NOVA

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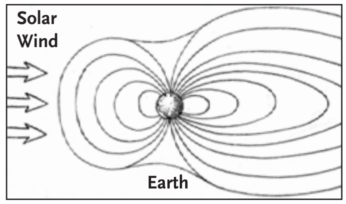
Magnetic Storm

PROGRAM OVERVIEW

NOVA explores what creates Earth's magnetic field and why it might be headed for a reversal.



The program:

- explains how scientists think Earth's magnetic field is generated and describes the role of the magnetic field in shielding our planet from radiation.
- explores the possibility that Mars once had a magnetic field that protected an atmosphere.
- shows how scientists use ancient pottery and volcanic rock to study changes in the direction and strength of Earth's magnetic field over time.
- presents a working model of a self-sustaining electromagnetic dynamo thought to replicate the processes occurring in Earth's core.
- relates when magnetic field reversals have occurred in the past and speculates when the next reversal might take place.
- features a computer model showing the flipping of the poles.
- discusses how cooling of Earth's core may be the cause of the weakening magnetic field.
- explores how a changing magnetic field might affect life on Earth.

BEFORE WATCHING

1 Demonstrate how magnetism is a property that can be changed. Drag a paper clip along a bar magnet 15 times so that the paper clip becomes magnetized. Use this paper clip to pick up another paper clip. Then, bang the magnetized paper clip on the table. Now try to pick up the other paper clip again. (See Activity Answer on page 3 for an explanation of this concept.)

2 Discuss with your students the difference between the geographic North Pole and the magnetic North Pole. (The geographic North Pole is the point at 90 degrees North latitude. The magnetic North Pole is where the magnetic field lines are vertical and enter Earth, presently at about 82 degrees North latitude and 112 degrees West longitude.)

AFTER WATCHING

1 Have a class discussion on how the weakening and shifting magnetic field may affect life on Earth. (With a weakened magnetic field, more radiation would enter Earth's atmosphere resulting in increased deaths from cancer.)

2 Discuss with students how Earth changes over time. The magnetic field is not the only thing that changes. Ask them to think of other examples of changes. (Oceans have become mountains, the average global temperature has fluctuated, and the amount of carbon dioxide in the atmosphere has changed.)

CLASSROOM ACTIVITY

Objective

To study the magnetic fields around different shapes of magnets.

Materials for each group

- copy of the "Visualizing Magnetic Fields" student handout
- 1 tablespoon of iron filings in paper cup
- 8 1/2-inch x 11-inch paper
- tape
- magnets of different shapes, including round, bar, and horseshoe magnets
- compass
- ruler

Procedure

1. Earth has a magnetic field that shields it from harmful cosmic radiation. In some ways, Earth's magnetic field behaves in the same way that magnetic fields on ordinary magnets behave. Tell students they will be exploring some of the properties of magnetic fields in this activity.
2. Organize students into groups and distribute the "Visualizing Magnetic Fields" student handout, iron filings, paper, compasses, rulers, and different-shaped magnets to each group.
3. Have students select a magnet and place a sheet of paper on top. Instruct them to lightly sprinkle iron filings over the paper. Ask them to sketch the magnetic field on another piece of paper.
4. Have students use their compasses to determine the direction of the field and indicate this with arrows on their diagrams.
5. Ask students to move a compass farther and farther out to where the magnetic field weakens. (At this distance the compass will switch from indicating the magnet's magnetic field to indicating Earth's magnetic field.) Students should record this distance on their diagrams.
6. Have students repeat the experiment with magnets of different shapes.
7. Have each group answer the questions on its student handout. Discuss students' findings. What caused the compass to change direction when moved away from the magnet? What direction did the compass exhibit when moved away from each of the magnets? Why might this be?
8. As an extension, have students create a timeline of Earth's magnetic field reversals. Find more information at www.pbs.org/nova/magnetic/

STANDARDS CONNECTION

The "Visualizing Magnetic Fields" activity aligns with the following National Science Education Standards.

GRADES 6–8
Science Standard D:
Earth and Space Science
Structure of the Earth system

- The solid Earth is layered with a lithosphere; hot, convective, mantle; and dense, metallic core.

GRADES 9–12
Science Standard D:
Earth and Space Science
The origin and evolution of the Earth system

- Interactions among the solid Earth, the oceans, the atmosphere, and organisms have resulted in the ongoing evolution of the Earth system. We can observe some changes such as earthquakes and volcanic eruptions on a human time scale, but many processes such as mountain building and plate movements take place over hundreds of millions of years.

Video is not required for this activity.

Classroom Activity Author
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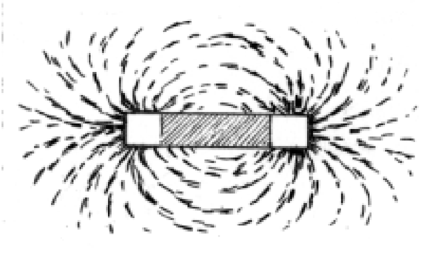
ACTIVITY ANSWER

In a material with magnetic properties, such as a paper clip, groups of atoms are like tiny magnets with north and south poles. When a paper clip is stroked with a magnet, the north and south poles are temporarily aligned. This creates a magnetic pull strong enough to pick up another paper clip. When the paper clip is banged on the table, the alignment is disrupted and the magnetic effect ceases.



