to a distance in real life. Even if you do not have a ruler, you can measure distances on the map with a bar scale. Just line up the edge of an index card under the bar scale and transfer the vertical marks to the card. Label the distances each mark represents. You can then move the card around your map to determine distances. You might wonder what you should do if a location falls between the vertical interval lines. You must use estimation to determine that distance. Be careful to look at the scale before estimating. For example, if the distance falls half-way between the 10 and the 20 kilometer scale marks, estimate 15 kilometers. If the scale is different and the distance falls half-way between 30 and 60 kilometer marks, you must estimate 45 kilometers.



Let's explore the different kinds of scales. You will need centimeter graph paper, plain paper, an index card, and a centimeter ruler or measuring tape for these activities.

EXAMPLES

Fractional scale

Materials: Graph paper

Trace a simple object on a piece of graph paper. (A large paper clip, pen, small scissors, or paperback book work well.) Now make a scale drawing of the object using the fractional scale of 1/4. (Remember this means that for every 4 blocks occupied in the original tracing, you will have only one block on the scale drawing.) Be sure to label the scale on the finished scale drawing.

Verbal scale

Materials: Centimeter graph paper and centimeter measuring tape or ruler.

You are going to make a scale drawing of a person. Ask a classmate to stand against a wall with his/her arms outstretched to the side. Take 4 measurements in centimeters: 1) Distance from top of head to floor. 2) Distance from right finger tip to left finger. 3) Distance from top of head to shoulders. 4) Distance from shoulders to waist. Write the verbal scale of "1 cm equals 10 cm" on the bottom of a piece of centimeter graph paper. On that paper translate the measurements that your took into a simple figure drawing of your classmate. (Remember if a measurement is 25 centimeters in real life, you will have to make a drawing that is within 2 ½ centimeter blocks of the graph paper.)

Bar scale

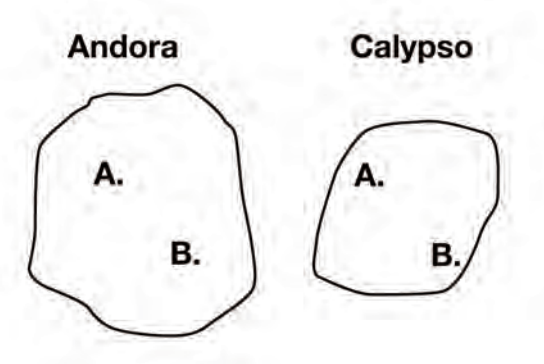
Materials: Plain paper and centimeter ruler or tape.

Position the paper so that it is wider than it is long.

Draw a bar scale that is a total of 6 centimeters long at bottom of the paper. Make four vertical marks at 0 cm, 2 cm, 4 cm, and 6 cm. Write "0"over the first mark, "50" over the second, "100" over the third and "150" of the last mark. Underneath the bar write "Kilometers." Mark "N" for north at the top of your paper. Now use your imagination to draw an island (of any shape) that is 450 miles long and 200 miles wide at its widest point. Draw a star to mark the capital city, which is located on the northern coast 100 miles from the west end of the island.

PRACTICE

1. Answer these questions about Andora and Calypso:
   a. Which island appears bigger?
   b. Can you tell whether you can ride a bike in one day from point A to point B on either map? If no, why not?
   c. Measure the distance from the center of the dot to the right of A to the center of the dot to the left of B on both maps. Are the measurements the same?
   d. If the measurements are the same on both maps, does that mean the distance from point A to point B is the same on both maps? Explain your answer.



   e. Let's write in the scale for these two islands. Write the scale of 1cm = 5 km on Andora. Write the scale of 1 cm = 1000 km on Calypso. Now answer the question, which island is bigger?

2. On the next page is a map of Monitor Island. Use the bar scale to find distances on this island. Assume that you are measuring "as the crow flies." That means from point to point by air because there are no roads to follow. Always measure from dot to dot, and be sure to label your answers in kilometers.
   a. Point L to Point M
   b. Point Y to Point Z
   c. Point Z to Point P
   d. Point P to Point M

e. Point Q to Point T

f. Point Q to Point M

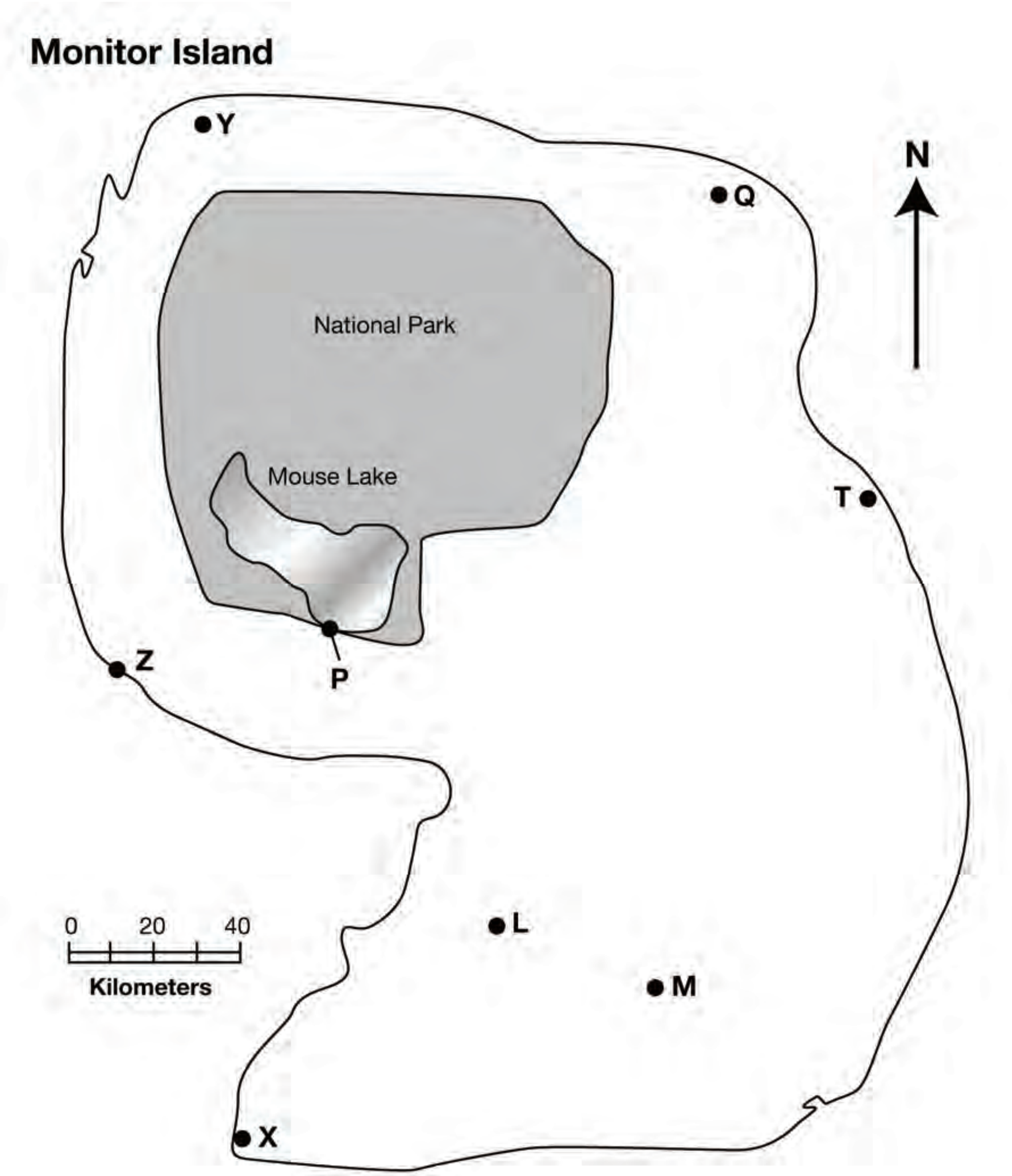
g. Point T to Point M

h. Point Z to Point P to Point X

i. Point X to Point L to Point M

j. Point X to Point P to Point Z to Point Y

Bonus: Measure around the coast of Monitor Island. It's hard to be exact, but write your best estimate.



