Activity #2
It's All About the Atmosphere *[Cadette]*

Adapted from: *NOVA's How to Get an Atmosphere:* http://tinyurl.com/oc7yltg and *Introduction to the Atmosphere — The Goldilocks Principle: A Model of Atmospheric Gases.* Unless otherwise noted, all images are courtesy of SETI Institute.

1. Introduction

In this activity you will explore atmospheric density. You will also "Think like a scientist!"

2. Science Objectives

Examine the atmospheric density of Venus, Earth, and Mars using a model.

Scientists use models to test ideas about objects or processes that cannot be directly studied. A model is not the real thing, but a substitute that can be tested and used to make predictions.

3. Materials

For each group of 3–4 Cadettes.

- [1] set of 3 Atmosphere Models: Venus, Earth, and Mars

4. Get Ready

4.1. Read *Background Inner Planets Table of Information* (page 4).

4.2. How are atmospheres described?

Atmospheres are described in terms of the **amounts and kinds of different gases** and **how much those gases push on a surface area.**

If there are **more closely packed (dense)** gas molecules, they push down more 🡇 on the same-sized surface, and the atmosphere has **more** pressure.

If there are **fewer closely packed (less dense)** gas molecules, there are fewer molecules to push down on the surface and the atmosphere has **less** ↓ pressure.

4.3. How does a planet "get" an atmosphere?

Of the four inner Solar System planets only three — Venus, our Earth, and Mars — wear some sort of blanket of gas called an atmosphere. Why just these three? Why does Mercury have an almost negligible atmosphere?

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It turns out that “**getting**” an atmosphere and “**holding**” onto it come down to *mostly* a combination of **how large the planet is** and **how close it is to the Sun**. If you are a planetary geologist, the story is a lot more complicated than size and location. For now, if we look at only these two variables, we can go far in understanding why Earth ended up such a nice cozy place while Mars turned into an icebox. Later on we will explore other factors that contribute to whether an atmosphere hangs around or not.

In the beginning of our Solar System…when the planets were forming, all the four inner planets started out with the same kind of air: mostly hydrogen and helium. During this period, the Sun was not very bright or hot. Hydrogen and helium are lightweight molecules and our inner four had enough gravity to hang onto this early atmosphere briefly.

Over a very long period of time, the Sun grew hotter and brighter, and heated up the small lightweight molecules of hydrogen and helium. Over a few hundred million years, almost all of the hydrogen and helium escaped, leaving Earth and the other three inner planets little more than balls of rock.

We know that Earth and Mars are very different now, so something must have changed! Later we will explore how a planet can lose an atmosphere over time.

Some sources of heavier molecules like nitrogen, carbon dioxide, and water vapor were:

- **Comets** that regularly slammed into the planets; and
- A molten planetary core that kept the mantle extremely hot — enough to form magma and produce **volcanoes** which spewed gases out of the interior beginning as long as 4.4 billion years ago.

5. Explore

5.1. Compare the three labeled models representing the atmospheres of Venus, Earth, and Mars by holding each in the palm of your hand. The grains of sand represent gas molecules in the atmosphere of each of the planets. Each model has about the same volume, but not the same number of sand grains. This means the density is different.

5.2. Shake the models to see the grains of sand moving around.

5.2.1. Which model has sand grains that are closest together?

5.2.2. Which model has sand grains that are the farthest apart?

5.2.3. Which atmosphere would be the heaviest and warmest around a planet?

5.2.4. Which atmosphere would be the lightest and and coldest around a planet?

5.3. Show the video *Olympus Mons on Mars* (BBC): http://www.seti.org/ggtm

5.3.1. For Mercury, Venus, Earth, and Mars: Reflect on the video, what you learned about size and the distance these planets are from the Sun (Activity #1), and the atmospheric pressure:

5.3.1.1 Which planet is smallest, closest to the Sun, and has no atmosphere?

5.3.1.2 Which planet is large, closer to the Sun than the Earth is, and has a lot of atmosphere?

5.3.1.3 Which planet is smaller, far away from the Sun, with little atmosphere?

5.3.2. Look at the Inner Planets Table of Information on page 4. Compare the data for Mercury and Venus. Explain the temperature of Venus relative to Mercury.

5.4. It's All Up in the Air…clearly atmospheres can change drastically over time. What can cause atmospheres to change? What happens when atmospheres change? We will explore what can happen to an atmosphere in other activities.

