Girls Go To Mars Overview
A Tale of Two Planets: Earth and Mars *[Adult]*

1. Introduction

"Girls Go to Mars" (GGTM) is a short series of investigative activities for Cadette Girl Scouts that begins with an overview of our inner Solar System; emphasizes the planetary histories of Venus, Earth, and Mars; and concludes with evidence for the greenhouse effect on Earth. The activities reflect the scientific goals of NASA's Mars Atmosphere and Volatile Evolution Mission (MAVEN), and were developed by the SETI Institute in collaboration with Girl Scouts of Northern California. The investigations engage the Cadettes' senses as they conduct collaborative hands-on experiments that utilize online NASA resources and integrate NASA's MAVEN discoveries about the atmosphere of Mars.

Cadettes simultaneously learn about new technologies and gain new knowledge as they explore career pathways and develop potential service projects linked to the Cadette leadership journey *Breathe: It's Your Planet — Love It!* Air Care Team Take Action Plan. Upon completion, the Girls Go To Mars event patch (as shown in upper right corner) is available through Girl Scouts of Northern California.

2. General Description of the MAVEN Project

On November 18, 2013, an Atlas V vehicle lifted off at Cape Canaveral Air Force Station in Florida and sent the MAVEN spacecraft on its way to study Mars' upper atmosphere. Scientists expect that data gathered during the MAVEN mission will help explain how Mars' climate changed long ago due to the loss of atmospheric gases. The spacecraft arrived at Mars on September 21, 2014, and is gathering information until the mission ends in April 2016. MAVEN can be found on social media via MAVEN2Mars on Facebook and Twitter. The mission websites provide mission details, status updates and multimedia files. View the mission page: http://tinyurl.com/cfzbfxo and the NASA MAVEN page: http://tinyurl.com/chucl8r. (Adapted from *MAVEN Mission Facts and Stats*: http://tinyurl.com/mnmwurz)

3. Overarching Science Questions and Background Information for Leaders

3.1. Why is Mars so cold and dry and Earth, warm and wet?

Around 3.8 billion years ago, Mars likely had a similar climate to Earth's. Today, Mars is a cold and barren desert world. However, when Mars was young, it appears to have had a thick atmosphere, warm enough to support oceans of liquid water. NASA has prepared a new video to illustrate the MAVEN mission's investigation of dramatic climate change on Mars. This video is an artist's concept that shows the transition from an ancient, habitable Mars capable of supporting liquid water on its surface to the cold desert world of today. View video *Maven Mars Evolution* (NASA): http://www.seti.org/ggtm

3.2. Why is Mars' size important? There are several reasons.

3.2.1. Loss of heat:

Planets change throughout time. Like all planets, Mars and Earth were heated as they formed from the radioactive decay of elements and from the constant pummeling by impacts from space during formation.

Soon after the planets formed, they began a process of reorganizing. Their interiors either melted or partially melted. Denser elements like iron and iron-rich compounds sank to the interior and the least dense materials formed the crust.

However, Mars and Earth did not change at the same rate; large rocky planets cool more slowly than small planets. While heat is held in the volume of a planet, it is lost through its surface area. Smaller planets — for example Mars — have a larger surface area-to-volume ratio, which means that Mars would cool more quickly than Earth. Think about leaving a small cup of hot tea on the counter versus a one-gallon bucket of water, both at the same initial temperature. When you return 10 minutes later, which container will have the warmest water?

View the image below for a comparison of the volume to surface areas of Earth, Mars, and our Moon.

3.2.2. Core cooling changes the surface landscape and ultimately impacts the atmosphere:

As long as the iron core remained fluid, and the mantle remained extremely hot, Mars probably had a magnetic field as Earth does today. For the most part, Earth's mantle stays in solid form because the pressure deep inside the planet is so great that the material can't melt. In certain circumstances, however, the mantle material does melt, forming magma that makes its way through the outer crust.

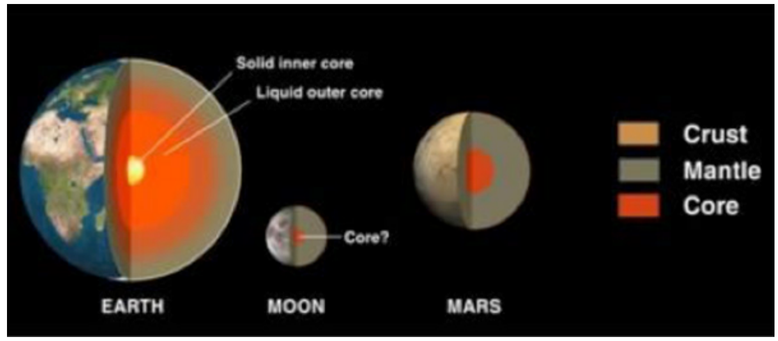

Image credit: Lunar and Planetary Institute

However, millions of years ago on Mars — *which is smaller than Earth* — both the mantle and core cooled enough so that its global magnetic field and volcanic activity disappeared.

