

# Activity #3

## How Do Atmospheres Change Over Time? The Role of Magnetosphere and Solar Wind

### [Cadette]



Adapted from *The Earth as a Magnet*: <http://tinyurl.com/2c6kavn>; *Planetary Magnetism: How crucial is a planet's magnetic field?* Produced by the Center for Science Education at UC Berkeley's Space Sciences Laboratory, with support from NASA's MAVEN mission and written by Kyle Fricke. Unless otherwise noted, all images are courtesy of SETI Institute.

### 1. Introduction

In this activity, you will observe the properties of magnets and magnetic fields, and then build a model of Mars and Earth to demonstrate that Mars cannot effectively protect its atmosphere from the solar wind. You will also “Think like a scientist. Be a Scientist!”

### 2. Science Objectives

You will:

- apply skills learned previously about using models;
- build scale models of Earth's and Mars' magnetic fields; and
- use your new knowledge about the magnetic fields of Earth and Mars to ask questions about the ability of the solar wind to change a planet's atmosphere over time.

### 3. Materials

For each group of 4 to 6 Cadettes. Pick up your materials as directed by your adult leader.

- [1] file or copier paper box lid
- [1] 5.1 cm (2 in) diameter paper cup Mars model. Martian diameter is 52% of Earth's.
- [1] 8.9 to 10.2 cm (3.5 to 4 in) diameter lid Earth model
- [1] 7.6 cm (3 in) bar magnet wrapped in plastic and/or transparent tape
- several pea-sized pieces cut from a flexible magnetic sheet
- iron filings in “salt” shaker container
- small envelope or paper cup half-filled with paper hole punches
- flexible straws — unique color for each team member
- [1] quart-sized Ziploc® bag (to hold magnets and for cleanup)
- small paint brush for cleanup



#### 4. Safety Precautions

- 4.1. Iron filings can be sharp and irritating if they get under fingernails. Do not handle filings with your bare hands. Keep iron filings away from your eyes, nose, and mouth.
- 4.2. Do not inhale iron filings through straw. **Take the straw out of your mouth when you inhale.**

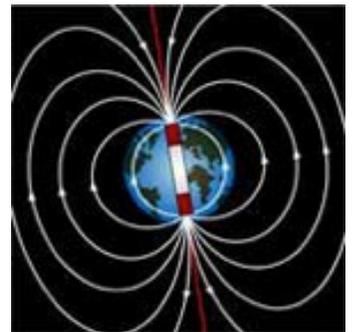
#### 5. Preparation for Activity #3

- 5.1. Read together *Background Escape of the Atmospheres!* (see [page 6](#)) Discuss and answer the following about the images:
  - 5.1.1. Which molecule would more easily escape? Why?
  - 5.1.2. Which planet do you think has greater mass? Which planet holds onto an atmosphere more easily?
  - 5.1.3. Which planet is least likely to have an atmosphere? Are you surprised that the answer is NOT Venus? Why?
  - 5.1.4. How effective do you think Mars' magnetosphere is compared to Earth's in protecting its atmosphere?
- 5.2. Watch this video: [Raging Solar Wind \(BBC\): http://www.seti.org/ggtm](http://www.seti.org/ggtm)

#### 6. Explore

**Equipment Manager: check that the necessary materials are in the box.**

- 6.1. Place 1 or 2 sheets of clean white paper inside a copier paper box lid. Place a wrapped bar magnet lengthwise in the center of the paper (see top right image).
- 6.2. Carefully sprinkle some iron filings over the entire area until you see a pattern develop. Do not remove the filings.
  - 6.2.1. Observe the pattern and briefly sketch it in your Data Sheet. **The lines of iron filings help you see the magnetic field lines produced by the magnets. Where the lines are closest together, the magnetic force is strongest.**
  - 6.2.2. On your sketch, **mark** where the magnet is strongest.
  - 6.2.3. Compare the bar magnet lines and the image of Earth (center right image), demonstrating magnetic field lines in the north and south directions.  
Does the image look similar to your sketch?
- 6.3. Use the labeled Earth model and cover the bar magnet. Sprinkle more iron filings over the Earth model and the field lines so that they are very apparent (see bottom right image).