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

Start your Air Log today, refer to page 103 in *Breathe. It's Your Planet — Love It!*

Activity #2: BACKGROUND *Inner Planets Table of Information*

Currently, scientists interpret data from spacecraft to determine:

Inner Planets	What Happened to the Water?	Planet Diameter Relative to Earth	Average Surface Temperature	Distance from Sun (km)	Energy from the Sun (Watts per Sq Meter)
Mercury	None	4,878 km 38% of Earth	Very cold (−183°C) to very hot (427°C) [−297 to 800°F]	58,000,000	9,116
Venus	All **water vapor burned off** long ago. Could not form oceans to absorb carbon dioxide.	12,100 km 95% of Earth	Extremely hot! +465°C (869°F)	108,000,000	2,611
Earth	All water vapor that belched out of volcanoes cooled and turned into **liquid water**. Over many eons, liquid water formed oceans.	12,742 km	Average surface temperature is a comfortable 15°C (59°F); varies from −89 to 58°C (−128 to 136°F)	150,000,000	1,366
Mars	May have had oceans 3.8 million years ago. Volcanoes ceased. **Water vapor froze** out of atmosphere; trapped under surface in form of ice.	67,94 km 53% of Earth	Brrrrr! −125° to 20°C (−193 to 68°F)	228,000,000	589

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?

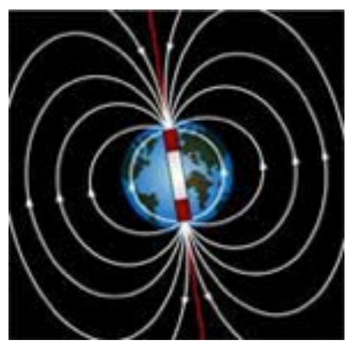
5.2. Watch this video: *Raging Solar Wind* (BBC): http://www.seti.org/ggtm

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?

Image credit: NASA JPL

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.

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	Mars-like

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.

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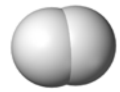
Activity #3: BACKGROUND *Escape of the Atmospheres!*

Why do gases leave the scene?	Evidence

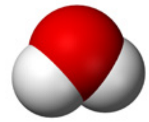
a. Atmosphere composition:

Some molecules of gas are small and lightweight, and they can more easily get away.

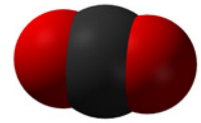
Which molecule would most easily escape?



#1 hydrogen



#2 water



#3 carbon dioxide

b. Planetary mass:

Gravity is a force of attraction that acts between all objects with mass, including between atmospheric gases and planets.

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."

Earth vs. Mars

Which planet do you think has greater mass?

Which planet do you predict would do a better job of "holding onto" an atmosphere?

Image credit: NASA

c. Distance from the Sun:

Think about Activity #1 Scale Model of the Solar System — where were Venus, Earth, Mars, and the Sun relative to each other?

A planet closer to the Sun has a hotter atmosphere, with more molecules moving faster and, therefore, more likely to escape.

Which planet is least likely to have an atmosphere?**

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

** Predict: **Venus**. Evidence shows **Mars** has very little atmosphere. **Clearly factors other than distance are involved too.**

d. Solar wind:

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 **magnetosphere**. Not all planets have a strong magnetosphere and that may cause their atmosphere to be more open to attack by the solar wind.

How effective do you think Mars' magnetosphere is compared to Earth's in protecting its atmosphere?

Earth's Magnetosphere and Solar Wind (drawing)

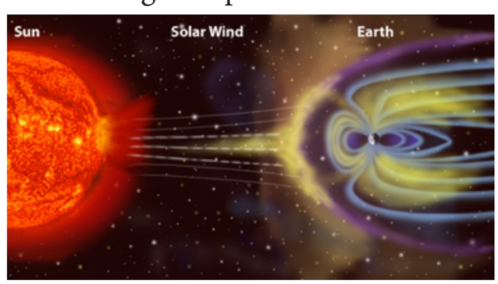
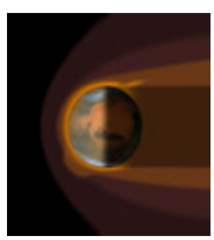


Image credit: NASA

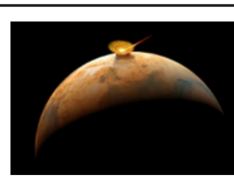


Artist's conception of Mars' magnetosphere

Image credit: ESA

Other Factors:

Planets lose atmosphere to meteorite impacts and to the capture of gas molecules into rocks.



Meteorite impact on Mars (artist's conception)

Image credit: NASA

Activity #4
Evidence for an Atmosphere on Mars Over Time: Water Surface Features *[Cadette]*

Adapted from: "Did Water Create Features On Mars?" from NASA's *Mars and Earth: Science and Learning Activities for Afterschool:* http://tinyurl.com/pcfbln3 and *Rivers on Mars?:* http://tinyurl.com/qfeqv4q with permission from the Lunar and Planetary Institute, LPI Contribution Number 1490. Unless otherwise noted, all images are courtesy of SETI Institute.