Today Mars has only a disorganized magnetic field detected in rocks, and has no active volcanoes — important differences between Mars and Earth.

The release of gases due to volcanic activity is vital to the atmosphere.

To understand the comparison between Mars and Earth, and the impact of Mars' cooler core, watch the *Olympus Mons on Mars* (BBC) video at http://www.seti.org/ggtm

3.3. Why is an atmosphere important to a planet? Sustaining liquid water is one reason.

To have liquid water on its surface, Mars must have had a thick atmosphere with a lot of greenhouse gases that kept it warm (the greenhouse effect), such as carbon dioxide, water, and molecular hydrogen. On Earth, greenhouse gases (carbon dioxide and water vapor, to name two) in our atmosphere keep us at a reasonable temperature. What happened to Mars' atmosphere and its greenhouse gases? Where did the surface water go? Scientists aren't sure, but they do have some ideas.

This split panel image compares a section of Arizona's Grand Canyon (left) to a section of Mars' Nanedi Valles (right). The northern part of the Nanedi Valles image shows that a river once cut through it, similar to the one flowing through the Grand Canyon.

The average width of the Grand Canyon is 16 km (10 mi). Although this section of Nanedi Valles is nearly 2.5 km (1.55 mi) in width, other portions are at least twice as wide. Slight differences in shape between the two canyons are attributable to the great age differences between the regions and the correspondingly higher degree of erosion on Mars.

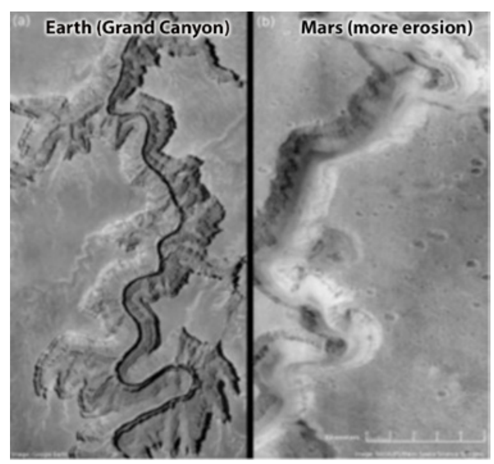

Image credit: Pennsylvania State University

Somewhere around 3.8 billion years ago, Mars' atmosphere started to change. To search for clues, scientists often compare what ancient Earth and Mars looked like to give them ideas as to what might have happened on Mars.

3.4. Exploring these differences is linked to understanding planetary atmospheres and the greenhouse effect on Earth, and guides the science and content of the activities in *Girls Go To Mars*:

3.4.1. Distance from the Sun: **Mars** is farther from the Sun than **Earth**. The farther a planet is from the Sun, the less energy it will receive. The Sun's solar wind, composed of super-hot gases streaming from its surface, also attacks a planet's atmosphere. The closer a planet is to the Sun, the more vulnerable it becomes to the solar wind.

3.4.2. Magnetic Field: The flow of a liquid iron core generates electric currents, which in turn produces magnetic fields. **Earth** has a magnetic field produced by a molten iron core. It's as though there is a giant magnet inside of the **Earth**, and the reason we can use a compass is because the dial in your compass lines up with **Earth**'s magnetic field. **Earth**'s magnetic field protects our planet's surface and atmosphere from the Sun's solar wind. Watch the video *Death of a Planet* (BBC): http://www.seti.org/ggtm

Mars had a magnetic field about 4.1 billion years ago, but something happened that made the magnetic field shut off. While **Mars** probably had molten iron in its core, it likely stopped flowing as **Mars** cooled down. Now **Mars** does not have a global magnetic field like Earth's.

One of the goals of MAVEN is to explore the role of the solar wind and its likely impact on **Mars'** once more-robust atmosphere.

3.4.3. Gravity: Gravity is a force of attraction that acts between all objects with mass, including atmospheric gases and planets. If a planet has less mass, there is less gravity, and it's harder for that planet to hold on to its atmosphere.

While **Mars** once had a lot more atmosphere, **Mars** doesn't have as much gravity as **Earth. Earth** has about 9 times the mass of **Mars.** When a comet or meteorite hits a planet, it splashes into the atmosphere like a rock dropped into water. If you had a big splash from a big meteorite, some atmosphere could have escaped **Mars'** low gravity. Low gravity also makes it easier for the solar wind to carry away smaller, lighter particles and atmospheric gases, including important greenhouse gases.

