Solar Dynamics Observatory

Activity Name	Grades	Suggested Activity Time	Prep Time	Materials*
Magnetic Fields of the Earth and Sun	5-12	20-30 min	15-20 min	Per group: - 10 disc magnets (1/4" x 1/16") - One magnaprobe - One bar or cow magnet - Image of Earth's magnetic field - Magnetogram image of the Sun (see pages 4-5)

Objectives- Students will be able to:

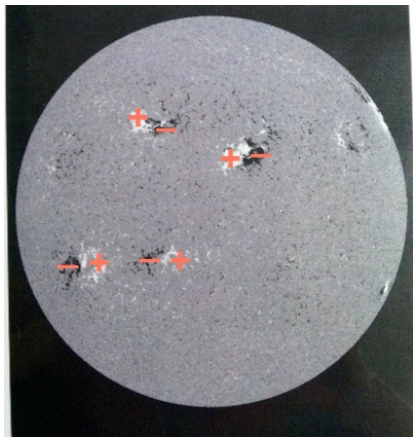
- Investigate the Earth's and Sun's magnetic fields using a magnaprobe
- Identify the differences between the Earth's and Sun's magnetic fields
- Explain that complex magnetic field of the Sun causes solar activity (i.e. solar flares, eruptions)

Description:

Using magnaprobes (magnetic field detectors), students will be able to visualize what the magnetic fields of the Earth and Sun look like. Students will recognize that the magnetic field of the Sun is much more complex than the magnetic field of the Earth, and that the complexity of the Sun's magnetic field relates to solar activity.

How to Prepare:

Print out the images from pages 4-5 on 8 ½ x 11-inch paper. (Laminate them for best results.) The disc magnets should be glued to the back of the magnetogram image on page 5 (see example on left). The black areas on the image represent negative poles and the white areas represent positive poles (see *front* image on left). Make sure magnets are glued in pairs under the black/white regions (see *back* image on left). You should glue the magnets so that when you move the magnaprobe over the black areas, the magnaprobe flips to blue. Oppositely, when you move it over the white areas, the magnaprobe should flip to red. This will allow students to see that



front

back

the magnaprobe flips when they move between black and white areas, meaning that the magnetic poles flip.

***Note:** *Store the magnets and magnaprobes separately. If stored together, the magnaprobes will eventually stop working correctly.* Magnaprobes can be found online at www.arborsci.com and other sites.

Background Information:
The magnetic field of the Earth is roughly a dipole (meaning it has two poles). Although slightly more complex than a simple dipole, which is the magnetic field that forms around a bar (or cow) magnet, it is much less complex than the Sun's magnetic field. The magnetic field that forms around the Earth and extends into space is called the "magnetosphere". It protects Earth from potentially harmful charged particles that come off the Sun; without it we could not survive.

The magnetic field of the Sun is volatile and constantly changing. It is a multipole magnetic field (meaning it has more than two poles) that can become very volatile and cause intense solar activity, including solar flares and eruptions. These events can causes disruptions to technological, navigation, and communication systems on Earth. The Solar Dynamics Observatory (SDO) satellite is studying the magnetic fields of the Sun and solar activity to help scientists predict solar activity, and prevent the problems it can cause on Earth.

Vocabulary:
- magnaprobe
- magnetic field (dipole/multipole)
- magnetogram
- magnetosphere
- Solar Dynamics Observatory (SDO)
- solar activity (i.e. solar flare, eruption)

