EARTH'S MAGNETOSPHERE

PLANNING YOUR EXPEDITION

At this point students should be making some inferences on their own about magnetism, magnetic fields, and their application in the real world. The subject of Earth's magnetic field seems to get buried in the discussion of either the North and South Poles or Earth's gravity. This activity will illustrate the difference between Earth's magnetic north and south pole and geographic North and South Pole.

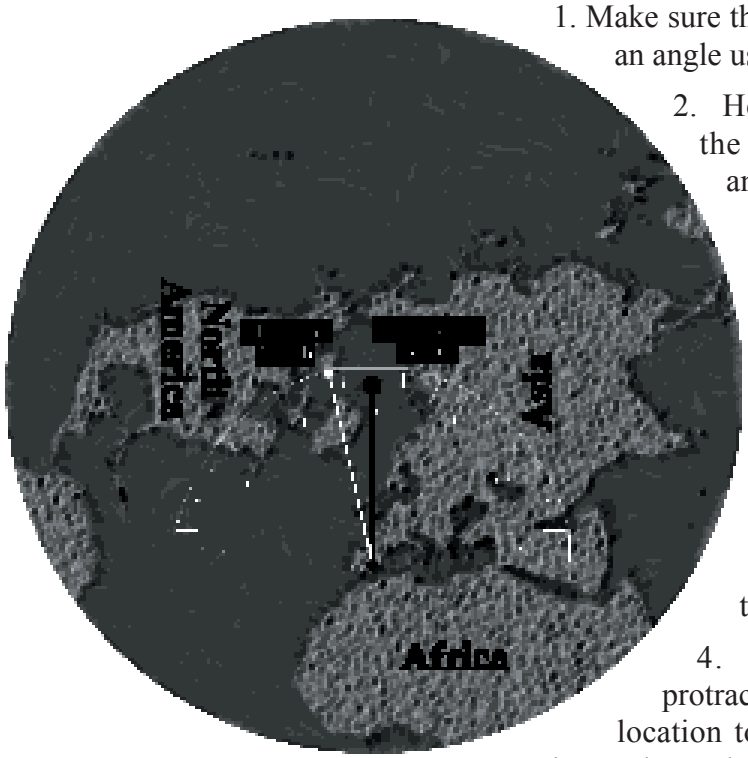
This is an ideal place to begin reading aloud a nonfiction book about either the North or South Pole (see "For Your Planbook" section). Linking both fiction and nonfiction to science content makes the information more meaningful; likewise, linking what one is reading to what one is learning at the time makes the literature more meaningful. Reading aloud is also an excellent management tool. Setting aside the last 10 minutes of a class period for reading to students allows them time to get ready for the next class, time to finish up, or time to gather their thoughts or clarify thoughts before moving on to another subject.

It might be useful to ask your students how many of them believe that gravity and the Earth's magnetic field are the same thing. There are probably some students who think that magnetism causes tides. Identifying the misconceptions that students bring with them to the classroom is important to your practice.

Students have looked at a number of magnets, but have they considered the Earth as a magnet? They probably have heard of the magnetic field surrounding the Earth. Students may even know a little about it, but have they thought of the planet as a magnet? In this activity, students will discover that there are many ways to think about things in science. This will be a new way to think about their planet.

The recommended assignments related to this subject are somewhat different than those that preceded it since there is no experiment to be done or investigation to be conducted. This is an activity that makes the distinction between Earth's magnetic poles and geographic poles and includes gathering of information to support prior knowledge. It is an enhancement of prior activities and provides information that will help students better understand the compass activities to follow.

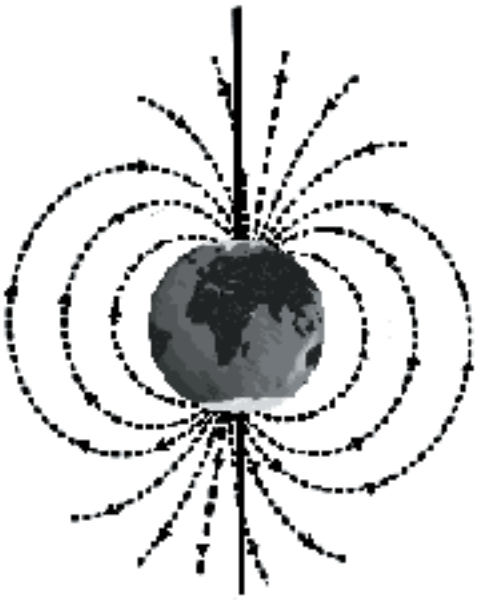
In January 1997, Earth's magnetosphere was in the news as a cloud of gas weighing a billion tons distorted the Earth's magnetic field. It was the most likely cause of the destruction of a communications satellite estimated to be worth $200 million. Whether students believe this to be of use or interest to them, it is still important for a well-educated person to be able to read a magazine or newspaper article with some degree of understanding, such as the many articles that appeared following the January 1997 event. Because of their understanding of magnetism, magnetic field lines, and Earth's magnetic field, your students will be better consumers of information.