1. Introduction

In this activity, you will compare images of Mars and Earth surface features that have been eroded by water. Then you will construct, observe, and test a model of flowing water and look for similar erosion patterns. You will also "Think like a scientist. Be a Scientist!"

2. Science Objectives

You will:

- construct models to test ideas about processes that cannot be directly studied on Mars;
- ask experimental questions, collect data, and use evidence to answer those questions about flowing water erosion;
- relate evidence of *sustained flowing* water on Mars as support for a thicker early Martian atmosphere and a warmer climate more like Earth's; and
- appreciate evidence of ancient water erosion that points to changes in Mars' atmosphere over a very long period of time.

3. Materials

For each group of Cadettes: recommend teams of 4 Cadettes. Pick up your materials as directed by your adult leader.

- [1] model **Stream Table**
- [1] conglomerate rock
- [1] 1.0 liter (34 oz) disposable water bottle filled with tap water
- [1] plastic catch-bucket, about 4 liters (about 1 gal) or even larger for drainage water
- [3–4] thinly-sliced foam florist blocks to raise one end of the tray; view on Amazon.com: http://tinyurl.com/knv57cc
- [1] protractor
- [4–5] assorted rocks from thumb- to palm-sized
- [2] colored pencils (2 per Cadette; any color)
- newspapers to place under tray and bucket (for cleanup)
- (optional) latex gloves (caution: check for allergies), sponges, rags, and brooms

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4. Safety Precautions

4.1. Keep area dry to reduce the chance of someone slipping on a wet floor. Place newspapers under the catch bucket and on the table to absorb excess water.

4.2. River bottom and other sources of heterogeneous sand may be contaminated with bacteria. It is recommended that gloves be provided for handling erosion material.

Preparation for Activity #4

4.3. Read together *Background Evidence for an Atmosphere Over Time: Water Erosion* (see page 6). Discuss and answer the following about the images:

4.3.1. What do you look for as evidence of *ancient* flowing water in an image?

4.3.2. How does the evidence for ancient flowing water look different from continuously blowing wind?

4.3.3. Equipment Manager: Retrieve the **conglomerate rock** and show it to everyone. Compare the sample of **conglomerate rock** to the images in Background reading. This type of rock can be found on Earth along swiftly flowing streams or at beaches with strong waves. NASA's *Curiosity* also found exposed conglomerate rock on Mars.

4.3.4. What does the conglomerate rock evidence suggest about the likelihood of sustained flowing water on Mars at some point in time?

4.4. Watch this video: *River Fans on Earth and Mars* (JPL): http://www.seti.org/ggtm

4.4.1. How does observing alluvial fans on Earth and Mars help scientists learn more about Mars?

4.5. Guided Sensory Imaging: Think about the ***feel*** of moving water.
Equipment Manager: Get a palm-sized amount of sand and place that sand in a teammate's hand. While standing over the bucket container, ask your teammate to close her eyes and pour water slowly over the sand. What is happening to the sand particles in her hand? Ask her to describe how it feels.

4.5.1. Repeat this mini-experiment for everyone if time permits. Consider how sand particles move objects and also "sands" them smooth. How do you imagine these Earth surface features might form from sustained flowing water?

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5. Go and Explore


Prop up the sand-filled end 10 degrees with foam slices.

5.1. Equipment Manager: Use the protractor and different combinations of slices of florist foam to prop up the short side of your stream table until the side with the sand is lifted about 10 degrees.

5.2. Leader-organizer: Line up the hole in the pan with the catch-bucket on the floor. **TEST:** Make sure that any water from the pan flows out of the drain hole at the end and into the bucket.

5.3. Check that newspapers are under the bucket and your Stream Table.

5.4. Group takes turns for steps 5.4–5.6: Begin pouring water from the water bottle ***slowly*** and steadily over the top of the wet sand until the water flows down the plastic area and out the hole in the pan into the bucket, checking to make sure the water flows into the bucket.

5.5. Observe the channels that form in the sand. Keep pouring, observing the movement of the particles. Look for signs of erosion and channels. Are all the particles moving at the same speed?

5.5.1. What happens to the particles when the water slows down at the end of the tray?

5.5.2. What types of surface features did you observe?

5.6. Now experiment and find out what happens in a flood. Pour water ***faster*** down one channel.

5.6.1. What happens to some of the particles as the water flows over old channels?

5.6.2. What kinds of new features did you make? Once the water has gone away, what features are left at the end of the channel? (Review your Background reading.)