3.5. What are some questions the MAVEN Mission attempts to address?

- What happened to Mars' atmosphere?
- How did the solar wind affect the atmosphere?
- What is the history of liquid water on ancient Mars?

4. How will Girls Go To Mars connect with the MAVEN Mission?

4.1. Girls GoTo Mars will:

- build on existing Girl Scout science, technology, engineering, and math (STEM) by focusing on the theme of Mars exploration and the MAVEN Mission;
- enhance Girl Scout programs designed to increase Cadettes' and adults' understanding of and interest in Solar System exploration in general, and of Mars specifically; and
- expose girls to space science careers.

4.2. Links between the planetary history of Mars and Earth, and MAVEN.
In a series of interrelated activities, girls will explore the following questions:

- What are the present atmospheric properties of Venus, Earth, and Mars?
- What makes Earth so heavenly, Mars so cold, and Venus so hot?
- When we can't go "there," what types of evidence do scientists study to learn about a planet's atmosphere?

- What evidence indicates that the atmospheres of Mars and Earth were different in the past?
- What forces contribute to change in atmospheric composition and pressure?

4.3. The Cadettes will learn by hands-on experiments about the nature of scientific processes and examine evidence that scientists use to compare and contrast Mars' and Earth's atmospheres. During guided investigations, the girls will explore planetary atmospheric properties such as pressure and composition, magnetic fields, surface physical features, size, and location in our Solar System. Furthermore, scientists in videos who serve as role models and experts will guide the girls in interpreting these physical properties that are linked to the history of a planet's evolution.

4.4. In the final investigation, the Cadettes will demonstrate their growing knowledge about Earth's atmosphere and the nature of scientific investigation. They will conduct an investigation on the greenhouse effect, then in a connected activity collaborate on a project aligned with *Breathe. It's Your Planet — Love It!* leadership journey.

5. Girls Go To Mars: A Series of Investigations for Cadettes

Overview of Activities:

Overarching goal for GGTM: Think like a scientist. Be a scientist!

5.1. Activity #1. *The Goldilocks Question: Just Right, Too Cold, or Too Hot?*

Solar System Orientation and Scale: This whole-group activity provides a general introduction to all the planets in the inner solar system with a focus on interpreting the importance of the mass and location of Venus, Earth, and Mars relative to the Sun. A planet's features and temperature are significantly influenced by a variety of interrelated factors: distance from the Sun, amount of solar radiation reaching the surface, mass, and the presence of an atmosphere.

Big Picture Objectives: Cadettes will learn how some planetary features such as surface temperature can be determined by size, location in space, and atmospheric properties by comparing Venus, Earth, and Mars.

In this activity, Cadettes are introduced to a recurring theme: scientists investigate processes that cannot be directly observed through the use of models. Models can be built to scale out of common materials with evidence gathered from spacecraft images and tested to see how well that model explains a phenomenon. This process leads to discussions about the limitations of models, their usefulness when dealing with objects very far away, and at the same time, reflects one aspect of how science goes forward.

5.2. Activity #2. *It's All About the Atmosphere*

This small-group activity introduces an additional planetary feature — atmospheric pressure — by comparing density of the atmospheres. The planets' surface temperatures, atmospheric pressure, and their relative abilities to retain smaller, lighter molecules such as water on the surface are discussed.

Big Picture Objectives: Using a visual model, Cadettes will discover that Venus, Earth, and Mars have different atmospheric pressures. In the case of low pressure, Cadettes will speculate that small molecules will be able to more easily escape the atmosphere, and that fact combined with reduced sunlight to the surface will most likely produce a colder planetary environment.

This activity sets the stage for understanding one of the key factors of this program: the development of a planet's atmosphere and the forces that might cause an atmosphere to change. Evidence for these ongoing forces is currently being studied by the MAVEN mission and will be explored by Cadettes in Activities #3 and #4. Other forces for atmospheric change on Earth will be investigated in an experiment in Activity #5 *The Greenhouse Effect*.

Again, in this activity, Cadettes visit the recurring theme that scientists investigate processes though the use of models that cannot be directly observed. Models can be built to scale out of common materials with evidence gathered from spacecraft images and tested to see how well that model explains a phenomenon. This leads to discussions about the limitations of models, their usefulness when dealing with objects very far away and at the same time, reflects one aspect of how science goes forward.

Big Picture Objective: Cadettes will construct models to test ideas about objects or processes that cannot be directly studied.

Activity #2.Extension. ***Women in STEM***

Small groups of girls explore NASA careers and role models via the internet. This activity may be completed at any time. Since Activity #2 takes the least amount of time, Women in STEM can be completed in a single meeting.

Big Picture Objectives: Cadettes will explore their own perceptions of scientists and successful career pathways of women in STEM.