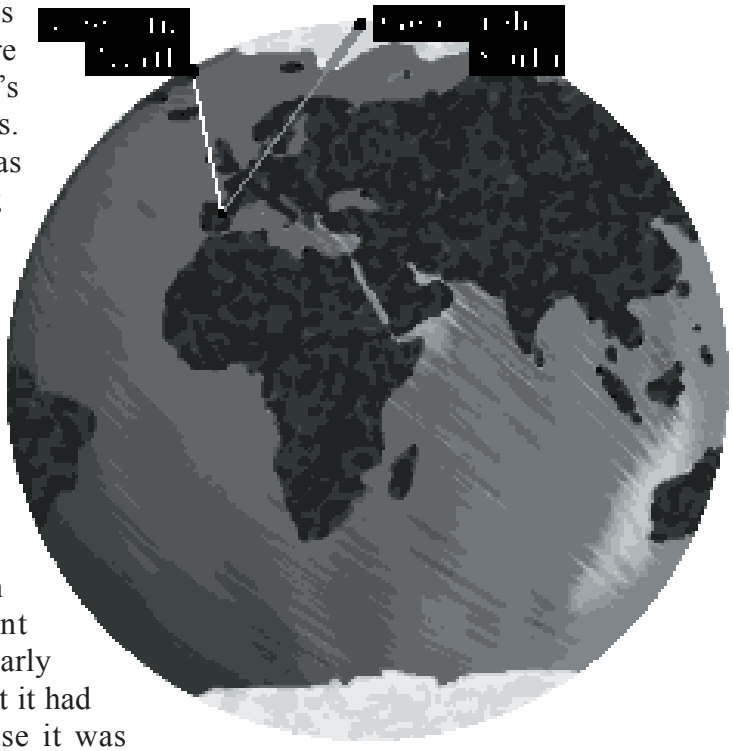


1. Make sure that students know how to measure an angle using the protractor.
2. Help students distinguish between the polar projection (Appendix D) and other types of maps.
3. Each group will choose 10 cities in the northern hemisphere and locate them on the map so they will need geography books or world maps to work with. Make sure that they represent areas close to and far away from the poles. Encourage students to choose at least one location with which they are familiar or a place that they have visited.
4. Using the straightedge of the protractor students draw a line from the location to each of the poles and measure the angle, and record the number of degrees of declination in the Alpha Log. Students will determine that the farther the city is from the poles, the smaller the angle of declination will be.
5. Finally, students answer the question: What implications does this information have for explorers, adventurers, cartographers, or travelers?
6. If students need extra help using the protractor, refer them to the CD-ROM tutorial.

BACKGROUND

The Earth acts like a magnet in space due to the rotation of the inner core. Since the inner core is most likely made of solid iron and nickel, as it spins the material takes on magnetic characteristics and creates a magnetic field. The magnetic field created by a bar magnet is a good model of the Earth's magnetic field and is a good visualization tool. As the earth rotates on its axis, the spinning inner core creates a magnetic field that extends from approximately 1000 kilometers to 64000 kilometers depending whether the earth is facing the sun.





Modeled in the illustration, Earth's magnetic north and south poles are in a different location than Earth's geographic North and South Poles. The magnetic poles represent areas that exhibit magnetic qualities; geographic poles are those that represent the earth's axis.

A solar wind pushes the magnetosphere out into space on the side of the earth away from the sun. This phenomenon is intensified from time to time creating a magnetic cloud that disturbs the magnetosphere depending upon the speed at which the cloud is traveling. A recent magnetic cloud event was particularly significant, not because of the effect it had on the magnetosphere, but because it was the first time that humans could monitor the phenomenon from the time it started until the effect was no longer apparent. Because there are a number of satellites that do nothing but look at the sun, scientists at NASA's Goddard Space Flight Center in Greenbelt, Maryland, were able to study the solar cloud and its significance to the earth's magnetic field. (Some sample sources for researching this phenomenon are The New York Times, Thursday, January 23, 1997; Science News, January 11, 1997, February 1, 1997; Time, September 9, 1996., Aviation Week & Space Technology, January 27, 1997.)