6.4. Add about 1 teaspoon of paper hole punches about 13 cm (5 in) from “Earth” and the end of the magnet.

6.5. Using a straw, **gently blow** the hole punches straight towards “Earth” for about 10 seconds and observe what happens to the field lines and hole punches. Note how the straw is held so the bent part is close to the pile of paper hole punches (see top right image). Where do the punches end up? What happens to the pattern of iron filing lines? Are field lines disturbed? **Your breath represents the solar wind. The hole punches are tracers for what happens to the solar wind when it reaches “Earth.” The iron filings represent the Earth’s magnetosphere.**



6.5.1. What happened to the “solar wind” as it reached “Earth”?

6.5.2. Were the iron filings representing the magnetosphere disturbed by the “solar wind”?

6.5.3. Make a brief sketch on your Data Sheet page of the iron filings and hole punches after the “solar wind.”

6.6. Pick up the Earth model and bar magnet. Return them to the Ziploc® bag. Carefully tilt the box lid so that iron filings and hole punches slide over to the corner of the box.

6.7. Select 4 or 5 pea-sized pieces of flexible magnetics. Group them so they are in a 2.5 cm (1 in) circle on the white paper in the box lid (see center right image).



6.8. Sprinkle a small amount of additional iron filings over the magnets. What does this pattern of iron filings look like? Does Mars show a pattern similar to Earth’s? Briefly sketch what you observe on your Data Sheet.

6.9. Leave the iron filings in place. Cover the flexible magnets with the labeled Mars model (see bottom right image).



6.9.1. Based on your observations in Step 6.5, **predict** what might happen when you gently blow hole punches at your Mars model.

6.9.2. Will the iron filings remain close by? Where will the hole punches go?

6.9.3. Does Mars have a magnetosphere that behaves like Earth’s magnetosphere? Discuss your predictions with your team.

6.10. Now do it. Put a small pile of hole punches about 13 cm (5 in) from your Mars model. Using a straw, **gently blow** toward Mars for about 10 seconds.

6.10.1. Was your **prediction** correct? What happened to the iron filings and the hole punches?

6.10.2. Sketch in your Data Sheet the iron filings and hole punches after the “solar wind.”

6.10.3. How do the results of this Mars model differ from the Earth model when you blew the hole punches?

6.10.4. What does this tell you about Mars' magnetosphere? Is it weak or strong?

6.10.5. Do you think Mars' magnetosphere is able to adequately protect its atmosphere?

6.11. The image to the right depicts Mars' magnetic fields (circled in white) on the surface rather than coming from the core as observed with Earth's.



*Image credit: NASA JPL*

## 7. Cleanup

- 7.1. Pick up the Mars model and the flexible magnets. Put them in the Ziploc® bag along with the Earth model and the bar magnet. Use the small paint brush to sweep the hole punches and iron filings into a pile. Pick up the paper and form a funnel. Put the Ziploc® bag in the lid of the box and dump the iron filings and punches inside.
- 7.2. Tightly close the bag and return it to your equipment box.

## 8. Data Sheet

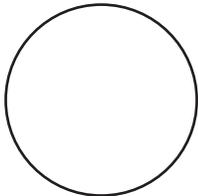
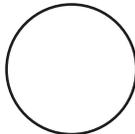
### Go to Work

Sketch pattern of magnet + iron filings: Can you mark where magnet is strongest?

Earth-like
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Mars-like
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Complete the table below comparing Mars and Earth following experiment directions

Question	Earth?	Mars?
Make a sketch of iron filings and hole punches after solar wind:		

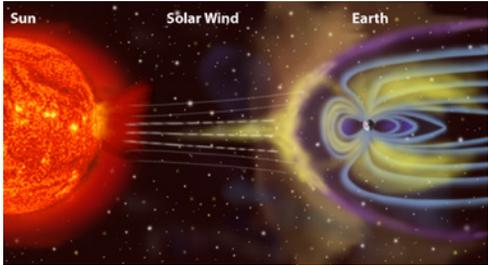
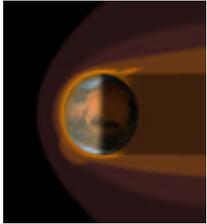
### Questions to think about and to further explore.