Directions:
1. Tell students they will be exploring the magnetic fields of the Earth and Sun. Ask them what they know about magnets and magnetic fields. What are the poles of a magnet? What would happen if I put two magnets together?
2. Now walk around the class with a magnaprobe and bar (or cow) magnet. Move the magnaprobe back and forth along the length of the bar magnet to allow students to see how it works. Ask students what they think the magnaprobe is doing. What does it means when it flips from side to side? What do the red and blue parts mean on the magnaprobe? (They distinguish the positive end from the negative end of the magnet. The colors on the magnet in the magnaprobe may be different than this depending on where you buy them.)
3. Explain to students that a magnaprobe is a magnetic field detector. It can be used to trace a magnetic field in three-dimensions as well as show us the direction of magnetic poles in magnets. Tell them they will be using magnets and magnaprobes during the activity to investigate the magnetic fields of the Earth and Sun.
4. Break students into small groups and provide them with the materials listed at the top of page 1.
5. Have them look at the illustration showing Earth's magnetic field (page 4) and instruct them to place a bar magnet along the axis of the Earth in the picture. Where is the North Pole in the picture? The South Pole? Do these areas relate to the poles of the magnet?
6. You can explain that the magnetic North Pole of the Earth (which constantly moves) is relatively close to the geographic North Pole; although they are not in the exact same place, they are close. The same is true for the South Pole (click on the National Earth Science Teachers Association—Earth's Magnetic Field link under Resources for more information).
7. Have students move the magnaprobe up and down (north and south) along the bar magnet to see how the magnaprobe reacts. Ask them to explain what they observe.
8. Ask students to now look at the magnetogram image of the Sun (page 5). Explain that this is a solar image taken by the Solar Dynamics Observatory (SDO) that is that shows the Sun's levels of magnetic activity (a magnetic map of the Sun). The black and white areas on the magnetogram indicate regions of high magnetic activity and the gray areas indicate no magnetic activity. (For more information, click on the

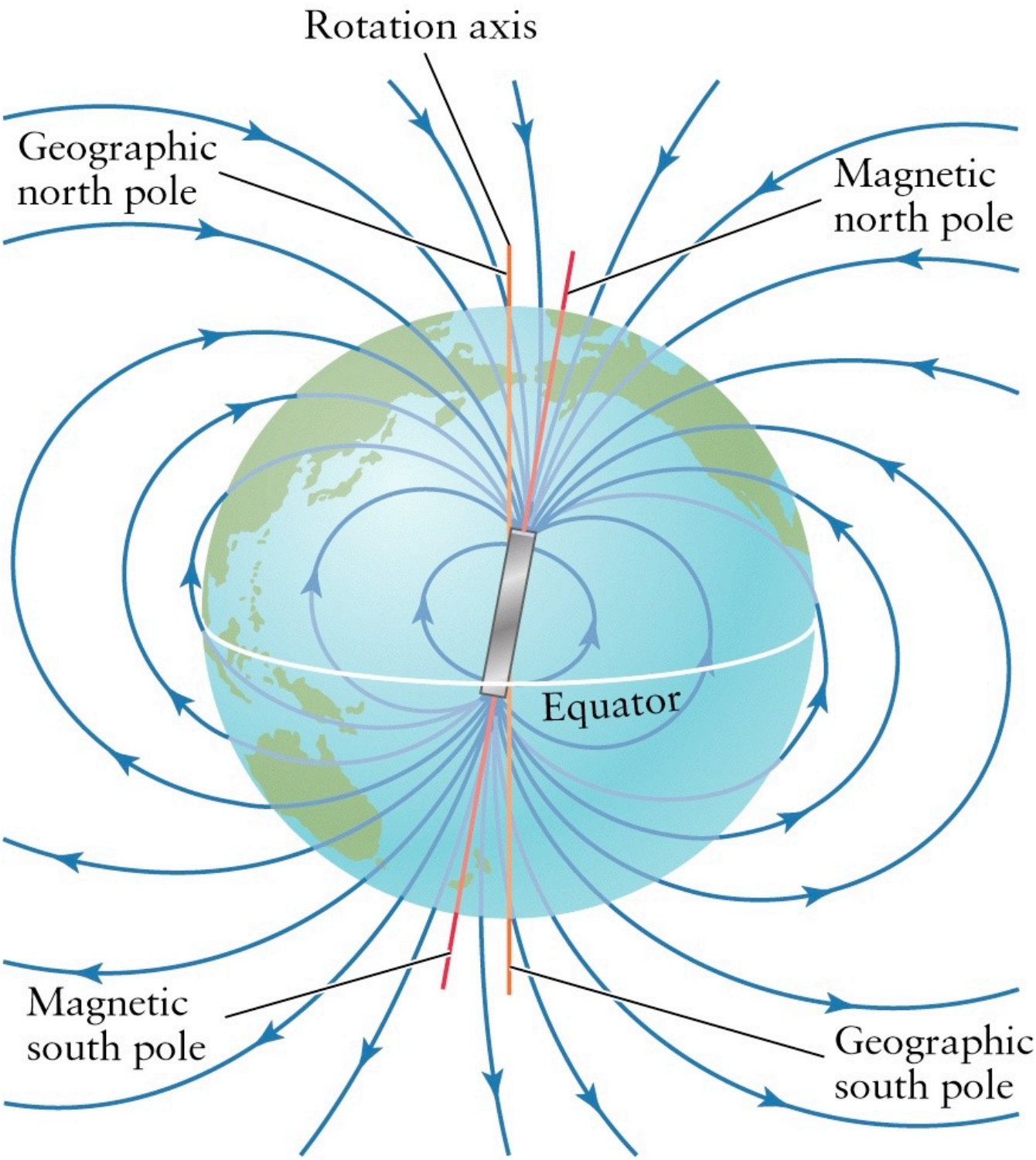
Stanford Solar Center link under Resources).
9. Have students move their magnaprobe over the entire surface Sun in the image. What do they notice? When does the magnaprobe "flip" (from red to blue or vice versa)? What does this mean? Ask them how this is different from what they saw when tracing the magnetic field of the Earth, and which magnetic field is more complex—the Earth's or the Sun's.
10. Explain that Sun's magnetic field is much more complex than the Earth's. Have them look at the illustration of the Earth's magnetic field and point out that they are looking at a dipole magnetic field. Point out that the magnetic field around the Earth is called the "magnetosphere", which protects us from harmful charged particles that come off the Sun (for more information, see Background Information and Resources.)
11. Have students compare the magnetic field lines on the Earth image (blue lines) to those on to the magnetogram (the curved, thin white lines). Ask them: Does the Sun have a dipole magnetic field? How do you know? Have them support their answers.
12. Explain that the Sun has a multipole magnetic field that is constantly changing! Tell students that the complex magnetic field structure on the Sun can cause intense solar activity (i.e. solar flares, eruptions) that can affect us on Earth. Although the Earth's magnetosphere helps protect us from much of the disastrous effects that this solar activity can cause, our technological, navigation, and communication systems can significantly be affected (see Background Information and Resources for more information).
13. If students are not familiar with solar flares or eruptions, you can show them recent videos from the SDO Gallery (see link under Resources).
14. To further explain how solar activity affects the Earth, show students the National Geographic video on Electromagnetic Sun Storms (see link under Resources). After the video, ask students why it is important for SDO scientists to study solar activity and how it affects the Earth.