Iron filings will align with each magnet's magnetic field. The shape of the magnet and the location of the poles determine the shape of the field. Bar magnets and horseshoe magnets show the filings clumped near the poles. Round magnets have a round magnetic field, which will form the iron filings into a semi-spherical shape above the paper. Most of the magnetic field lines will occur near the magnet's poles. On a round magnet, one flat side is the north pole and the other flat side is the south pole.

Moving the compass around the magnet will reveal that the magnetic field increases in strength as the compass gets closer to the magnet. When the compass is moved far enough away from the magnet, its needle will align with Earth's magnetic field rather than the magnet's magnetic field. This is because as the magnet moves away from the magnet's magnetic field it becomes more strongly influenced by Earth's magnetic field.

Earth is like a magnet because it also has a magnetic field. Earth's magnetic field is most similar to the magnetic field generated by a bar magnet. Earth's magnetic field differs from that of a bar magnet in that it is much less symmetrical, an effect due to solar wind spreading out magnetic lines that lie on Earth's nightside. (These lines form Earth's magnetotail, which is the main source of the polar aurora.) Since Earth generates a magnetic field, a compass will align with its field and point to the North Pole.

You may want to point out to students that what is considered Earth's magnetic North Pole is actually its magnetic South Pole. This is because magnetic field lines flow from the north to the south on a magnet. Earth's magnetic field lines flow outward from the Southern Hemisphere and inward to the Northern Hemisphere, technically making the magnetic North Pole Earth's southern magnetic pole.

LINKS & BOOKS

Links

NOVA Web Site—Magnetic Storm
www.pbs.org/nova/magnetic/
In this companion Web site for the NOVA program, learn about the impact of magnetic fluctuations on animal navigation, scan a timeline of magnetic reversals, view a gallery of auroras, and see how Earth's magnetic field works.

Ask the Space Scientist About Earth—Magnetic Field
image.gsfc.nasa.gov/poetry/ask/amag.html
Lists frequently asked questions about Earth's magnetic field, including questions about magnetic field reversal and its effect on humans.

Core Convection and the Geodynamo
ees5-www.lanl.gov/IGPP/Geodynamo.html
Discusses a mechanism that may be responsible for continuous generation of Earth's magnetic field.

Magnetism
www-istp.gsfc.nasa.gov/Education/Imagnet.html
Explores magnetism and explains magnetic field lines and electromagnetic waves.

North Magnetic Pole
www.geolab.nrcan.gc.ca/geomag/northpole_e.shtml
Provides background on what a magnetic pole is and discusses how scientists track magnetic pole movement.

Books

Livingston, James D.
Driving Force: The Natural Magic of Magnets.
Cambridge, MA: Harvard University Press, 1996.
Tells the history of magnets and how they have been used in motors, VCRs, and high-speed trains. Also discusses the impact of magnetism on culture.

Lee, E. W.
Magnetism: An Introductory Survey.
New York: Dover Publications, 1990. Describes magnetic phenomena.

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Visualizing Magnetic Fields

Magnetism is an unseen force. To help you visualize a magnetic field, you will observe the alignment of iron filings around a magnet. The iron filings align in the direction of the magnet's field and make the field visible. In this activity, you will try out different shapes of magnets and compare their magnetic fields.

Procedure

1 Choose a magnet and place a piece of paper on it. Lightly sprinkle iron filings onto the paper over the magnet. If you sprinkle the filings on too quickly and can't see the magnetic field, get another piece of paper and try again.

2 On another piece of paper, draw the pattern the iron filings make as they experience the magnet's force. Draw the magnet's shape.

3 Use a compass to determine the direction of the magnetic field lines at various places around the magnet. Draw arrows on your diagram to indicate this direction.

4 Move the compass away from the magnet until the compass no longer points to the magnet. Record this distance and the direction the compass is pointing on your diagram.

5 Predict whether different-shaped magnets will produce magnetic fields shaped like the one you just drew.

6 Repeat steps one to four with the other magnets.

Questions

Write your answers on a separate sheet of paper.

1 How did the shape of the magnet influence its magnetic field?

2 Where are most of the magnetic field lines on each of the magnets? Did your results agree with your prediction? Explain.

3 Where are the north and south poles on the round magnet?

4 What did you learn about the strength of each magnet's magnetic field by moving the compass?

5 When you moved the compass away from the magnet, what happened?

6 How is Earth like a magnet?

7 Look at the illustration of Earth's magnetic field below. How is the shape of Earth's magnetic field similar to that of the magnets you experimented with? How is it different?

8 How might a compass be used in conjunction with Earth's magnetic field?