Name: ______________________ Date: ______________

SKILL and PRACTICE 8.1

Navigation Project

READ

Nautical charts have long been used by ship captains to navigate the oceans. As land has been increasingly developed and harbors built, more and more information is needed to safely navigate near shore. Additionally, offshore shallow banks, reefs, islands, seamounts, and other obstructions needed to be identified so that they don't hinder the passage of boats.

In this project, you and two other captains will navigate through the waters around Puerto Rico and some of the Virgin Islands using three real nautical maps. Your journey includes a stop at Isla de Vieques, which was a US Navy testing ground for bombs, missiles, and other weapons. It was vacated in May 2003 and now is used by locals and tourists. Bon Voyage.

Materials:

- NOAA map #25640 (laminated)
- NOAA map #25641 (laminated)
- NOAA map #25647 (laminated)

Note:
Laminated maps are available from NOAA (www.noaa.gov) or boating/marine supply stores, as well as some Coast Guard Stations.

- Internet access
- Erasable overhead projector marker

Getting started:

1. Have all three maps accessible.
2. Before beginning your imaginary journey, spend some time studying the maps. Look at any legends (example: note on pipelines and cables), abbreviation lists, and Notes (such as Note E on map 25640). Look at the map scale. Note whether the soundings are in fathoms or feet.
3. Note that the maps are laminated, so you can use an erasable marker to outline your path.

Making predictions:

a. What kind of ecosystem do you expect to find in these warm, sunlit waters?

b. What does this mean about navigating this area?

It’s time to go!

1. You and your two partners are tri-captains on a boat that is 12 feet deep. On board, you have a small row boat. Besides your clothes and toiletries for the trip, you will bring along wading boots, a solar still, a radio, your three maps, water, and food.
2. You will be traveling from the west coast of Puerto Rico, eventually ending your trip on the island of St. John. As captains, you will be making decisions about the course the boat will be taking based on directions given below. You will need to look out for (among other things) shallow water, pipelines, and other obstructions. Listen to what the map is telling you.
3. Let's start with map 25640. What is the scale of this map?
4. What does that mean?
5. How many feet are there in a fathom? Hint: The answer is outside the border of the map.
6. Find Punta Higuero on the west coast of Puerto Rico. What is located here? Use your abbreviations. You will probably have to look it up.
7. You will now be moving south along the west coast and then the south coast of Puerto Rico. Notice the light blue area around the coast. At the seaward edge of this area is a line. Every few inches along this line, you will see a number 10. What this means is that anywhere along this line the depth of the water is 10 fathoms. Remember, your boat is 12 feet deep. How many fathoms is this?
8. So your boat is fine anywhere along the line. However, as you head toward the coast from this 10-fathom line, the depth decreases, but since the depth is not marked again, you do not know how quickly it decreases and thus can't take your boat any closer to the shore. Remember this as you travel. So start traveling south. What do you encounter near the Bahia de Mayaguez?
9. What does this mean?
10. Is the depth of the water still suitable for traveling?
11. Travel around the marine conservation district. Should anyone be fishing here?
12. Can you pass between Bajas Gallardo and the Marine Conservation District?   If so, trace the path through and if not, find another way around towards the south shore.
13. Stay near to shore so you can have great views of the beautiful shallow blue waters. Find Punta Cayito and Punta Barrancas on the south shore. In the area offshore, there is a section between the 10 fathoms line and the next depth line of 100 fathoms were there are several abbreviated notations. Name three by noting the abbreviation and what it means.
14. Find the lighthouse near Cayos de Ratones. What type of lighthouse is it and why is that different than occulting?
15. 5M means that it can be seen for 5 nautical miles, which is 1.852 kilometers or 1.15 miles.
16. As you travel towards the southeastern coast of Puerto Rico, what area in a square dashed purple box do you see?
17. Do you think it would be a good or bad idea to drop anchor there?

18. Head to Isla de Vieques. There are supposed to be two beautiful bays that are filled with organisms that are bioluminescent. These one-celled organisms give off a blue-green glow when disturbed. You'll have to wait here till night-time in order to see this natural wonder. Can you take your ship right up to the shore? If not, what can you do to get there?
19. How many lighthouses are there on the Island?
20. Two lighthouses are flashing. One is occulting. What is the fourth, what does the symbol mean, and what two colors are associated with it?
21. How far out can you see the flashing and occulting lighthouse lights on the Island?
22. Your next stop is Savana Isle, a small island just west of St. Thomas. As you travel in that direction, what do you notice there are many of in the area of the Virgin Passage?
23. What does that mean you should NOT do in this area?
24. Can you bring your boat in directly to Savana Isle?
25. What does the (269) mean?
26. Now you are going to move to map 25641. The soundings are done in what units?
27. Orient yourselves for a minute. You are currently at Savana Isle. Find it on the map.
28. What is the scale on this map?
29. You can see that the scales on the maps are quite different. What do you notice when you look at the maps themselves. How are they different?
30. When you are sailing in this area, where do you call to report spills of oil and hazardous substances? There are two choices.
31. For weather information, to what station do you tune?
32. From Savana Isle, head toward Cricket Rock using Salt Cay or Dutchcap Passage. How many fathoms deep is the coastline?
33. Should you anchor and row in or go right up to the shore?
34. How much rock is covered and uncovered?
35. What are the local bottom characteristics?
36. By the way, what is a cay?

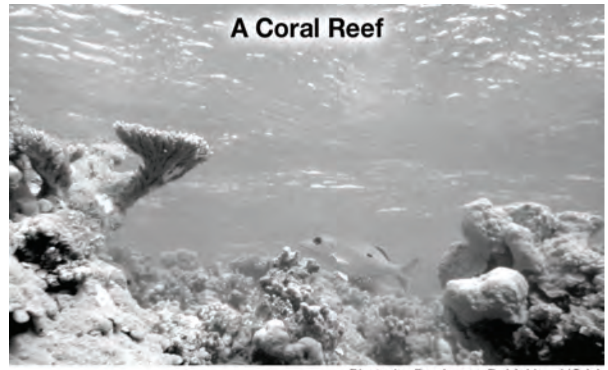


Photo by Dr. James P. McVey, NOAA.

37. Now you will head to White Horseface Reef at Hans Lollik Isle. Watch your depths as you travel in that direction. What is submerged en route to the Isle?

38. Anchor where you can and spend some time snorkeling. Once you have completed your swim and returned to the ship, start heading through the Leeward Passage. Move to map 25647 at this point. In what units are the soundings measured?