5.7. Test your own idea — advance preparation.
Group: Look at the selection of rocks and consider an erosion effect you want to test.

5.7.1. Using the protractor as a scraper, smooth the sand so the channels are largely covered over.

5.7.2. Decide: Will you pour the water slow or fast?

5.7.3. Think about the effect of adding rocks in different places along the channel(s) you will produce.

5.7.4. Make a Prediction: What will happen when water rushes by? How will the rocks affect the flow of water?

5.7.5. Sketch your Stream Table setup with the rocks in your Data Sheet.

5.7.6. Using a colored pencil, briefly sketch your **Start** conditions, including the rock location and sand features formed by water.

5.8. Now Do It! Run your experiment and see if your prediction was accurate.

5.8.1. Pour water to produce the channel(s).

5.8.2. Add the rock(s) as planned.

5.8.3. Sketch the Stream Table.

5.8.4. Pour water to observe the effect of the adding rocks.

5.8.5. Add the new observations to your sketch by using a different pencil color.

6. Cleanup

Everyone participates in cleanup.

6.1. Follow your adult leaders' directions.

6.2. Dump the water outside. Do not pour the contents of the waste water down the sink. Sand is not good for drains!

6.3. Clean up spilled water on tables, counters, and floors with towels or rags.

6.4. Dispose of newspapers as directed.

7. Data Sheet and Information Processing

Test your own idea.

Sketch the water flow before and after you add rocks. Use different pencil colors to show the change in appearance. Draw the rocks.

Pencil Key: Color
Start:
End:

7.1. Group Work:

7.1.1. If you saw the same erosion surface features on another planet, how do you think those surface features might have happened? Together as a group, watch video clip: *River channels on Mars* (BBC): http://www.seti.org/ggtm

7.1.2. What does the presence of surface features created by sources of sustained flowing water suggest about the possibility of more atmospheric pressure on Mars in the past? (Hard question — reflect on our second activity, "The Goldilocks Question.")

7.1.3. What can happen when Mars' atmospheric pressure is low and there are small molecules like water vapor near the surface?

7.2. Summary for Group Presentation (4 or 5 minutes). Now look at the images of Mars: Do you see evidence for "flowing water" on Mars? Review images, video clip, and your experimental model of stream surface features.

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

Start thinking about why the atmosphere and Global Warming are important to you. Activity #5 will help you understand Global Warming.

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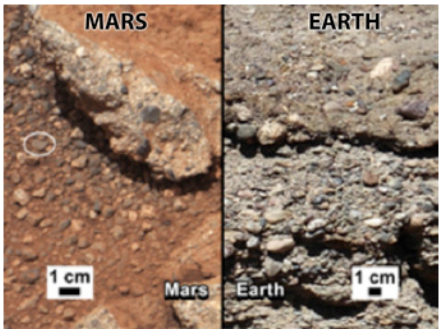
Activity #4: BACKGROUND *Evidence for an Atmosphere Over Time: Water Erosion*

Like fingerprints, there are surface features that appear as a result of sustained flowing water and erosion (wearing away). Water shapes a planet's surface features along with the other forces of blowing wind, volcanic eruptions, plate tectonics, and impacts of large objects from space such as asteroids. What does continuously flowing water do? Water erodes channels, moves large and small particles long distances, and deposits materials over wide areas. Continuously blowing wind also moves materials over wide areas as well.

Water Erosion

What surface features are observed as a result of sustained flowing water?



Conglomerate rock. Image credit: NASA MRO

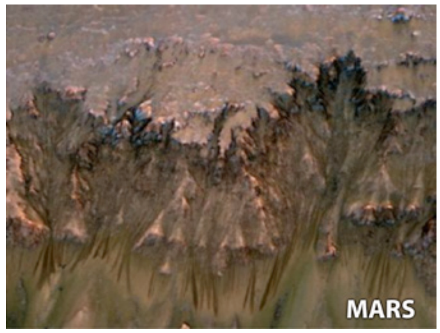


Image credit: NASA/JPL-Caltech/MSSS and PSI

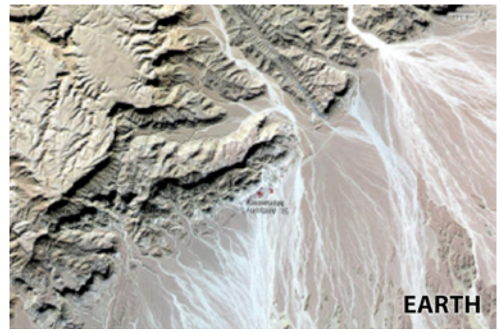


Image credit: NASA/JPL/ASTER

- Moving water erodes the sides of a river channel and the rocks and other particles (sediments) become part of the stream.
- The sediments are carried further down stream and finer fragments are carried in the water. Some materials are dissolved in the water too.
- A river channel may widen or narrow as sediments are picked up or dropped along the way. As the river channel changes its size, the water will also change how fast it flows.
- Eventually, the stream flow slows enough for the grains to be completely dropped. Areas where more particles are dropped from rivers at the base of a mountain form *alluvial* or *flood* plains.