- 8.1. How might a magnetosphere protect a planet's atmosphere?
- 8.2. What happens when the solar wind strikes a magnetosphere? What might happen if a planet has a magnetosphere that is weak or has holes in it?
- 8.3. Can an atmosphere be changed by the solar wind?

## 9. Connection to the Leadership Journey *Breathe. It's Your Planet — Love It!*

Add to your Air Log.

### Activity #3: BACKGROUND *Escape of the Atmospheres!*

Why do gases leave the scene?	Evidence														
<p><b>a. Atmosphere composition:</b></p> <p>Some molecules of gas are small and light-weight, and they can more easily get away.</p> <p>Which molecule would most easily escape?</p>	 <p>#1 hydrogen</p>	 <p>#2 water</p>	 <p>#3 carbon dioxide</p>												
<p><b>b. Planetary mass:</b></p> <p>Gravity is a force of attraction that acts between all objects with mass, including between atmospheric gases and planets.</p> <p>If a planet has a higher mass, it has stronger gravity. This gravity makes it harder for molecules to get away — to reach “escape velocity.”</p>	<p><b>Earth vs. Mars</b></p> <p>Which planet do you think has greater mass?</p> <p>Which planet do you predict would do a better job of “holding onto” an atmosphere?</p> <p><i>Image credit: NASA</i></p>														
<p><b>c. Distance from the Sun:</b></p> <p>Think about Activity #1 Scale Model of the Solar System — where were Venus, Earth, Mars, and the Sun relative to each other?</p> <p>A planet closer to the Sun has a hotter atmosphere, with more molecules moving faster and, therefore, more likely to escape.</p>	<p>Which planet is least likely to have an atmosphere?*</p> <table border="1" data-bbox="773 835 1500 1031"> <thead> <tr> <th>Planet</th> <th>Distance from Sun</th> <th>High Surface Temp.</th> </tr> </thead> <tbody> <tr> <td>Mars</td> <td>228,000,000 km</td> <td>20°C</td> </tr> <tr> <td>Earth</td> <td>150,000,000 km</td> <td>58°C</td> </tr> <tr> <td>Venus</td> <td>108,000,000 km</td> <td>465°C</td> </tr> </tbody> </table> <p>** Predict: <b>Venus</b>. Evidence shows <b>Mars</b> has very little atmosphere. <b>Clearly factors other than distance are involved too.</b></p>			Planet	Distance from Sun	High Surface Temp.	Mars	228,000,000 km	20°C	Earth	150,000,000 km	58°C	Venus	108,000,000 km	465°C
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<p><b>d. Solar wind:</b></p> <p>The solar wind flows in all directions and blasts every planet in its way. Some planets have a way to protect their atmospheres. They generate a magnetic field from their molten iron core that acts like a shield. Scientists call the region surrounding Earth where its magnetic field is located, the <b>magnetosphere</b>. Not all planets have a strong magnetosphere and that may cause their atmosphere to be more open to attack by the solar wind.</p> <p>How effective do you think Mars’ magnetosphere is compared to Earth’s in protecting its atmosphere?</p>	<p>Earth’s Magnetosphere and Solar Wind (drawing)</p>  <p><i>Image credit: NASA</i></p>  <p>Artist’s conception of Mars’ magnetosphere</p> <p><i>Image credit: ESA</i></p>														
<p><b>Other Factors:</b></p> <p>Planets lose atmosphere to meteorite impacts and to the capture of gas molecules into rocks.</p>	 <p>Meteorite impact on Mars (artist’s conception)</p> <p><i>Image credit: NASA</i></p>														