39. What is the scale?

40. Once again, what do you notice about the scale and amount of detail in the map?

41. On this map, what do the green solid and dashed green lines represent?

42. How does that affect your boat?

43. Heading through Leeward Passage and south of Thatch Cay, there is a rectangular box with a blue tint in the waterway. It is there to let you know, as captains, that there is an obstruction, a fish haven, which is an artificial reef. These are usually made of rock, concrete, car bodies, and other debris. If you'll notice, inside the box, it states an authorized minimum depth of 60 feet. If you look at the depth of the water on the map around the box, the values are deeper than 60 feet. Because of the artificial reef, the map is telling you that you can be assured to not have any obstruction down to 60 feet, but it is hazardous after that depth. The minimum depth is checked by sweeping the area with a length of horizontal wire. If there is an obstruction, the wire would get snagged. Is your boat okay to travel through this area?

44. Continue to Cabrita Point and through to St. James Bay. You are headed towards Jersey Bay, but you are going to have to be very careful navigating the Jersey Bay area as you will then head into Banner Bay Channel. It is recommended by the map that you seek local knowledge about some broken piles (wooden columns driven into the harbor sand beds on which structures can be built in the water) which may be below the waterline and are not marked on the map. As you look at the channel, make note of the depth of the water. Will you be able to take your boat in or row in? How can you tell?

45. Bring your wading boots just in case you need them. The symbols that look like ties (colored in green and purple) will help you navigate your way. These are buoys. The first letter of each buoy is either an R for ‘red’ or G for ‘green.’ The rule of thumb is to keep red buoys to the right (starboard) when returning to a harbor and green buoys to the left (port). Using that rule, get yourself to the coast and have some lunch in town, especially after all that rowing.

46. Take a taxi ride west of the harbor to the mangrove lagoon. Can you wade in there with your boots?

47. Mangroves are trees and shrubs that grown in saline marine areas. The mangrove roots impede the water flow. Since the water is carrying sediment, the slowed water deposits the sediment over time and actually builds coastline. These are very special ecosystems.

48. Spend some time here, take the taxi back to the row boat, and get back to your ship.

A Mangrove Lagoon

Photo by Ben Mieremet, NOAA.

49. Find a path to St. John and choose a landing site. Describe three more nautical notations that you encounter and how they influenced your route.

50. Congratulations! Your voyage has ended. Hope you learned how important map reading is for nautical navigation. Show your teacher your route.

Name: ______________________ Date: ______________

SKILL and PRACTICE 8.1

Geography Scavenger Hunt

READ

Being able to find your way around a world map or globe is a handy skill. With practice, you can hone that skill.

Today, you will work in teams of three or four members. Let's see how quickly your team can complete the following scavenger hunt. Work together to find the answers to these 15 questions about places around the world. When your team has completed this skill sheet, send one member to the teacher who will immediately correct your team's answers. However, your teacher will only tell you, “Congratulations, your skill sheet is correct,” or “Sorry, you have ___ error(s). Go back and find them.”

If you have an error or two, quickly review all your answers and try to find it. Go back to your teacher with the corrected paper as soon as possible. Work quickly and quietly so other teams will not hear your answers.

EXAMPLE

The Equator passes through which three South American countries?

The answer is Ecuador, Columbia, and Brazil.

Note: Be certain to use capital letters and correct spelling in your answers. Otherwise, your teacher may consider this type of carelessness an error.

PRACTICE

Wait until your teacher says, “GO!” Try to be the first team to answer ALL the following questions.

Table 1:

Can you find...	Answer...
1. What country is located where the Prime Meridian crosses the Tropic of Cancer?	
2. What country lies east of Pakistan and south of Nepal?	
3. What island country is found in the North Atlantic and its northern border passes through the Arctic Circle?	
4. The Andes Mountains run through 4 countries found on the western coast of South America. What are these 4 countries?	

Table 1:

Can you find...	Answer...
5. What country lies on the 100ºE meridian and is bordered by Laos and Cambodia?	
6. What is the large North American country that spans from Newfoundland on the Atlantic Ocean to Vancouver Island on the Pacific Ocean?	
7. What country is made up of a chain of islands east of North Korea and South Korea?	
8. What island continent is found on the Tropic of Capricorn and is bordered by both the Indian and Pacific Oceans?	
9. What bay separates Greenland and Canada?	
10. What is the name of the boot-shaped country in the Mediterranean Sea where Mount Vesuvius and Mt. Etna are found?	
11. What two central American countries border Mexico on the south?	
12. What country lies between the Black Sea, the Aegean Sea, and the Mediterranean Sea?	
13. What is the name of the sea that is bordered by Central America on the west, South America on the south, and Cuba on the north?	
14. What country can be found at 30ºS and 30ºE?	
15. What oceans surround Antarctica?	

Name: ______________________ Date: ______________

Topographic Maps

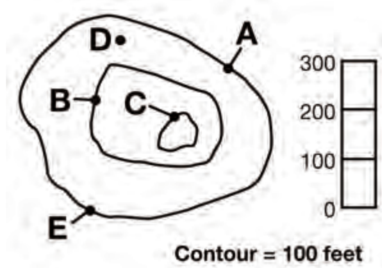
PRACTICE 112m = 4 sec 8.2

READ

Flat maps can easily show landmasses and political boundaries. However, mapmakers need to draw special maps, called topographic maps, to show hills, valleys, and mountains. Mapmakers use contour lines to show the elevation of land features. The 0 contour line refers to sea level. The height above sea level is measured in equal intervals. Always look at the legend to see the elevation of each contour line interval. Sometimes these contour lines describe an increase of 20 feet. On other maps, especially those showing mountains, the contour lines may show elevation intervals of 100 to 1000 feet.

EXAMPLES

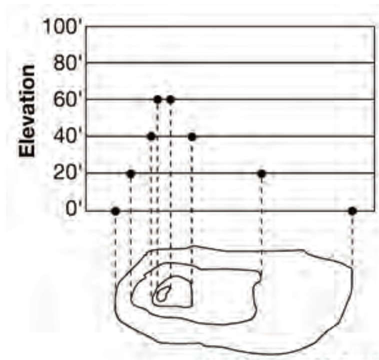
- **Contour lines and elevations**



Look at Figure 1. On this map, the contour interval is 100 feet. Let's look at the letters marked on the map. Point A is at sea level. That means it is on the 0 contour line all the way around the island. Point B is on the next contour line. That means that B is 100 feet above sea level. What is the elevation at Point C? If you said 200 feet, you would be correct. At what elevation is Point D? The correct answer is somewhere between 0 and 100 feet. You can't be exact because D is not on a contour line. Where is Point E? Yes, it's at sea level, the same level as A.

Take a minute to color the contour key and the map. Color green between 0 and 100 feet, color yellow between 100 and 200 feet, color red between 200 and 300 feet. Mapmakers generally use blue for water only, so do not use it in a contour key.