You will observe alluvial fans in the video and also experiment with how they are produced.

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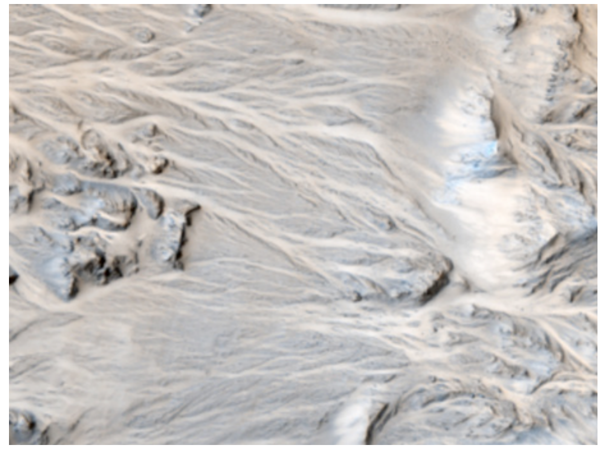
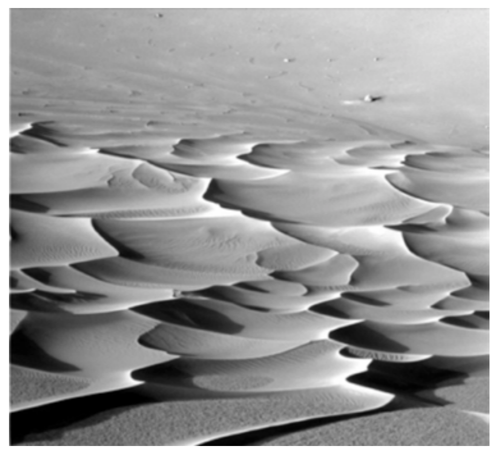
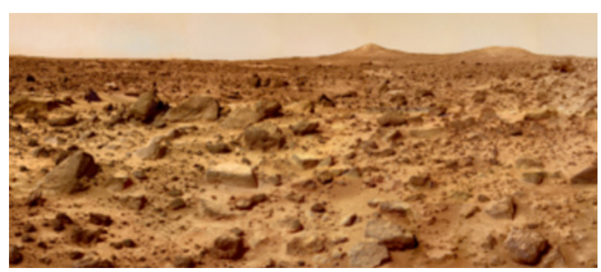
Wind *and* Water Erosion

	Earth	Mars
Water Erosion Alluvial Fan	**Death Valley**  *Image credit: USGS*	**Mars Mojave Crater**  *Image credit: NASA MRO*
Wind Erosion Dunes	**Rub' al Khali, Saudi Arabia**  *Image credit: Nepenthes*	**Mars Dunes**  *Image credit: NASA JPL Rover*
Wind Erosion	**Turpan Depression, China**  *Image credit: USGS*	**Mars**  *Image credit: NASA Mars Pathfinder*

Activity #5
How Do Atmospheres Change Over Time?
The Greenhouse Effect *[Cadette]*

Adapted from: *Global Warming & The Greenhouse Effect, Great Explorations in Math and Science (GEMS)* Lawrence Hall of Science, 1997, by the Regents of the University of California
ISBN: 0-912511-75-3. Unless otherwise noted, all images are courtesy of SETI Institute.

1. Introduction

In this activity, Cadettes will observe how the greenhouse effect can change an atmosphere on Mars or on Earth. They will "Think like a scientist. Be a scientist!"

2. Science Objectives

You will:

- construct models to test ideas about processes that cannot be directly studied on Earth or Mars;
- appreciate that the atmosphere is a large and complex system, so experiments concerning it are difficult to perform; and
- use skills you have learned about atmospheric composition and apply that knowledge to new situations.

