How Do Latitude and Longitude Coordinates Help Us See Patterns on Earth?

Investigation Overview
Students inspect a table of sea surface temperatures recorded at specific latitude and longitude coordinates. They have difficulty discerning any relationship between location and temperature. Students review the concepts of latitude and longitude with an interactive animation. Next, they organize the data geographically by plotting the indicated temperatures according to latitude and longitude. After plotting the data, students can discern the relationship between temperature and location easily. They use colored pencils to show the pattern on their printed maps. Students observe animations of sea surface temperature over time to recognize that some natural processes vary through time as well as by location. Finally, students are introduced to global positioning system (GPS) technology as a means of gathering latitude and longitude data.

Instructional Context
Latitude and longitude are paired concepts that, when taught together, can be confusing for students. This investigation gives students the opportunity to look at each set of lines separately. They toggle latitude and longitude lines on and off a global map to comprehend or review these concepts. Latitude is a primary controlling factor of climate; lines of longitude are directly tied to methods of keeping time. A discussion of these topics could be used for either introducing or culminating this investigation.

KEY CONCEPTS
- Latitude and longitude coordinates make it possible to specify precise locations on Earth.
- Geographic patterns can be difficult to interpret in tabular form.
- Data displayed by latitude and longitude coordinates reveal geographic patterns.

KEY SKILLS
- Plotting latitude and longitude coordinates onto maps
- Analyzing geographic patterns
- Evaluating the relevancy of using latitude and longitude

ESTIMATED TIME REQUIRED
- 45 minutes Internet use
How Do Latitude and Longitude Coordinates Help Us See Patterns on Earth?

1. How does sea surface temperature change with latitude?
   Accept all answers. (Any relationship is difficult to discern from the data in this form.)

2. How does sea surface temperature change with longitude?
   Accept all answers. (No apparent relationship)

3. Which lines (longitude or latitude) run from north to south?
   Longitude lines run from north to south.

4. Which lines (longitude or latitude) run from east to west?
   Latitude lines run from east to west.

5. Which line is the reference line for longitudes?
   The prime meridian is the reference line for longitudes.

6. Which line is the reference line for latitudes?
   The equator is the reference line for latitudes.

7. Use colored pencils to trace these patterns onto the printed map. Describe the distribution of sea surface temperatures around the world.
   Distinct bands of color are apparent. The warmest temperatures are found along the equator; the coldest areas are found at the poles.

8. How does sea surface temperature change along latitude lines?
   Sea surface temp. remains constant along latitude lines.

9. How does sea surface temperature change along longitude lines?
   Answers will vary. Sea surface temperature decreases from the equator to the poles.

10. What conclusion might you have drawn had you looked at global sea surface temperature along only one latitude line?
    An analysis along only one latitude line might lead you to conclude that sea surface temperature remains constant on Earth.

11. How do sea surface temperature patterns change over the course of a year?
    The bands of similar sea surface temperatures shift latitudes as seasons change.
Investigation Overview

Students begin by watching a simulated flyby over a river and sand dunes in the Namibia Desert of Africa. They make detailed observations about the topography they encounter during the flyby. Then, students are introduced to the topographic map, a specialized type of map that uses contour lines to show the shape of Earth’s surface. Students explore animated, 3-D models of surface features to find out how contour lines represent hills, valleys, steep areas, and depressions. Students try to recognize features on topographic maps as they take a topographic tour of major landforms of the United States. Last, they discover how space-based technologies are contributing to the design of more detailed topographic maps showing remote areas of the world that have historically been difficult to map.

Instructional Context

Visualizing landforms represented on a topographic map can be a difficult skill for students to master. This spatial task requires students to translate two-dimensional lines on the map into three-dimensional images in their minds. In addition to working with computer models of topography, having students create their own topographic maps from physical models can be a very useful strategy. Students can make clay models of geographic features. If they place these models into large containers and cover them with water at one centimeter intervals, students can generate a contour map by drawing where the water meets the model. Also of great value would be taking students outside with a local topographic map of their area and helping them recognize key features on their maps.

KEY CONCEPTS

• Topographic maps use contour lines to represent Earth’s surface.
• Closely spaced contours indicate steep slopes, while widely spaced contours indicate gentle slopes.
• Hachures on contour lines show decreases in elevation.

KEY SKILLS

• Interpreting topographic maps
• Identifying landform features such as hills, valleys, and cliffs on topographic maps
• Visualizing three-dimensional landforms from two-dimensional contour lines

ESTIMATED TIME REQUIRED

• 45 minutes Internet use
How Are Landforms Represented on Flat Maps?

1. Write a detailed description of the topography that you encounter during this flyby.
   Answers will vary.

2. Compare the photo to the topographic map. Describe the pattern of the contour lines around features on the photo.
   Answers will vary. Students may notice that contour lines surround hills and are more closely spaced when the topography is steep.