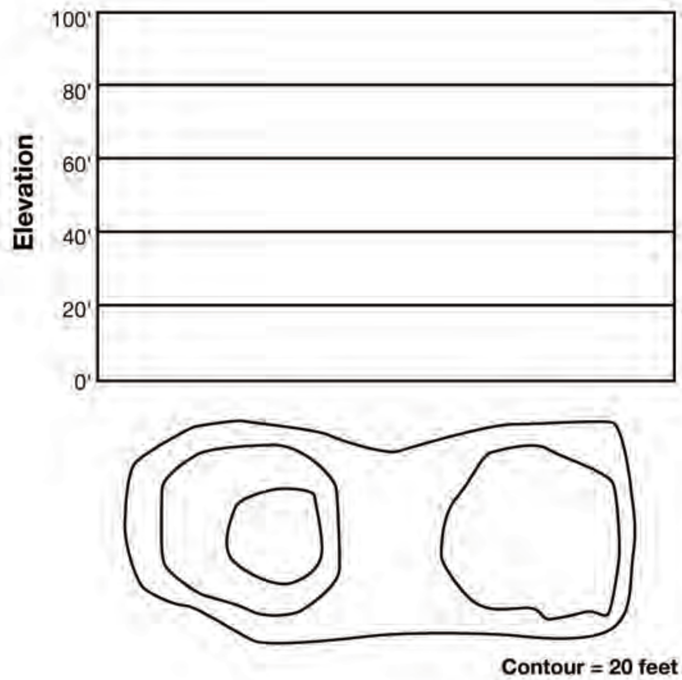
- **Profile Maps**



You can also translate contour lines into a profile map. In this way you can actually draw what you would see if you were approaching by sea. Look at the following map as you read the steps to create a profile map. First, you draw a graph above the map that shows the intervals. The contour is 20 feet so you would label the elevation in 20-foot intervals on the left. Your task is to make dots on the lines of the graph directly above the island contour lines. Put a ruler against the left hand edge of the island, and make a dot on the 0' line of the graph. Slide your ruler to the right hand edge of the island and make a second dot on the 0' line. Next go to the second contour line and mark two dots on the 20-foot interval line in the graph above the map. Continue marking two dots at the widest dimensions for contour lines 40 feet and 60 feet. Now connect the dots. This shows you the profile of the island. Note, the island's elevation is probably a little more than 60 feet, so you could draw a peak on the top of the hill taller than 60 but less than 80 feet. Even if the island were 79 feet tall, there would not be an 80-foot contour line.

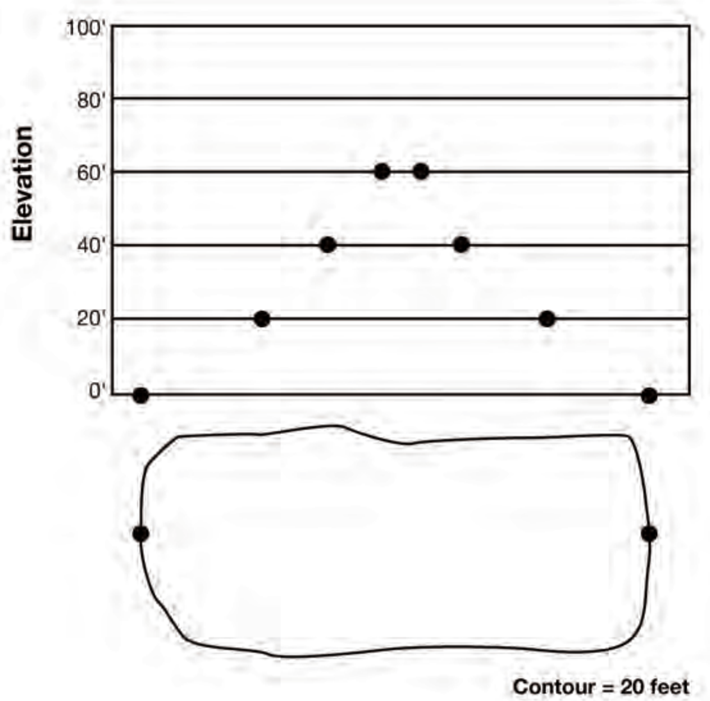
PRACTICE

1. Draw a profile map of the island in Figure 3. (Hint: You will have four dots on the 20' line.)

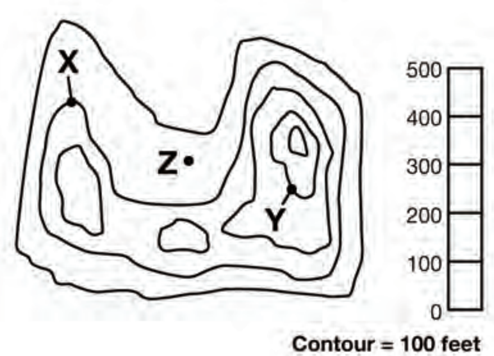


PRACTICE 8.2

2. Reverse the process to make a topographic map from the profile map. For each dot on the graph, you will make a small dot on the map showing where the contour line begins or ends. Draw a free form contour line that runs through the two dots. The 0' contour (sea level) has been done for you.



3. Color the following map and contour key, and answer the questions.



a. What is the lowest elevation on this map? _______

b. What is the highest elevation on this map? _______

c. What is the elevation at X? _______

d. What is the elevation at Y? _______

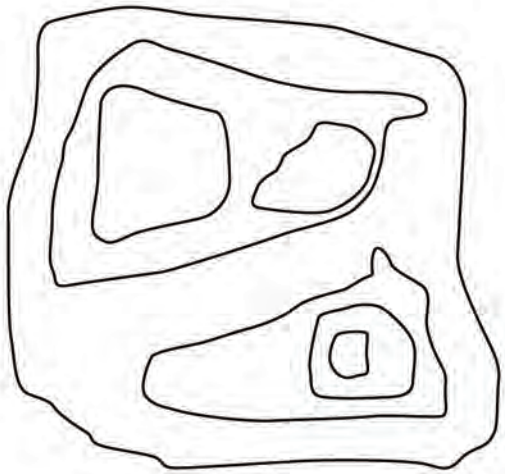
e. What is the elevation at Z? _______

4. Today scientists worry that global warming may cause the ice caps to melt, causing the sea levels to rise. Look at the map below. It has a contour of 15 feet.

a. Let's pretend that the sea level has risen 15 feet. Color the first contour (0-15') of the map dark blue, so that the new sea level is revealed. How has this island changed?

b. Now let's pretend that the sea level rises another 15 feet. Color the next contour light blue and describe the changes in the original island.

c. What if the sea level rose by 30 feet due to global warming, and a hurricane hit the island? Could the people find dry land if there were a 35 -foot storm wave?



Contour = 15 feet

Name: ____ Date: ____________________

SKILL and PRACTICE 8.3

Bathymetric Maps

READ

Imagine that all the water in the oceans disappeared. If this happened, you would be able to see what the bottom of the ocean looks like. Fortunately, we don't have to drain water from the ocean to get a picture of the ocean floor. Instead, scientists use echo sounding and other techniques to "see" the ocean floor. The result is a bathymetric map. This skill sheet will provide you with the opportunity to practice reading a bathymetric map.

PRACTICE

Main features on a bathymetric map

1. Main features on a bathymetric map are mid-ocean ridges, rises, deep-ocean trenches, plateaus, and fracture zones. Find one example of each of these on a bathymetric map.
   a. Mid-ocean ridge:____________________
   b. Rise: ____________________
   c. Deep-ocean trench: ____________________
   d. Plateau: ____________________
   e. Fracture zones: ____________________
2. All the ridges you see on the bathymetric map behave in the same way even though they may not be in the middle of an ocean. What happens at mid-ocean ridges?
3. Find the Rio Grande Rise on the bathymetric map. Then, find the East Pacific Rise.
   a. Which of these features is an example of a mid-ocean ridge?
   b. Find another example of a rise that is a mid-ocean ridge. Justify your answer.
   c. Find another example of a rise that is **not** a mid-ocean ridge. Justify your answer.
4. There are a number of deep-ocean trenches on the western side of the North Pacific Ocean. What process is going on at these trenches?
5. What plate tectonic process probably caused the fracture zones in the North Pacific Ocean? Justify your answer.

How is the East Pacific Rise different from the Mid-Atlantic Ridge?