5.3. Activity #3. *How Do Atmospheres Change Over Time? The Role of Magnetosphere and Solar Wind*

This small-group activity introduces one of several ways that an atmosphere can lose gases, and links directly to the goals and objectives of the MAVEN mission. Girls observe the properties of magnets and magnetic fields as they build a model of Mars and Earth to demonstrate that Mars cannot effectively protect its atmosphere from the Sun's hot solar wind.

Big Picture Objectives: Using skills they previously learned about with the use of models, Cadettes compare the planetary size and add new information about the magnetic fields of Mars and Earth to ask questions about the force of the solar wind to change a planet's atmosphere over time.

5.4. Activity #4. *Evidence for Atmosphere on Mars Over Time: Water Surface Features*

Spacecraft images from several regions of Mars show evidence of ancient water flows. This small-group activity directs girls to compare select images of Mars and Earth water erosion surface features and then to construct, test, and observe a model of flowing water for similar erosion patterns. Evidence for once-flowing water on ancient Mars means that Mars also had a thicker atmosphere and a warmer climate reminiscent of Earth's, providing evidence for a change in Mars' atmosphere over a very long period of time. What happened to Mars' atmosphere? The MAVEN Mission is looking for some of the answers.

Big Picture Objectives: Science is about asking questions, collecting data and using evidence to answer questions. Cadettes will rely on laboratory experiments and modeling to better understand and test their ideas about whether ancient Mars had flowing water and an atmosphere.

5.5. Activity #5. *How Do Atmospheres Change Over Time? The Greenhouse Effect*

This small-group activity demonstrates how the atmospheric temperature increases with the build-up of one greenhouse gas and directly links to Activity #6 Steps Along the Journey: Global Warming. Cadettes construct a physical model of the atmosphere using familiar materials. They discover that when exposed to infrared light, heat builds up more in a closed than in an open container containing moist soil. The information gathered from this experiment is concretely linked to global warming in the final activity. Global warming is the rise in the average temperature of Earth's atmosphere and oceans over time.

Big Picture Objectives: Cadettes construct models to test ideas about processes that cannot be directly studied on Earth or Mars. Cadettes use skills they have learned about atmospheric composition and apply that knowledge to new situations.

5.6. Activity #6. *Summative Activity — Steps Along the Journey: Global Warming*

This activity focuses on atmospheric change over time, linking the scientific understanding of forces that lead to change and the evidence supporting such changes that have occurred in the Earth's atmosphere due to the introduction of greenhouse gases, with a focus on carbon dioxide rather than water vapor.

Completion of this activity meets some of the steps along the leadership journey of *Breathe. It's Your Planet — Love It!*, "How to Guide Girl Scout Cadettes on *Breathe: It's Your Planet — Love It!* A Leadership Journey": http://tinyurl.com/oznhwyh

Big Picture Objectives: Cadettes use skills they have learned and apply them to new situations. Cadettes decide what topic(s) they want to explore and how they want to go about doing them.

Activity #1
The Goldilocks Question: Just Right, Too Cold, or Too Hot? Scale Model of the Inner Solar System *[Adult]*

Adapted from *The Earth As A Peppercorn*: http://tinyurl.com/2ooch5 Guy Ottewell, NOAO.
Unless otherwise noted, all images are courtesy of SETI Institute.

1. Introduction

In this activity, you will "Think like a scientist!"

Scientists construct 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.

2. Science Objectives

Cadettes will learn how a planetary feature such as surface temperature can be determined by size and location in space by comparing Venus, Earth, and Mars.

In this activity, Cadettes are also introduced to a recurring theme that scientists investigate processes that cannot be directly observed though the use of models. Models can be built to scale out of common materials, with evidence gathered from spacecraft images, and tested to see how well that model explains a phenomenon. This process leads to discussions about the limitations of models, their usefulness when dealing with objects very far away, and at the same time, reflects one aspect of how science goes forward.

3. Materials

- [2] dolls or action figures of different sizes (i.e., different scales)
- Sun: any ball, diameter 20 cm (about 8 in), for instance, a soccer ball
- Index cards
- Mercury: a pin point
- Venus: a peppercorn, diameter 0.20 cm (0.08 in)
- Earth: a second peppercorn
- Mars: a pinhead, diameter 0.08 cm (0.03 in)

Outer planets are optional, but recommended:

- Jupiter: a chestnut or a puff ball, diameter 2.3 cm (0.90 in)
- Saturn: a hazelnut, acorn, or a puff ball, diameter 1.8 cm (0.70 in)
- Uranus: a wooden or plastic bead, diameter 0.76 cm (0.30 in)
- Neptune: a second wooden or plastic bead, diameter 0.76 cm (0.30 in)
- Pluto: a third pin point (or smaller, as Pluto is the smallest on the list)
- [2] balls: a large ball and a ball approximately half the diameter of the large ball