3. Which part of this land is the last to flood as the water rises?
   The flat top of the cliff is the last part to flood.

4. What is the elevation of the lines marked at A, B, and C?
   The elevation at A is 6320 feet. The elevation at B is 6440 feet. The elevation at C is 6700 feet.

5. Describe the overall shape of the landscape.
   This map shows a cliff with steep sides and a flat top.

6. What do closely spaced contour lines indicate about the shape of a feature? In other words, when the lines are close together, does the feature have gentle slopes or steep sides?
   When contour lines are spaced closely on a map, the structure represented by the lines is very steep.

7. What is the pattern of the contour lines around a simple hill?
   Contour lines around a hill form closed, nested loops that are round or oval.

8. Make a sketch of the pattern of the contour lines moving up the valley. Draw an arrow to indicate the direction in which water flows across the lines.

9. What landform feature does the model show, and what do hachures on contour lines indicate?
   The model shows a volcano. The hachures show where the contour lines decrease in elevation. On the volcano, this occurs at the depression on its top.

10. Describe the structure inside the box on the map.
    The structure is a valley descending from Mount Shasta.

11. Identify the features marked at A and B. Where is the elevation highest on this map? Where is it lowest?
    A is a peak, B is a valley. The elevation is highest at the top of the northernmost peak, and lowest in the southwestern corner of the map.

12. Which of the landforms was easiest to recognize from its topographic map?
    Answers will vary.
How Do We Know about Layers Deep within Earth?

Investigation Overview
Students begin the investigation by considering the dynamic nature of Earth both above and below its surface. Next, they explore earthquake waves and their paths through different materials. Students view a series of animations showing P and S waves traveling through model planets with different interior compositions. They observe the P and S wave behavior in each model and compare the behavior to the structure of the planet. After exploring these animations, students examine P and S wave data for Earth and use the information to estimate the depth and state of Earth's layers. Last, students investigate seismic tomography models that are helping to refine three-dimensional views of Earth's structure.

Instructional Context
Recent advances in seismic technology allow researchers to map areas where seismic waves move anomalously fast or slowly. This research, referred to as seismic tomography, facilitates development of three-dimensional models that are useful for studying the details of plate tectonic processes. While these models are not fictional, they are theoretical and mathematically derived. Help students understand that scientists use earthquake waves as an inferential tool. Researchers try to build models that approximate reality. Discuss with students how models help scientific researchers simulate conditions and run experiments in ways that would otherwise not be possible.

KEY CONCEPTS
• The interior structure of Earth can be inferred from the trajectories of P and S waves moving through the planet.
• Models can be used to simulate conditions and conduct experiments when direct observation is not possible.

KEY SKILLS
• Interpreting graphs
• Visualizing earthquake waves moving through Earth's interior
• Modeling the interior structure of planets

ESTIMATED TIME REQUIRED
• 45 minutes Internet use
How Do We Know about Layers Deep within Earth?

1. What evidence do you see of the dynamic nature of our planet?
   Answers will vary. Students may mention swirling clouds, the African rift valley, or coastlines experiencing erosion.

2. Describe how the material is flowing.
   The material appears to be rising and sinking as it flows.

3. What types of material do P waves pass through?
   P waves pass through both solids and liquids.

4. What types of material do S waves pass through?
   S waves pass through solids, but not through liquids.

5. Based on the pattern of the P and S waves, what type of material is this planet made of?
   The entire planet is solid.

6. Observe the path taken by P and S waves in the model planet. Sketch the layers on your diagram and indicate if they are solid or liquid.

7. Observe the path taken by P and S waves in the model planet. Sketch the layers on your diagram and indicate if they are solid or liquid.

8. What happens to the size of the S wave shadow zone as the diameter of the liquid layer increases?
   With increasing diameter of a liquid layer, the size of the S wave shadow zone becomes larger.

9. Observe the path taken by P and S waves on Earth. Sketch the layers on your diagram and indicate if they are solid or liquid.

10. Where are the cool and hot regions of the mantle located?
    Cool regions occur at the centers of large plates, while the warmest regions are found at the edges, especially along spreading ridges.

11. What does this tomographic model indicate about the underlying structure?
    The subducting plate is moving faster than the surrounding rock materials. The plate sinks and cools as it moves under the adjacent plate.
Investigation Overview

Students manipulate the number of subatomic particles (protons, neutrons, and electrons) in a simplified model to build atoms of common elements. Students add subatomic particles to the model to construct atoms, isotopes, and ions (unbalanced atoms). They receive instant feedback on the element's name and any additional particles needed to make it stable and balanced. Students use the model to build atoms of simple elements. Then, they use a periodic chart to determine the number of subatomic particles in several heavier elements.

Instructional Context

The small size of atoms precludes direct visualization of their internal structure and composition. This interactive computer simulation gives students the opportunity to examine visual models that represent abstract items. Though the model is very simple, it is useful for preparing students to comprehend how chemical compositions affect the properties of minerals.
1. What elements are in these common items?
   - Diamonds, carbon; Balloons, helium; Rusting car, iron and oxygen; Nuggets, gold; Lighted sign, neon; Beverage can, aluminum.