6. Look carefully at the Mid-Atlantic Ridge. Describe what this ridge looks like. Be detailed in your description.
7. Now, look carefully at the East Pacific Rise. Describe what this ridge looks like. Be detailed in your description.
8. Which of these features has a noticeable dark line running along the middle of the feature? Look at the legend at the bottom of the map. What does this dark line indicate?

9. Based on your observations of these two features, draw a cross-section of each in the boxes below.

Mid-Atlantic Ridge cross-section	East Pacific Rise cross-section

10. One of these mid-ocean ridges has a very fast spreading rate. The other has a very slow spreading rate. Which one is which? Justify your answer based on your answer to questions 8 and 9.

Name:____ Date: _________________

SKILL and PRACTICE 8.3

Tanya Atwater

Tanya Atwater is a professor of Earth Science at the University of California, Santa Barbara. She has studied sea floor spreading and propagating rifts. She is currently researching the plate tectonic history of western North America. One of her main goals as a geologist is to educate people about our Earth.

Artist and adventurer

While growing up, Tanya Atwater wanted to be an artist. She loved figuring out how to record on paper the things she could see in three dimensions.

Atwater and her family went on many vacations, where, she says, "I always hogged the maps, taking great pleasure in translating between the paper map and the passing countryside." Whether it was camping, hiking, or river rafting, all of the trips had one thing in common—adventure. As a result, Atwater developed a deep love for the outdoors.

Geology in the mountains and at sea

Atwater started her college career at the Massachusetts Institute of Technology (MIT). She tried a variety of majors, including physics, chemistry, and engineering. Atwater then attended the Indiana University geology summer field camp in Montana. There, she learned about geological mapping and how land structures translate into lines and symbols. Atwater was hooked on geology!

Atwater transferred to the University of California at Berkley. She had already completed many math and physics courses at MIT, so she decided to major in geophysics.

After graduation, Atwater held an internship at Woods Hole Oceanographic Institute in Massachusetts. There, she combined the adventures of ocean sailing with geophysics.

A close look in a tiny submarine

In 1967, Atwater began graduate school at the Scripps Oceanographic Institution in La Jolla, California. During this time, many exciting geological discoveries were being made. The concept of sea floor spreading was emerging, leading to the current theory of plate tectonics.

While at Scripps, Atwater joined a research group that used sophisticated equipment on ships to study the sea floor near California.

Part of Atwater's later research on sea floor spreading involved twelve trips down to the ocean floor in the tiny submarine Alvin. Only Atwater and two other people could fit in it. Using mechanical arms, they collected samples on the ocean floor nearly two miles underwater! Atwater's firsthand view through Alvin's portholes gave her a better understanding of the pictures and sonar records she had studied.

She was also amazed to see hot springs gushing out of the ocean floor near volcanoes. She adds, "A whole bunch of brand new kinds of animals were living there. We saw giant white tubes with bright red worms living in them, giant clams, octopuses, crabs, giant anemones, and lots of slimy things. Weird!"

Propagating rifts

In the 1980s, Atwater was part of a team that researched propagating rifts near the Galapagos Islands off the coast of Ecuador. Propagating rifts are created when sea floor spreading centers realign themselves in response to changes in plate motion or uneven magma supplies.

Atwater also discovered many propagating rifts on the sea floor in the northeast Pacific Ocean and in ancient sea floor records worldwide.

An Earth educator

Atwater has been a professor at the University of California, Santa Barbara for over 25 years. She has received many awards for her work in geophysics. She currently studies the plate tectonic history of western North America. This includes how the San Andreas Fault and Rocky Mountains were formed.

Atwater also works with media, museums, and teachers and she creates educational animations to educate people about Earth. She explains, "My job as a geoscience educator is to help as many students as possible to know and understand and respect our planet—to help them really care about it and act on their caring."

Reading reflection

1. How did Atwater's family contribute to her passion for planet Earth?
2. Why was it an exciting time to study geology while Atwater was in graduate school?
3. Describe how Atwater has gotten close-up views of the ocean floor.
4. What are propagating rifts and where has Atwater observed them?
5. How does Atwater educate people about Earth?
6. **Research:** The Woods Hole Oceanographic Institution—Marine Operations has used the submarine Alvin for many research endeavors for over 40 years. Describe some of Alvin's noteworthy trips.

Name: ______________________ Date: ______________

SKILL and PRACTICE 9.1

Relative Dating

READ

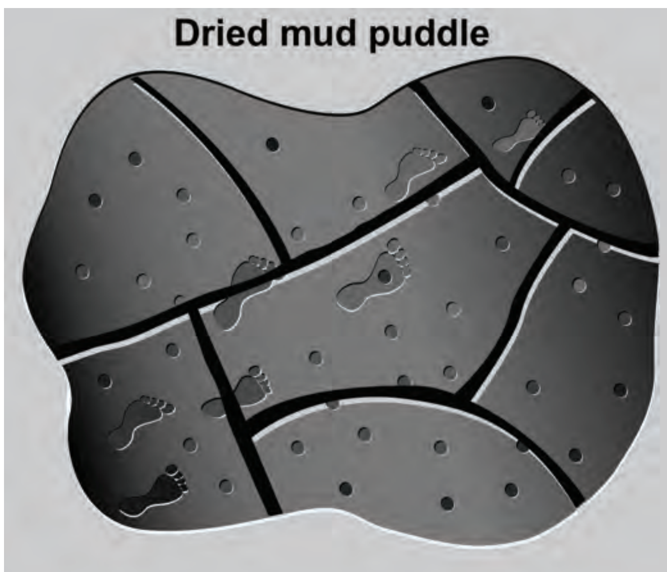
Earth is very old and many of its features were formed before people came along to study them. For that reason, studying Earth now is like detective work—using clues to uncover fascinating stories. The work of geologists and paleontologists is very much like the work of forensic scientists at a crime scene. In all three fields, the ability to put events in their proper order is the key to unraveling the hidden story.

Relative dating is a method used to determine the general age of a rock, rock formation, or fossil. When you use relative dating, you are not trying to determine the exact age of something. Instead, you use clues to sequence events that occurred first, then second, and so on. A number of concepts are used to identify the clues that indicate the order of events that made a rock formation.

PRACTICE

Sequencing events after a thunderstorm

Carefully examine this illustration. It contains evidence of the following events:

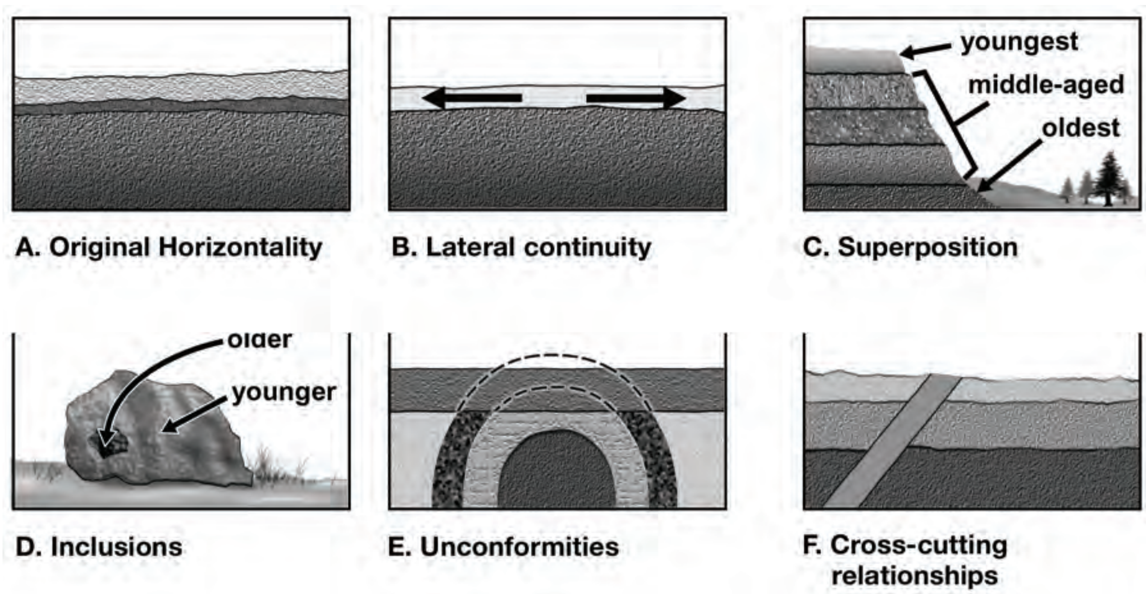


- The baking heat of the sun caused cracks to formed in the dried mud puddle.
- A thunderstorm began.
- The mud puddle dried.
- A child ran through the mud puddle.
- Hailstones fell during the thunderstorm.

1. From the clues in the illustration, sequence the events listed above in the order in which they happened.
2. Write a brief story that explains the appearance of the dried mud puddle and includes all the events. In your story, justify the order of the events.

Determining the relative ages of rock formations

Relative dating is an earth science term that describes the set of principles and techniques used to sequence geologic events and determine the relative age of rock formations. Below are graphics that illustrate some of these basic principles used by geologists. You will find that these concepts are easy to understand.



A. Original Horizontality
B. Lateral continuity
C. Superposition
D. Inclusions
E. Unconformities
F. Cross-cutting relationships

Match each principle to its explanation. One relative dating term will be new to you! Which is it? There is one explanation that does not have a matching picture. Write the name of this explanation.

Explanations

3. In undisturbed rock layers, the oldest layer is at the bottom and the youngest layer is at the top.
4. In some rock formations, layers or parts of layers may be missing. This is often due to erosion. Erosion by water or wind removes sediment from exposed surfaces. Erosion often leaves a new flat surface with some of the original material missing.
5. Sediments are originally deposited in horizontal layers.
6. Any feature that cuts across rock layers is younger than the layers.
7. Sedimentary layers or lava flows extend sideways in all directions until they thin out or reach a barrier.
8. Any part of a previous rock layer, like a piece of stone, is older than the layer containing it.
9. Fossils can be used to identify the relative ages of the layers of a rock formation.

Sequencing events in a geologic cross-section

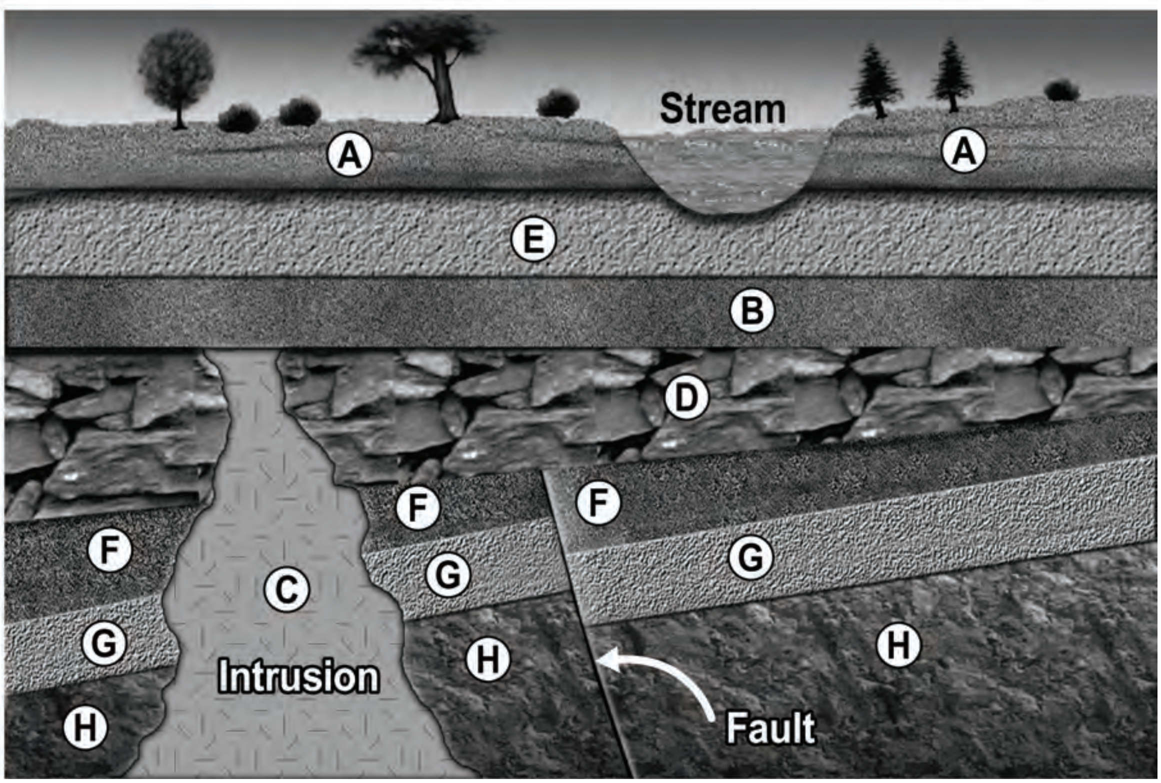
Understanding how a land formation with its many layers of soil was created begins with the same time-ordering process you used earlier in this skill sheet. Geologists use logical thinking and geology principles to determine the order of events for a geologic formation. Cross-sections of Earth, like the one shown below, are our best records of what has happened in the past.

Rock bodies in this cross-section are labeled A through H. One of these rock bodies is an intrusion. Intrusions occur when molten rock called magma penetrates into layers from below. The magma is always younger than the layers that it penetrates. Likewise, a fault is always younger than the layers that have faulted. A fault is a crack or break that occurs across rock layers, and the term faulting is used to describe the occurrence of a fault. The broken layers may move so that one side of the fault is higher than the other. Faulted layers may also tilt.

10. List the rock bodies illustrated below in order based on when they formed.

11. Relative to the other rock bodies, when did the fault occur?

12. Compared with the formation of the rock bodies, when did the stream form? Justify your answer.



Extension—Creating clues for a story

Collect some materials to use to create a set of clues that will tell a story. Examples of materials: construction paper, colored markers, tape, glue, scissors, different colors of modeling clay, different colors of sand or soil, rocks, an empty shoe box or a clear tank for clues.

Then, give another group in your class the opportunity to sequence the clues into a story. Follow these guidelines in setting up your story:

- Set up a situation that includes clues that represent at least five events.
- Each of the five events must happen independently. In other words, two events cannot have happened at the same time.
- Use at least one geology principle that you learned through this skill sheet.
- Answer the questions below.

13. Describe your set of clues in a paragraph. Include enough details in your paragraph so that someone can re-create the set of clues.
14. What relative dating principles are represented with your set of clues? Explain how these principles are represented.
15. Now, have a group of your classmates put your set of clues in order. When they are done, evaluate their work. Write a short paragraph that explains how they did and whether or not they figured out the correct sequence of clues. Describe the clue they missed if they made an error.