Advance Preparation

a. Glue planets to index cards and label. Alternate set-up: for planets other than Mercury, Mars, and Pluto, use a marker to draw a spot on a card for each planet in the size specified.

b. Place the planets in a small box or bag.

c. Refer to *The Earth as a Peppercorn* Activity Instructions: http://tinyurl.com/2ooch5

d. Experiencing the entire solar system model is an eye- and mind-opening experience. At a minimum, the Sun and inner planets must be modeled to set the stage for the Girls Go To Mars Activities #2–5. The inner planets can be modeled in a large room or in a hallway, with reference made to the location of the outer planets (e.g., across the parking lot, in the next building, at the stoplight). The activity was written before Pluto was determined to be a dwarf planet. Pluto remains a favorite planet of many people.

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4. Leader Will Lead Large Group

4.1. Using the dolls/action figures, explain that each doll is a "model" human, to scale. The parts of a model are to the same scale. In this case, the model is smaller than actual, all parts and lengths are in proportion.

4.2. Ask the following questions:

4.2.1. Why would scientists use smaller models?

To examine very large systems like the solar system.

4.2.2. Why would scientists use models that are larger than actual?

To investigate or explain miniscule objects like molecules or DNA.

4.2.3. Would the shoes (pants, shirt, etc.) of model A fit model B?

No, they would not be to the same scale.

4.3. Explain that the solar system model will have the objects and distances to the same scale.

4.4. The soccer ball is the Sun. Ask all in the group to show using their hands and fingers, the size of the Earth compared to the ball. After checking with everyone, take out model Earth. Explain the size difference between Earth and the Sun.

4.5. Ask everyone to use their hands to show how far the Earth is from the Sun in the model. After checking everyone, tell them they will explore that by walking.

4.6. Line up the group and take 10 giant steps from the Sun (at a wall, or the starting point outside). This is Mercury's location! Proceed through all of the planets through Mars at a minimum.

Scale Model Steps Between Objects

Sun/Planet	Giant Steps to Next Object	Total Distance
Sun	0	—
Mercury	10	—
Venus	18	—
Earth	25	—
Mars	38	—
Subtotal: Inner Solar System	**91**	**91 m (.05 mi)**
Jupiter	130	—
Saturn	238	—
Uranus	478	—
Neptune	749	—
Pluto	983	—
Total Steps	**2,669**	**1 km (0.6 mi)**

4.7. Ask the following questions:

4.7.1. What was surprising?

Answers vary.

4.7.2. What did you learn?

Answers vary.

4.7.3. What aspects of this model are accurate?

The distances in between the planets are proportional to the planet sizes; the planets and distances are the correct size.

4.7.4. What aspects of this model are inaccurate?

The planets are always moving in their orbits around the Sun. The planets are not in a straight line.

4.7.5. Why are models important to scientists?

They aid in understanding relationships and concepts.

4.8. Conclude by showing the Earth and Mars models (two balls).

4.9. Ask "If the large ball is Earth, which planet is the smaller ball?"

Mars.

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

Inform the Cadettes that the temperatures of the atmosphere on Earth and Mars are related to the planets' sizes and distances from the Sun. The difference in size is important to recall in later activities. Have Earth and Mars on display during the later activities.

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

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.

- [3] quart-sized Ziploc® bags
- [4] cups plus [2] teaspoons clean sand
- clear tape
- marker

Advance Preparation

Leaders or Cadettes with adult supervision:

a. Prepare 3 bags for each group

b. Label each bag by planet name.

c. Add the amounts of sand listed below for Venus, Earth, and Mars:

Venus 1000 mL (4 cups, about 200 teaspoons)

Earth 10 mL (2 teaspoons)

Mars 0.1 mL (tiny pinch, a few grains)

d. Fill Earth and Mars bags with air by almost completely sealing the bags and blowing into the bags, then quickly finish sealing the bags. Tape the bags closed.

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?

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?

Venus

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

Mars

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

Venus

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

Mars

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?

Mercury

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

Venus

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

Mars

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.

Venus is hotter than Mercury even though it is farther away from the Sun and receives less energy from the Sun. The density of the atmosphere plays a role in keeping Venus so hot.

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 #2 Extension
Women in STEM *[Adult]*

1. Introduction

In this activity, you will explore career opportunities in science, technology, engineering, and math (STEM).

2. Science Objectives

2.1. Explore Part I challenges Cadettes' stereotypical perceptions of scientists and encourages them to discuss their biases. When asked to draw a scientist, children as young as five years old will produce pictures that are not kindergartners like themselves.