2. List the three subatomic particles that make up atoms. Give the mass and charge of each one.
   - Proton: Mass = 1 atomic mass unit, +1 charge
   - Neutron: Mass = 1 atomic mass unit, neutral
   - Electron: Mass = 0, -1 charge.

3. Fill out the chart for these elements.
   Record the number of protons, neutrons, and electrons for balanced atoms of each element in the chart.

<table>
<thead>
<tr>
<th>Name</th>
<th>Hydrogen</th>
<th>Helium</th>
<th>Lithium</th>
<th>Carbon</th>
<th>Nitrogen</th>
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<tbody>
<tr>
<td>Symbol</td>
<td>H</td>
<td>He</td>
<td>Li</td>
<td>C</td>
<td>N</td>
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<td>7</td>
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</table>

4. Which particle controls what element an atom is? Describe how you used the model to come up with your answer.
   The number of protons in the model controls what element the atom is.
   Answers will vary. Students may respond that when they added protons to the model, the name of the element changed.

5. What do you get when you change the number of neutrons in the nucleus?
   Changing the number of neutrons makes an isotope of the atom displayed.

6. What controls the "weight" of an atom?
   Describe how you used the model to come up with your answer.
   The number of protons plus the number of neutrons equals the weight.
   Answers will vary. Students may respond that the weight always reflected the total number of protons plus neutrons they had in the model.

7. Try to cluster the electrons together or move them into another level. Describe the behavior of the model electrons.
   The electrons repel one another. They move as far apart as possible. No more than two electrons are ever in the first level (K shell).

8. What do you get if the number of protons and electrons in your model is not equal?
   An unbalanced atom.

9. Fill out the chart for these elements.

<table>
<thead>
<tr>
<th>Name</th>
<th>Oxygen</th>
<th>Neon</th>
<th>Aluminum</th>
<th>Iron</th>
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</table>
How Do Crystals Grow?

Investigation Overview
Students observe time-lapse video clips of crystals growing. They examine crystal forms and relate them to the structure of the atoms that make up the crystals. Students rotate three-dimensional lattices of crystals to view them from several perspectives. Students consider what variables might affect crystal growth, and in an interactive simulation, they select conditions under which to model crystal growth and view the results.

Instructional Context
Crystal growth occurs at the atomic level, and often takes so long that the process is difficult to observe. Time-lapse video clips enable students to witness crystal growth at an accelerated pace and at a size that allows them to analyze how crystals grow. This investigation emphasizes growth of crystals from aqueous solutions rather than magmatic crystal growth. Students can grow crystals under a microscope in class: Prepare saturated solutions of compounds such as sodium chloride (NaCl), copper sulfate (CuSO₄), magnesium sulfate (MgSO₄), and copper chloride (CuCl₂) in small test tubes with stoppers. Apply a small amount of solution to a microscope slide by touching the bottom of the wet test tube stopper to the slide. As students watch through the microscope, the heat of the lamp will cause the water to evaporate, and crystals will form.

KEY CONCEPTS
• Crystals grow as atomic particles are added to their ordered crystal structure.
• Temperature, pressure, and space limitations affect the growth of crystals.

KEY SKILLS
• Observing crystal growth
• Predicting crystal shapes
• Analyzing the effects of changing conditions on crystal growth

ESTIMATED TIME REQUIRED
• 35 minutes Internet use
How Do Crystals Grow?

1. Write a description of how crystals grow in size.
   Answers will vary. The ends or points of crystal structures appear to grow longer. New branches appear along the edges and extend outward.

2. What types of crystals exist, and where are they found?
   Answers will vary. The list may include ice, snow, gemstones, geodes, quartz, evaporating saltwater or sugar solutions, metals, minerals, and rocks.

3. Describe similarities shared by all crystals as they grow.
   Answers will vary. All crystals get larger over time, adding new material along points or edges at the outside of the crystal.

4. Describe ways in which the growth of each of the crystals is different.
   Answers will vary. Crystals appear to grow in different shapes. Sometimes the shape is wider than it is long; sometimes cube-shapes form, and sometimes flat crystals form.

5. Based on their crystal lattice structures, predict the shape of galena and quartz crystals.
   Galena crystals would have a cubic shape, while the quartz crystal would have a 6-sided (hexagonal) column shape.

6. Describe what happens when one growing crystal encounters another growing crystal.
   When one crystal encounters another, the forward growth is halted, but growth can continue in other directions. Crystals may interlock, growing into available space around each other.

7. Describe the effect of temperature on the growth of these crystals from a solution.
   Higher temperatures result in slower crystal growth.

8. Describe the effect of pressure on the growth of these crystals from a solution.
   Higher pressures result in faster crystal growth.