Name:____ Date: _________________

SKILL and PRACTICE 9.1

Nicolas Steno

Nicolas Steno was a keen observer of nature at a time when many scientists were content to learn about the world by reading books. Through dissection, Steno made important advances in the field of medicine. Later he applied his observational skills to the field of geology, identifying three important principles that geologists still use to determine the order in which geological events occurred.

Steno's childhood

Nicolas Steno was born in 1638 in Copenhagen, Denmark. He became ill at age three and spent most of his time indoors until age six. He saw few children, but spent time listening to adults discuss religion. Religion later became an important part of his life.

Steno, the son of a goldsmith, had skillful hands like his father. However, his skill was not in making jewelry. He was an expert in dissecting animals to learn about anatomy. He was fascinated by the structure of living things.

The young scientist

When Nicolas was not yet ten years old, his father died. He spent his teen years living in Copenhagen with a half-sister and her husband. Steno was smart, curious, and a good listener. He gained the attention of two scholars in Copenhagen.

The first scholar, Ole Borch, welcomed Steno into his alchemy laboratory. There, Steno watched as sediments settled out of liquid solutions. He thought it was interesting that even when the bottom of the jar was bumpy, the sediments formed a smooth horizontal layer on top of the bumpy surface.

Thomas Bartholin, a famous anatomist from the University of Copenhagen, also mentored Steno. Perhaps through this friendship, Steno developed a keen interest in dissection and anatomy. In 1660, he left Denmark to study medicine at the University of Leiden in the Netherlands. There, through careful dissection of mammals, he made discoveries related to glands, ducts, the heart, brain, and muscles.

A shark's tooth unlocks a mystery

In 1665, Steno moved to Italy. The following year, fishermen there captured a great white shark. The Italian Duke Ferdinand sent the head to Steno for dissection. Steno carefully observed the shark's teeth. They looked like glossopetrae or "tongue stones," common stony items found inside rocks.

While we now know that these tongue stones are fossilized remains of living things, in Steno's time many people believed tongue stones either grew inside rocks, fell from the sky, or even fell from the Moon.

Steno suggested a different explanation for the tongue stones. He said they had once been actual shark teeth! Then Steno started to think about how a solid object, like a shark tooth, could get inside another solid object, like a rock.

Three important principles

Based on his work, Steno came up with three important principles of geology.

- The principle of superposition says that layers of sediment settle on top of each other. The oldest layers are on the bottom and the more recent layers are on top.
- The principle of original horizontality says that sedimentary rock layers form in horizontal patterns, even if they form on a bumpy surface.
- The principle of lateral continuity says that sediment layers spread out until they reach something that stops the spreading.

Steno explained that the shark teeth had been in soft sediment that eventually hardened into a layer of rock. Steno used his principles to write a book about the geology of a region of Italy called Tuscany. Even today, geologists use Steno's principles to determine the order in which geologic events occurred.

Father Steno

In 1675, Steno gave up science to become a priest. He died in 1686 at the age of 48. In 1988, Pope John Paul II beatified Steno, the first step in the process of naming someone a saint. Today, the Steno Museum in Denmark and craters on both Mars and the Moon bear his name.

Reading reflection

1. Name and briefly describe the three important principles of geology developed by Steno.
2. How did most people in the 1600s explain the origin of fossils?
3. How did Steno explain the existence of tongue stones or shark teeth in rocks?
4. How did Steno's medical background and skills help him with his geological discoveries?
5. Observing is very important in science. What things do you like to observe? What have you learned through observation?
6. **Research:** Steno's father was a goldsmith and one of his teachers was interested in alchemy. What does a goldsmith do? What is alchemy? How could these two fields have been helpful to Steno's work?

Name:____ Date: __________________

SKILL and PRACTICE 9.1

Edmund Schulman

Schulman discovered Methuselah, the world's oldest known tree. The tree's exact location remains a secret to protect it from accidental or intentional damage.

In search of trees

Edmund Schulman started his scientific career as an astronomer. However, his interest turned to climate research. Schulman conducted climate studies for nearly 20 years in the western United States.

He was a student of Andrew Ellicott Douglass, the man responsible for the science of dendrochronology. Schulman worked as an assistant to Douglass at the Laboratory of Tree-Ring Research in Arizona. He did a great deal of work in Idaho looking for very old pines. Then Schulman heard about the White Mountains of California and decided to travel there searching again for old trees.

Bristlecones

Schulman studied all layers of the forest. However, higher zone trees tend to be more reliable in providing data because they are affected less by ground water.

The short bristlecone pines grow in this zone. They are a hardy tree with resinous wood that survives in a cold and dry environment. They are also able to withstand wind and the sun's ultraviolet rays. These trees grow in alkaline soils with minimal groundcover around.

Photo: David A. Abel

Since only the bristlecone seems to be able to survive under these conditions, they are able to utilize all the nutrients available in the soil. This sustains their growth and contributes to their longevity. Bristlecones survive a long time compared to other types of trees and are found in regions stretching from Colorado to California.

In the 1950s, Schulman searched the upper layer of the White Mountains for the oldest trees. From 1954-1957, he scoured the forest for ancient bristlecone pines. He was driven by the desire to understand the climatic history of the western United States.

Methuselah

The Ancient Bristlecone Pine Forest, a 28,000 acre preserve, is located in the Inyo National Forest of the White Mountains. This pine forest is nearly 11,000 feet above sea level. The dead wood of these pines decays slowly and some dead trees date as far back as 10,000 years. The living trees often appear dead because they do consist of mostly dead wood. But a thin layer of bark is enough to keep the trees alive. Even when a tree has died, it may not decay for another 1,000 years due to its thick, protective wood.

Most people at the time of Schulman thought sequoias were the oldest living trees. However, Schulman discovered some bristlecones 3000-4000 years old. In 1957, Schulman further confirmed this fact by finding a bristlecone 4,760+ years old. The living tree, found surrounded by dead trees on the ground, was named Methuselah. According to the Bible, Methuselah was a person who lived to be 969 years old. Now the oldest living tree was found. The Methuselah tree has been growing since the time of the great pyramids of Egypt.

Schulman's tree remains the world's oldest living tree. In 1964, scientists sampling a tree in Nevada ran into trouble when their wood coring tool jammed within the tree. The decision was made to cut down the tree to save the expensive piece of equipment. Upon examining the tree further, scientists discovered that the tree, known as Prometheus, was nearly 4,900 years old! The world's oldest living tree had been destroyed.

History is rewritten

Methuselah has helped scientists develop a continuous chronology of nearly 8,000 years. Schulman's work was extremely important to archaeologists around the world. In Europe, archaeologists determined that some of their wood samples were nearly 1,000 years older than they originally believed. In addition, Schulman's work refined and corrected radiocarbon dating.

Schulman died in 1958 at age 49 of a heart attack, shortly before his findings were published in National Geographic Magazine. Schulman Grove is named in his honor.

Reading reflection

1. Under what type of conditions can bristlecone pines survive?
2. What helps the bristlecone pine survive?
3. **Research:** Methuselah may be the oldest living tree on Earth. Using the Internet, research what scientists believe may be the oldest living thing on Earth.
4. **Research:** What and where is the world’s largest bristlecone pine?
5. **Research:** What is Schulman Grove?

Name:____ Date: _________________

SKILL and PRACTICE 9.2

Andrew Ellicott Douglass

Douglass, a successful American astronomer, is better known as the father of dendrochronology. His accomplishments in tree ring analysis and cross-dating allowed him to create a tree calendar dating back to AD 700 for the American Southwest.