3. Materials

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

- [2] **Atmosphere Model Chambers**
- [2] thermometers backed with cardboard
- [2] small strips of tape to attach thermometers inside of each chamber
- [1] piece of plastic wrap wtih rubber band
- 500 ml (2.1 cups) dark, very moist soil
- 250-watt infrared heat lamp (bulb) in a fixture with hood (unless you are conducting your experiment outside)
- colored pencils in red, orange, yellow, green, violet, and blue
- [1] piece of temperature-sensitive film
- enough safety glasses for each team member

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4. Safety Precautions

4.1. Heat lamp bulbs can get very hot. Do not touch when bulbs are turned on.

4.2. Handle bulbs with care. Do not drop or bang against hard objects. They are fragile.

5. Get Ready

5.1. Read together *Background Exploring Light and the Greenhouse Effect* (see page 7)**.** Direct team members to talk amongst themselves and answer the following:

5.2. Which has ***more*** energy? Underline your answer: VISIBLE or INFRARED light.

5.3. Which has more energy in the visible spectrum? RED LIGHT or BLUE LIGHT? (This answer is ***different*** than when an artist talks about warm and cool colors of paint!)

5.4. Look at the clouds in the image titled "The Greenhouse Gas Effect and Light Energy." How do thin, small clouds reflect outgoing heat differently than thicker clouds?

5.5. Watch this video: *The Electromagnetic Spectrum* (NOVA PBS): http://seti.org/ggtm

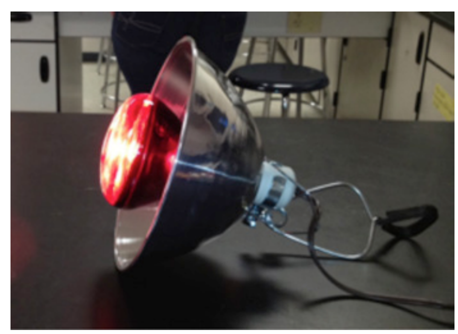
6. Explore: Part I

6.1. Equipment Manager: Obtain a piece of ***heat-sensitive film*** and the heat lamp, fixture, and hood. Locate an electrical outlet near a table. Everyone locate your copy of the electromagnetic spectrum (EMS) chart on page 7.

6.2. Get Started

6.2.1. Plug the heat lamp fixture into a nearby electrical outlet and lay the fixture and hood down on the table.

6.2.2. Adjust the fixture so that the lamp is parallel to the table. CAUTION: Infrared bulb is very HOT! Do not touch!



6.3. Go Directions

6.3.1. Group: Compare the heat lamp to your EMS Spectrum Chart.

6.3.1.1 What color is the heat lamp?

6.3.1.2 Where on the EMS chart would you most closely match the light energy of the lamp?

6.3.2. Group: Hold your hand various distances from the heat lamp. Do NOT touch the lamp!!! Feel the difference in heat energy as it relates to distance.

6.3.2.1 As my hand gets closer to the lamp, I feel (MORE/LESS) heat energy.

6.3.2.2 As planets get closer to the Sun, they will feel (MORE/LESS) heat energy. (Check your answer with Activity #2 It's All About the Atmosphere Background, page 4.)

6.3.2.3 Do your observations (AGREE/DISAGREE) with information from Activity #2?

6.4. Leader: Very briefly!! hold the film 15 cm (6 in) in front of the heat lamp. **Do not let the film touch the lamp!** The film will translate the energy coming from the lamp into a color and requires only a very short exposure.

6.4.1. The color of the warmest spot on the film is:

6.4.2. As the film cools, list the order of colors as the colors change:

6.4.3. Do the colors change in the same order of visible colors on your chart?

6.4.4. UNPLUG THE LAMP when you have completed step 6.4. CAUTION: Infrared bulb is very HOT! Do not touch!

6.5. Group: Turn this page over and lay your hand flat with your fingers spread out. Trace the outline of your hand. Turn the paper back over and finish reading the directions:

6.5.1. Let the film cool to room temperature, warm your hands briefly with the lamp, then make a handprint on the film by **pressing the film firmly between your two hands** for a few seconds. Remove **one hand** and quickly observe the *fading* order of the colors.

6.5.2. Turn this page *back to your hand outline* and using the appropriate colored pencils, sketch the color patterns as your handprint cools. Repeat making a "film" handprint if you need to see the *fading* color pattern more than one time to check the colors.

6.5.3. Use your EMS chart to help answer the questions below:

6.5.3.1 Are the color changes on the handprint in the same order as the visible colors on your chart?

6.5.3.2 What part of your hand in the sketch has a color associated with the MOST energy? Why?

7. Explore: Part II

Complete the set-up for your Atmosphere Model Chambers:

7.1. Equipment Manager: Check your **Atmosphere Model Chambers**. One chamber will serve as a ***Control*** and the other, an ***Experiment***.

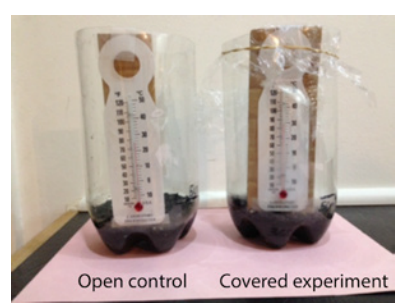
7.2. Leader: Read the activity directions and determine where the test bottles will be set up relative to the infrared fixture.