2.2. Explore Part II guides Cadettes in an investigation that provides profiles of successful women in STEM careers.

3. Materials

For each Cadette.

- Laptops, desktop computer, or tablets with access to the internet — can be shared
- [2] sheets of plain white paper
- *Draw a Scientist Check Sheet* of characteristics (page 3)
- Box of colored pencils or crayons (one per group of 3 or 4 Cadettes)
- Roll of tape to post Cadette drawings on wall for discussion

4. Get Ready

What does a scientist look like?

Ask the Cadettes if they can come up with a few observations about what they think scientists look like. At this time just listen and make no effort to be inclusive about gender or ethnic groups.

5. Explore Part I

5.1. Hand out a sheet of plain white paper to each Cadette.

5.2. Direct the Cadettes to close their eyes and imagine a scientist at work and to draw what they see. If time permits, they can also write a brief description of their scientist. Provide crayons or colored pencils as needed.

5.3. Allow about 20 minutes for descriptions and drawings.

5.4. After the Cadettes have finished their drawings, hand each one a copy of the *Draw a Scientist Check Sheet* (page 3). Allow 5 minutes for the Cadettes to evaluate their drawing using the check sheet.

The check sheet will show many common features such as old, white male, frizzy hair, glasses, lab coat, weird, explosive chemicals, solitary, working with test tubes, machines, wild writing.

5.5. Ask the Cadettes to compare their pictures' features using their check sheet. Do you see some common features checked on many of the lists? List some of those features.

5.6. Have the Cadettes look around the room at their friends' drawings. Does the scientist you drew look like your fellow Cadettes'?

5.7. Ask the Cadettes to post their pictures on the wall with tape.

5.8. Show video: [*Girl Scouts: What does a scientist look like?* (Girl Scouts): http://seti.org/ggtm](http://seti.org/ggtm)

6. Explore Part II: Women in STEM and in the Fields of Planetary Science and Astronomy

6.1. Ask the Cadettes to review the [Women@ NASA website, http://women.nasa.gov/](http://women.nasa.gov/) and to select one Woman in STEM to investigate. Investigate by reading the short bio and personal story, and viewing the video available for each woman by clicking on the image.

6.2. Using the second sheet of paper, Cadettes collect STEM career details such as related job titles, job description, areas of expertise/abilities, personal interests/story, school subjects/courses, education, and training needed. In small groups, share what they have learned about Women in STEM, and draw pictures of their selected Woman in STEM.

6.3. Replace the first drawings with new drawings. Look around the room again at your friends' pictures. Do the Women in STEM look like your fellow Cadettes'?

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

Identify two experts that can guide you to greater air awareness. Women at NASA can be contacted via their email addresses in the [NASA Directory; https://people.nasa.gov/](https://people.nasa.gov/). See page 103 in *Breathe. It's Your Planet — Love It!*

Activity #2 Extension: *Draw a Scientist Check Sheet*

Directions: Use this Check Sheet to score your drawing of a scientist.

Please put a ✔ mark by the words that are true for your scientist.

Characteristic	Description				
Personality	scary	friendly	nerdy	quiet	can’t tell
Hair	long	short	frizzy-wild	spiky	can’t tell
Gender	male	female			can’t tell
Appearance	wears lab coat	pens/pencils in pocket	wears dress/skirt	wears eyeglasses	facial hair
Location	indoors	lab	outdoors		can’t tell
Equipment	using test tubes	near a computer	using charts	near chalk board	books & filing cabinet
Experiments	near plants	near animals	with explosions	using numbers	near other people
Words on Drawing	“mad”	“weird”	symbols for: bubbles & gases	symbols for: noises!!!	write in your own:

Write a ONE-sentence brief summary of your drawing of a scientist from the characteristics summarized above:

Activity #3
How Do Atmospheres Change Over Time? The Role of Magnetosphere and Solar Wind *[Adult]*

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. Prepare materials for each team.

- [1] file or copier paper box lid
- [2] pieces of plain white copy paper to line inside of lid
- [1] 5.1 cm (2 in) diameter paper cup cut off about 1.25 cm (0.50 in) to simulate "Mars." Martian diameter is 52% of Earth's.
- [1] 8.9 to 10.2 cm (3.5 to 4 in) diameter lid or bottom of oatmeal container sufficient to cover 7.6 cm (3 in) bar magnet to simulate "Earth" (see image in Cadette Activity)
- Magnets: 7.6 cm (3 in) bar magnet (Do not use neodymium or rare earth magnets. Handle with care — don't drop or bump.); view bar magnets on Amazon.com: http://tinyurl.com/kjyfa85
- [1] small piece of flexible magnetic sheet (use free advertisements, calendars that are attracted to metallic surfaces); view flexible magnetic sheet on Amazon.com: http://tinyurl.com/lwkrsb3
- iron filings in "salt" shaker container; view iron filings on Amazon.com: http://tinyurl.com/lo832wk
- RSVP 12-piece mini salt and pepper shaker set with rack (for iron filings); view mini shaker set on Amazon.com: http://tinyurl.com/m275z7h. Use one shaker for each group.
- 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)
- transparent tape for wrapping bar magnets
- 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.***