The magnetosphere is made up of positively charged protons and negatively charged electrons that are caught by the earth's magnetic field and are concentrated in areas called the Van Allen Radiation Belts. These areas of trapped radiation are a form of protection since they trap radiation and prevent it from reaching the earth's surface.

If students ask, "So what?" The answer is one that affects students personally: their cable television stations are disrupted, satellite communications, credit card records, radio communications, and airplane travel are also interrupted.

EXCURSIONS

This would be applicable to more sophisticated science students who are competent readers. Have students read "Does the Sun Trigger Outbursts From Earth's Magnetosphere?" Science, Vol. 271, March 15, 1996 and "Solar Cloud Hits Earth's Magnetosphere," Science News, Vol. 151, February 1, 1997. Not only will students get a great deal of information and enhanced understanding of the sun's influence on the magnetosphere, but they will attempt to answer the question, "How does the 1997 information support the explanation proposed in the 1996 article?" Also, "Is this a comparatively long time for a scientist to wait for information to support or disprove a theory?" In answering these questions, students will do two things: first they will read about a scientist proposing a new idea from gathering data over a period of time; second, students will articulate that this is a very short time to wait for an answer in science. Many scientists *never* get this kind of answer.

SC.H.1.3.1-3, 7

LA.A.1.3.1-4, 2.3.1-8, LA.B.2.3.3, LA.D.2.3.3-6

Have students answer the question: What do the Van Allen Belts and the ozone layer have in common? Why is their purpose so important to life on earth? What would happen if they ceased to exist? Comparing and contrasting two aspects of the earth's atmosphere that play a protective role, students link magnetism and magnetic fields to issues of great practical importance.

SC.C.1.3.2, SC.D.1.3.5, SC.H.1.3.1-7, 2.3.1, 3.3.5-7

A natural tie-in here would be to the earth's layers. Going one step beyond identifying the earth's layers and what they are made of, students could study new theories and recent discoveries about what the earth's interior "looks" like. From this study, students understand the dynamic nature of science; that it is constantly changing and new ideas are being proposed and theories proved. An article of interest is "Anti-Matters," Earth, August 1995, that is taken from Naked Earth: The New Geophysics by Shawna Vogel.

SC.H.1.3.1-3, 7

Either read aloud to students or have them read "Antarctic Christmas" by Captain Robert F. Scott, found in Heroic Stories chosen by Anthony Masters, ISBN 1-85697-983-0. This experience could be used as a lead-in to student creative writing about being away from home at a significant time or about difficult conditions and how they can be overcome. It could also be the beginning of a discussion of geography and attempting to answer why the journey became so much more difficult than the team anticipated as they made preparations. Have students create lists of what equipment and supplies they would take if undertaking a journey such as Scott's. What would they do differently? What limitations would be set for them and what limits would they set for themselves? Is it possible to generate such a list now that would have been feasible at that time? A lively class discussion will help students clarify the differences between attempting travel in Antarctica then and now.

LA.A.1.3.1-4, LA.B.1.3.1-3, LA.C.1.3.1-4, LA.E.2.3.1-8

FOR YOUR PLANBOOK: Earth's Magnetosphere

Suggested Time: 1-3 hours

Gear: compass, protractor, polar projection, world maps or geography books.

Begin reading aloud to students: With Byrd at the Bottom of the World by Norman Vaughn, "Antarctic Christmas" in Heroic Stories, or Dr. Kane of the Arctic Seas by Pierre Berton (see Appendix C, Annotated Bibliography, for more information).

National Science Content Standards: A, E, G

Sunshine State Standards Benchmarks: SC.A.2.3.1, SC.B.1.3.1, SC.B.1.3.3, SC.B.1.3.6, SC.B.2.3.1, SC.C.1.3.2, SC.C.2.3.1, SC.C.2.3.2, SC.C.1.3.3, SC.G.1.3.4, SC.H.1.3.1, SC.H.1.3.2, SC.H.1.3.3. SC.H.1.3.4, SC.H.1.3.5, SC.H.1.3.6, SC.H.1.3.7

Sunshine State Standards Benchmarks—Language Arts: LA.A.2.3.4, LA.A.2.3.5, LA.A.2.3.6, LA.A.2.3.8, LA.C.1.3.4, LA.C.2.3.1, LA.C.3.3.3, LA.D.1.3.3, LA.E.2.3.8

Sunshine State Standards Benchmarks—Math: MA.A.4.3.1, MA.B.1.3.2, MA.B.1.3.4, MA.B.4.3.2

Sunshine State Standards Benchmarks—Social Studies: SS.A.2.3.4, SS.B.1.3.1, SS.B.1.3.7

Homework: Have students either create a concept map for the information that is covered in this activity (magnetosphere) or create one with some information already given to lead students to that which must be filled in.