7.3. Group: Set up both **Atmosphere Model Chambers**:

7.3.1. Add 250 ml (1 cup) of moist soil to each chamber.

7.3.2. Check the temperatures on both thermometers. Keep thermometers in the shade and wait until both are the same temperature.

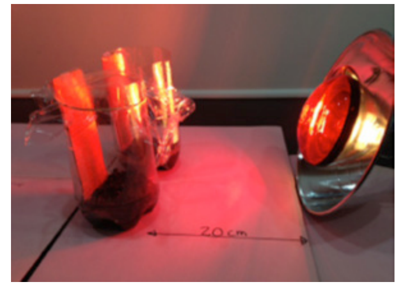
7.3.3. Tape the top of thermometers to the inside of the chambers at the top of the chamber, keeping the cardboard out of the moist soil.



7.3.4. Cover the **experiment** chamber with plastic wrap and secure the plastic with a rubber band. Your final set up should look like the above right image.

7.4. Equipment Manager: Place the chambers about 20 cm (8 in) from the light source. The bottles should be separated by 2 cm so as not to touch each other.

7.5. Make sure the test bottles are lined up so that the thermometer faces ***away*** from the lamp and the cardboard protects the thermometer from the direct heat of the lamp.



7.6. Recorder: Immediately record the **time** and **temperature** for each thermometer on your Data Sheet in the spot for "T=0." Ideally, the temperature values should be the same at the beginning. *Fill in the "Actual Temperature Read Times" on the DATA TABLE before starting*.

7.7. Timekeeper: Be prepared to record temperatures every 5 minutes for a maximum of 20 minutes during the Explore Part II activities.

7.8. Leader and Group: Check to see that your set-up looks like the image on the right, then ***turn on the heat lamp***. Caution: HOT!!

7.9. Every 5 minutes, record the time and two temperature values in your Data Sheet. Timekeeper and Recorder: Share data with other members of the team. Do you see any differences in the appearance of the two chambers? Write that in the observation column on your Data Sheet. Make sure each team member has completed the Data Table.

7.10. Equipment Manager: Turn off the infrared lamp at the end of 20 minutes of observation and recording time.

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8. Data Sheet

Complete in small groups.

Explore Part II DATA Table

Directions: Record the time on your watch or a clock and then add 5 minutes to each column on the left so you will know ahead of time when to read and record the next temperature values.

(A) is the time you begin your experiment. (A) + 5 minutes = (B) which is the time you make your next temperature reading. Your final read time at (E) should be 20 minutes after you started the experiment.

Actual Temperature Read Times	Experiment Time "T" (minutes)	CONTROL Temperature and Observations °F or °C	EXPERIMENT Temperature and Observations °F or °C
(A) Your watch/clock start time =	T = 0		
(A) + 5 minutes = (B)	T = 5		
(B) + 5 minutes = (C)	T = 10		
(C) + 5 minutes = (D)	T = 15		
(D) + 5 minutes = (E)	T = 20		

* Temperature difference between control and experiment is roughly 4–6 °F. Appearance of condensation in the covered chamber depends on how moist the soil is at the beginning of the experiment.

Questions:

8.1. Which bottle had the higher temperature at the end?

8.2. What difference did you observe in the appearance of the two bottles over time that might explain why one bottle had a higher temperature? Explain:

Elaborate — Thinking about the Greenhouse Effect and Global Warming

Watch the video: *Global Warming* (NASA): http://seti.org/ggtm

8.3. Discuss how science uses models to understand complex issues:

8.3.1. How well did our Atmosphere Model Chamber bottles function as a test for the greenhouse effect?

8.3.2. What was the greenhouse gas we studied?

8.3.3. In our model, what did the plastic wrap represent?

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8.3.4. In our model, what did the lamp represent?

8.3.5. Was this a good model for an atmosphere?

8.4. We can study one greenhouse gas and learn about other greenhouse gases:

8.4.1. This experiment studied water vapor, a greenhouse gas. Other greenhouse gases such as carbon dioxide and methane will be discussed in the next activity with respect to human control. How does water vapor differ from other greenhouse gases?

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

Now that you better understand greenhouse gases and the greenhouse effect, think about real atmospheric issues that are relevant to you on earth. In Activity #6, you will learn about global warming and you will develop your Air Care Team Action plan.