Advance Preparation

a. Wrap, trim, and tape plastic wrap or baggie to cover bar magnets to simplify cleaning the iron filings from the magnets at the end of the experiment.

b. Cut off about 1.3 cm (0.50 in) of the bottom of a 2.5 cm (1 in) diameter paper or plastic cup. Label: **Mars.**

c. Cut off about 1.3 cm (0.50 in) of the bottom of a cardboard oatmeal container or lid. Label: **Earth.**

d. Cut several pea-sized or small pieces of flexible magnetic material from the magnet sheet.

e. Using a pencil, poke a straw-sized hole in the short end of the box lid to accommodate the straw.

f. Fill as many of the mini-shakers as you need with the iron filings. Use a funnel made from paper or plastic if handy to help transfer the filings. Iron filings are a mechanical irritant and should be handled carefully.

g. After you fill the mini-shakers with iron filings, cut a 5 x 5 cm (1.2 x 1.2 in) square of plastic from a Ziploc® bag. Using a pen, poke a hole all the way through the plastic and place it over the opening to the glass shaker and then tightly screw the lid on. The purpose of the plastic is to act as a flow restrictor to the tiny iron filings — otherwise you will have a mess!

h. Optional: assign jobs from "Cooperative Group Responsibilities" (see separate pdf document).

5. Preparation for Activity #3

5.1. Read together *Background Escape of the Atmospheres!* (see page 7) Discuss and answer the following about the images:

5.1.1. Which molecule would more easily escape? Why?

Molecule #1, hydrogen, because it is the smallest/lightest; and gravity is less effective.

5.1.2. Which planet do you think has greater mass? Which planet holds onto an atmosphere more easily?

Based on the image, Earth is larger, therefore has more mass. Based on gravity, Earth would have an easier job of holding onto its atmosphere.

5.1.3. Which planet is least likely to have an atmosphere? Are you surprised that the answer is NOT Venus? Why?

From the information provided in the table and the paragraph, Venus has the highest temperature and is closest to our Sun of the three planets listed. However, Venus has a dense atmosphere now and Mars has a very thin atmosphere. More factors must be involved than distance from the Sun and temperature.

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

Mars' magnetosphere is relatively ineffective compared to Earth's and therefore is not able to protect the Martian atmosphere.

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

Video Note: This video shows how scientists are using their understanding of solar wind and Mars' distance from the Sun to learn about the history of Mars' atmosphere. Earth's magnetic field is vital for keeping our atmosphere in place. Without a strong magnetosphere, about a third of Mars' atmosphere has been stripped away by the solar wind.

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.**

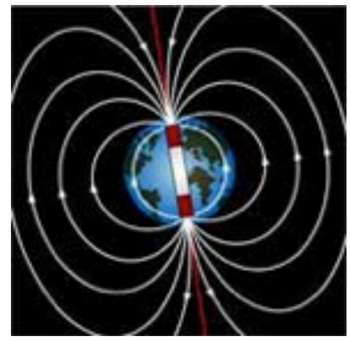


Image credit: NASA

6.2.2. On your sketch, **mark** where the magnet is strongest.

Lines should be close together near the magnet.

6.2.3. Compare the bar magnet lines and the image of Earth (second from top), demonstrating magnetic field lines in the north and south directions.

Does the image look similar to your sketch?

Yes.

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 second image from bottom).

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 bottom 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"?

"Solar wind" (i.e., hole punches) were deflected away from the model Earth.

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

If the Cadettes blew gently the filings were not disturbed.

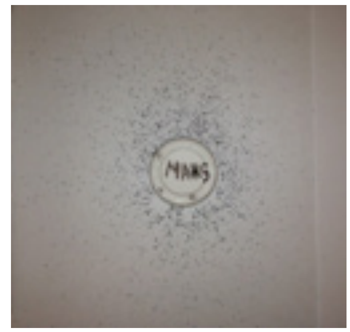
6.5.3. Make a brief sketch on your Data Sheet page of the iron filings and hole punches after the "solar wind."

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 top 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.

Mars' pattern will not look like Earth's. The small pea-sized magnets will have a disorganized pattern and will not demonstrate the magnetic field lines observed with the bar magnet.