Homework Assessment: Concept maps should have categories of information that include, but are not limited to, facts about the magnetosphere, implications (who does it affect?), and features created by the magnetosphere.

Assessment: Assign a creative writing story or a nonfiction report about the relationship between the Van Allen Belts and space travel. Student stories should reflect (at least) the knowledge that space explorers and space vehicles would need protection from the concentrated radiation in this area. Nonfiction reports would contain this information as well as data about the discovery of these areas in 1958. This is an example of real world problems being created by natural phenomena and the solutions created.

Check Alpha Logs for use of vocabulary, i.e., line of declination, angle of declination, geographic north, magnetic north. Use of correct language indicates that students have made the leap from the activity to articulating the information gained from the activity.

Scrutinize answers to the questions from the Itinerary for understanding of the difference between magnetic and geographic north. Answers should indicate understanding that the farther away a location is, the smaller the angle will be (and vice versa). There should also be some indication that students realize that the compass is actually flawed as an instrument if the person using it is expecting to go toward geographic north. Students are using the information they collected from measuring angles to determine its importance on a personal level.

Have students relate the book that is being read aloud to classroom study by drawing pictures that demonstrate mastery of the difference between the two poles; by writing a prediction from the title and book jacket of what will happen in the book; by creating a model of a scene or chapter from the book; by giving a book talk about the book and its relationship to classwork. Whichever task students choose, it should be a reflection of their content knowledge. At this point, students should be blending the specific content from the most recent activity with their overall knowledge of magnetism.

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Itinerary

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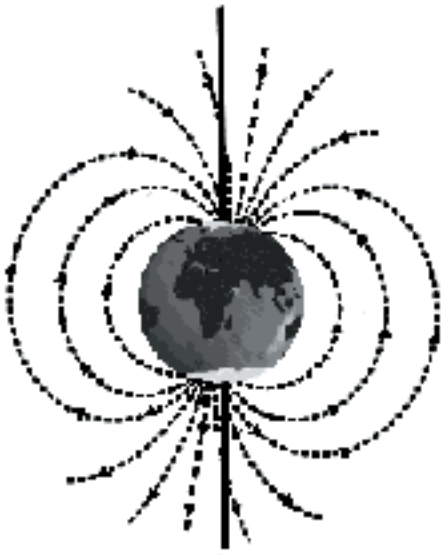

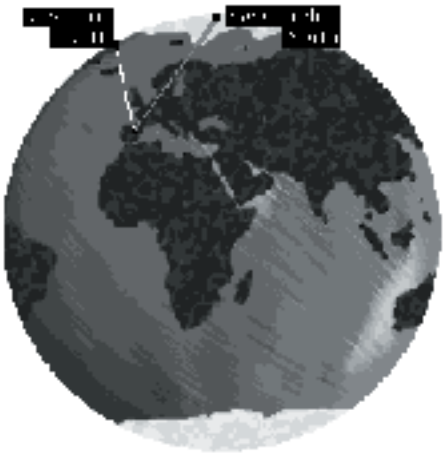

1. The Materials Manager should accumulate all materials you will need for this activity: compass, protractor, and polar projection.

2. Choose 10 locations in the northern hemisphere being sure to include one with which your group is familiar. Record these in your Alpha Log.
3. One at a time, measure the angle of declination (difference between the geographic North Pole and magnetic north pole) indicating the difference between magnetic north and geographic north. Draw a line to magnetic north and a line to geographic north. This will help you determine where to place your protractor. As you measure each angle, enter it in your Log.
4. Which location that you chose is farthest away from the poles? Which one is closest? Which location had the largest angle between the two poles? Which location had the smallest? What conclusion(s) can you draw from these answers? After discussing the answers with the group, write all of the answers to these questions in your Log.
5. Now, as a group, consider the following questions and write the answers in your Log: To which of the poles does your compass point? What does this mean? Why would the angle of declination be important? Who would need this information?
6. Discuss your answers with two other groups until you are all satisfied. Write the results of this discussion in your Log.