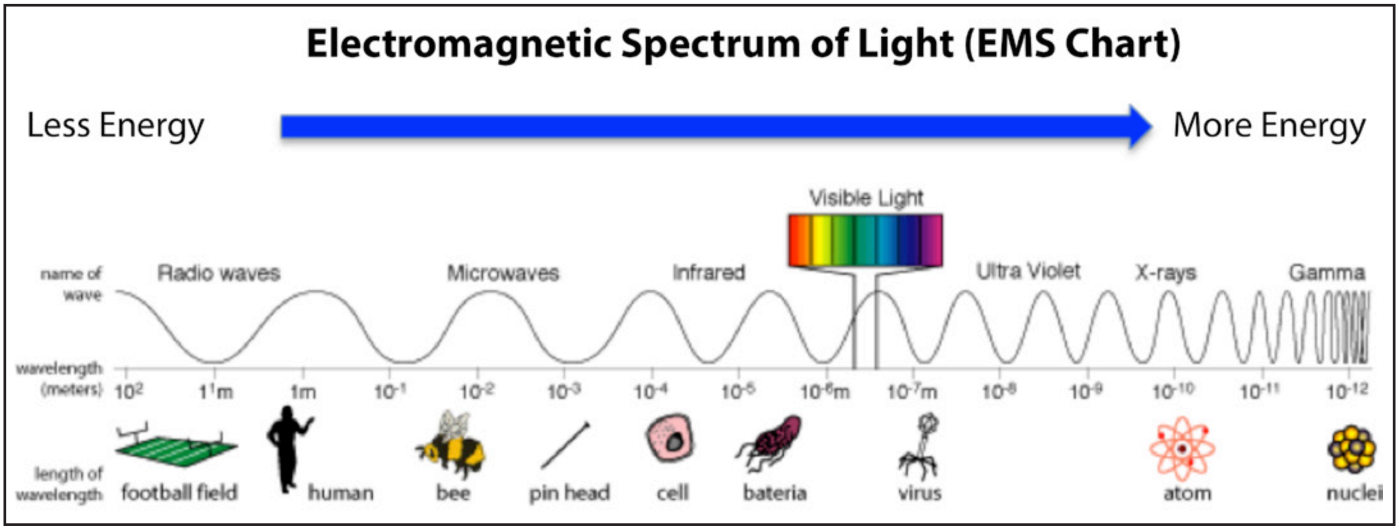

Image credit: NASA

The Greenhouse Gas Effect and Light Energy

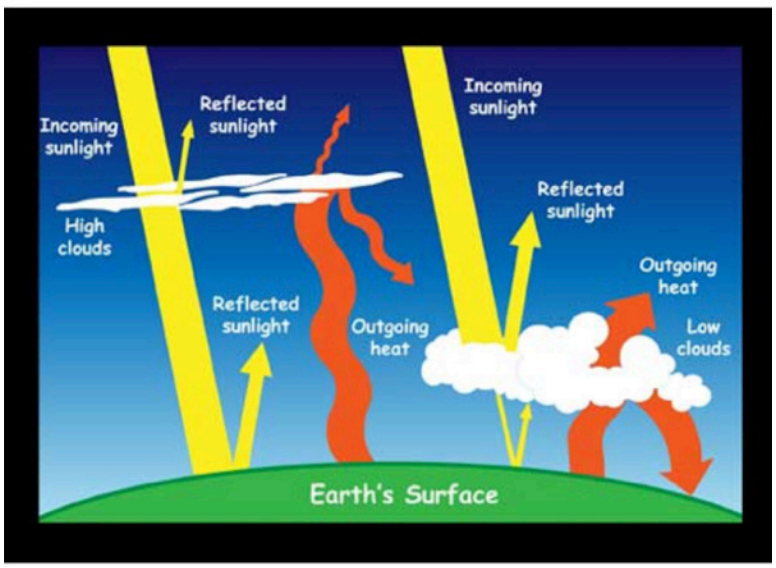

Image credit: NASA

Water in the atmosphere acts as a greenhouse gas. The atmosphere contains a lot of water. This water can be in the form of a gas — water vapor — or in the form of a liquid in clouds. Clouds are water vapor that has cooled and condensed back into tiny droplets of liquid water.

Earth's atmosphere acts like a greenhouse. During the day, the Sun shines through the atmosphere and the surface warms up in the sunlight. At night, Earth's surface cools and releases heat back into the air.

Some of the Sun's heat is trapped by the greenhouse gases such as carbon dioxide, water vapor, and other gases in the atmosphere. That's what keeps our Earth warm and cozy.

Note that two common gases making up Earth's atmosphere — nitrogen and oxygen — are NOT greenhouse gases.

Look at your Electromagnetic Spectrum (EMS chart) above to review infrared and visible light. A greenhouse gas is any gas which *transmits visible light but absorbs infrared light*.

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