Resources:
- NASA—Magnetic Field Lines: http://www-istp.gsfc.nasa.gov/Education/wfldline.html
- NASA Cosmicopia—Earth's Magnetosphere: http://helios.gsfc.nasa.gov/magnet.html
- NASA Sun Earth Day—Magnetism from A to B: http://SunEarthday.gsfc.nasa.gov/2010/TTT/71.php
- NASA Solar Dynamics Observatory (SDO) Gallery: http://sdo.gsfc.nasa.gov/gallery/main.php
- National Earth Science Teachers Assoc. (NESTA)—Dipole, Quadrupole, and Multipole Magnetic Fields: http://www.windows2universe.org/physical_science/magnetism/magnetic_multipole_fields.html
- NESTA —Earth's Magnetic Field: http://www.windows2universe.org/Earth/Magnetosphere/Earth_magnetic_field.html
- NESTA —The Sun's Magnetic Field: http://www.windows2universe.org/Sun/Sun_magnetic_field.html
- National Geographic—Electromagnetic Sun Storms (video): http://www.youtube.com/watch?v=W_cLSvP9qSU
- National Geographic—The Sun: Living with a Stormy Star: http://science.nationalgeographic.com/science/space/solar-system/Sun-stormy-star.html#page=1
- Stanford Solar Center—Solar Magnetograms: http://solar-center.stanford.edu/solar-images/magnetograms.html

Standards addressed:
A. National Science Education Standards addressed:
5-8: *Content Standard D:* As a result of their activities in grades 5 – 8, all students should develop an understanding of the structure of the Earth system, 1: The solid Earth is layered with a lithosphere; hot, convecting mantle; and dense, metallic core.

9-12: *Content Standard B:* As a result of their activities in grades 9 – 12, all students should develop an understanding of motions and forces, 5: Electricity and magnetism are two aspects of a single electromagnetic force. Moving electric charges produce magnetic forces, and moving magnets produce electric forces. These effects help students to understand electric motors and generators.

Earth's Magnetic Field



Magnetic Fields of the Sun

Magnetogram image of the Sun from 10/11/2011