Vermont Native

Andrew Ellicott Douglas was born on July 5, 1867 in Windsor, Vermont. Andrew was one of five children born to Sarah and Malcolm Douglass. Malcolm, an Episcopalian minister, and his wife moved frequently. They settled for a period of time in Windsor where Malcolm became a minister for St. Pauls Church and they raised their children.

Douglass attended Trinity College in Hartford, Connecticut. An astronomer, Douglass worked at Harvard College Observatory from 1889-1894. While working for the observatory, he traveled to Peru to find a suitable location for another observatory. He helped to establish the Harvard Southern Hemisphere Observatory in Arequipa, Peru.

From sunspots to tree rings

When Douglass returned home, he met astronomer Percival Lowell of Boston, Massachusetts. Working for Lowell, Douglass set out again to find a location for an observatory, but this time in Arizona. In 1894, he found a site on a Flagstaff mesa and oversaw the building of the Lowell Observatory. While at the observatory, Douglass was Lowell's chief assistant and worked with Lowell to observe the planet Mars. However, Douglass and Lowell did not always agree on how to use the gathered data and Lowell fired Douglass.

Douglass remained in Flagstaff to teach Spanish and geography at what is now known as Northern Arizona University. While in Flagstaff, he became interested in tree rings and their possible connection to sunspot cycles. While researching the eleven-year sunspot cycle, he examined ponderosa pine tree rings. He noted that rings held information about weather patterns and hoped he could find a link between periods of drought and sunspot activity.

In 1906, Douglass moved to Tucson, Arizona and taught at the University of Arizona. Here, he created the science of dendrochronology. He found that differences in tree ring width corresponded to weather patterns. A period of drought produced narrower rings than a time of increased rainfall. In 1929, Douglass was able to place a date on Native American ruins in Arizona with accuracy. He studied Ponderosa pine tree rings dating back to the time of these Native American dwellings. He matched wooden beam samples against pine tree rings to determine a precise date for the ancient ruins. Douglass development of this cross-dating technique was a tremendous breakthrough in the field of archaeology. Archaeologists now had a tool to date ancient ruins.

Despite his work in tree ring analysis, Douglass remained an active astronomer. From 1918 to 1937, Douglass worked at the Steward Observatory at the University of Arizona. Within this period of time, he also wrote *Climate Cycles and Tree Growth, Volumes I, II, and III*. In 1937, he retired as director of the observatory and devoted his time to tree ring research.

Dendrochronology and beyond

Douglass quickly discovered that tree ring studies required time and physical space. He asked the University of Arizona president for a tree ring research facility. In 1938, Douglass became the first directory of the Laboratory of Tree-Ring Research at the University of Arizona. The Laboratory of Tree-Ring Research has the largest number of tree ring samples in the world. He remained director of the laboratory until 1958.

In 1984, an asteroid was identified and named Minor Planet or Asteroid (2196) Ellicott, after Douglass middle name. Douglass died on March 20, 1962 at age 94. Later, Spacewatch astronomer Tom Gehrels discovered an asteroid in 1998 using a telescope that Douglass had dedicated to the Steward Observatory many years earlier. A second asteroid was then named after Douglass. On the planet Mars, a crater has also been named in honor of Douglass.

Reading reflection

1. How did Douglass move from studying planets and stars to studying trees?
2. What is the name of the science and specific technique that Douglass discovered?
3. How has Douglass work with tree rings been useful to archaeologists?
4. **Research:** The first asteroid named after Douglass is called Minor Planet (2196) Ellicott. What is the name of the second asteroid named after Douglass?
5. **Research:** The Harvard Southern Hemisphere Observatory, also called the Boyden Observatory, was originally located in Arequipa, Peru. It has moved. Where is the observatory now located?
6. **Research:** Tom Gehrels is an astronomer associated with the Spacewatch program. What is the Spacewatch program?

Name:____ Date: _________________

SKILL and PRACTICE 10.1

Jules Verne

Jules Verne was an enormously successful nineteenth century author. He introduced the world to science fiction. His stories of adventure and imaginative methods of travel were decades ahead of their time. His ideas have entertained and inspired generations of readers. Several of his books have been made into popular movies.

A great imagination yearning for adventure

Jules Verne was born on February 8, 1828 in the busy port city of Nantes, France. The oldest of five children, Jules came from a family with a strong seafaring tradition rich with the spirit for travel and adventure.

The family's summer home just outside the city of Nantes may have inspired Jules to search for adventure. The house was on the banks of the Loire River. Jules and his younger brother Paul would often play outside and watch ships from all over the world sail down the river.

The boys would make up stories about these ships; where they were from, where they were going, the characters aboard the vessels, and especially the wild escapades they had during their journeys.

While Jules' father was part of a family that included many travelers, he did not intend his sons to follow in those footsteps. Both Jules and Paul were sent to a boarding school, right in their hometown of Nantes. There they were expected to get an education that would take them out of the seafaring class and into wealthy society.

Expectations and creativity clash

After graduating from the boarding school, Verne's father sent him to Paris in 1847, where he was expected to study law. While he studied and prepared for the bar exam, Verne found his time was increasingly spent writing.

An uncle that had been asked to check up on Verne saw that he was having some quiet success writing the words for operas. This uncle understood Verne's true calling. He began to introduce Verne to people involved with Paris' literary circles.

Verne managed to get a few plays published and even performed. Although busy, he still was able to get his law degree. This came in handy, because as soon as Verne's father found out about his writing, he furiously stopped sending his son money. With his money supply gone, Verne took a job as a stockbroker. He hated this job, yet was quite good at it.

A career takes off

Around this time Verne began to meet important authors like Alexander Dumas and Victor Hugo. They offered advice to the young writer. In 1857 Verne married, and was encouraged by his wife to pursue his dream of writing.

Verne became a fan of Edgar Allen Poe, modelling some of his early work on Poe's style, and in 1897 he wrote a sequel to one of Poe's unfinished novels. In 1862 Verne met Pierre-Jules Hetzel, an editor with a keen eye and feel for what a story needed to be successful.

Verne's writing had often been criticized for being too scientific. Hetzel knew how to make Verne's stories appeal to the common person. In 1863, Verne began publishing his "Extraordinary Voyages" series of novels and thankfully quit his stockbroking job.

In rapid succession Verne tackled the sky, the sea, the land, and even space in his novels. In 1863 he wrote *Five Weeks in a Balloon*, a story about exploring Africa in a hot air balloon. In 1864 he wrote *Journey to the Center of the Earth*, a trek by scientists down a volcano on their way to Earth's core. In 1865 he wrote *From Earth to the Moon*, a visionary work that preceded NASA missions by 100 years. He published *20,000 Leagues Under the Sea* in 1869, introducing the world to Captain Nemo, a mysterious genius who built the futuristic submarine *The Nautilus*.

Jules Verne's 65 novels took readers on marvelous adventures, introducing futuristic ideas that while not always based on scientific facts, incorporated concepts that inspired future thinkers and entertained millions. Verne died in 1905, as the world's most translated author, making up for his lack of scientific training and actual travel experience with a vivid imagination.

Reading reflection

1. Why do you think Jules Verne's novels appealed so widely to readers around the world?
2. **Research** which novels written by Verne have been made into movies. Have any of them won awards?
3. **Research** the bar exam. Why would Jules Verne need to pass it?
4. **Research** Victor Hugo and explain why meeting him may have been important to Verne.
5. **Research** some of the machines, ideas, and predictions Verne made in his novels that have come to exist today.

Name: ______________________ Date: ______________

SKILL and PRACTICE 10.2

Earth's Interior