6.9. Leave the iron filings in place. Cover the flexible magnets with the labeled Mars model (see second image from top).

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.

With the disorganized magnetic field lines, the hole punches should travel directly into Mars' model and not be deflected by the iron filings.

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

Iron filings will be more easily disrupted by the hole punches.

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

Mars' magnetosphere does not appear to have an organized global magnetic field but has many random less effective surface magnetic fields.

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?

Check Cadette outcomes.

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?

Hole punches were not deflected by the iron filings which were also moved.

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

Mars' magnetosphere appears weak when compared to Earth's because the hole punches and breath moved the filings.

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

No.

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

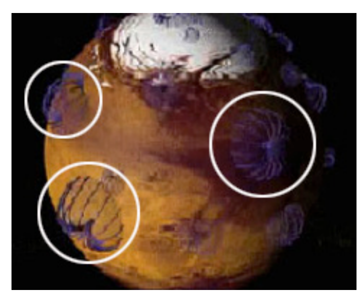


Image credit: NASA JPL

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	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?

A magnetosphere acts as a shield to keep the solar wind from damaging the atmosphere by stripping away some of the gas molecules.

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?

Solar wind can be deflected by the magnetosphere. If the magnetosphere is weak, then the solar wind can strip away parts of the atmosphere.

8.3. Can an atmosphere be changed by the solar wind?

Yes.

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!*

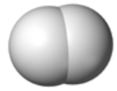
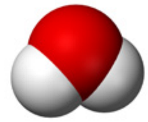
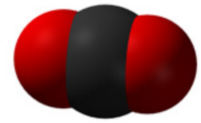
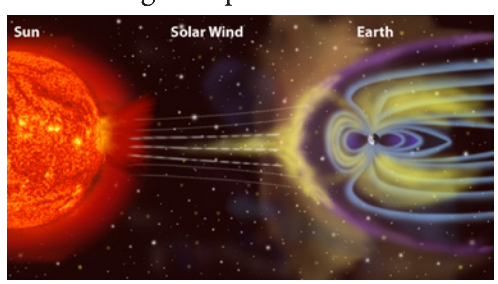
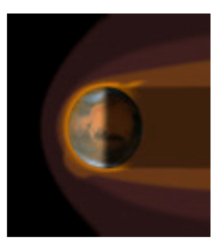
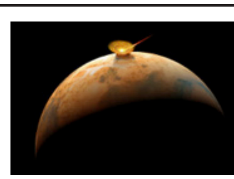
<table>
<tr><th>Why do gases leave the scene?</th><th>Evidence</th></tr>
<tr><td>a. Atmosphere composition:
Some molecules of gas are small and light-weight, and they can more easily get away.
Which molecule would most easily escape?</td><td> #1 hydrogen
 #2 water
 #3 carbon dioxide</td></tr>
<tr><td>b. 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.”</td><td>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
</td></tr>
<tr><td>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.</td><td>Which planet is least likely to have an atmosphere?**
<table>
<tr><th>Planet</th><th>Distance from Sun</th><th>High Surface Temp.</th></tr>
<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>
</table>
** Predict: Venus. Evidence shows Mars has very little atmosphere. Clearly factors other than distance are involved too.</td></tr>
<tr><td>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?</td><td>Earth’s Magnetosphere and Solar Wind (drawing)


Image credit: NASA

Artist’s conception of Mars’ magnetosphere
Image credit: ESA</td></tr>
<tr><td>Other Factors:
Planets lose atmosphere to meteorite impacts and to the capture of gas molecules into rocks.</td><td>
Meteorite impact on Mars (artist’s conception)
Image credit: NASA</td></tr>
</table>

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

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. Direct the Cadettes to find materials.

- [1] solid plastic growing tray (no holes), 28 x 53 x 6 cm (11 x 21 x 2.5 in) lined with a lightweight plastic sheet such as a paint drop cloth. Trays can be ordered from Amazon.com or found in local hardware stores. This will be your model **Stream Table**. Requires advance preparation, see page 2.
- heterogeneous sand, includes fine-grained sand and some fine-grained soil, to cover surface of tray to a depth of 1 cm (0.4 in) or sufficient to smooth out any patterns in the bottom of the tray, plus additional heterogeneous sand to place on top of the plastic sheet to a depth of 3 cm (1.75 in) covering ⅓ of the length of the tray.
- [1] conglomerate rock (purchased or collected as local laws permit); view on carolina.com: http://tinyurl.com/kmcp7wo. **Note:** conglomerate rocks may also be collected along stream beds or near coastlines — be sure to check with local regulations before removing materials (see photo on page 7).
- [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)
- set of images: Mars and Earth (print from materials provided)
- newspapers to place under tray and bucket (for cleanup)
- (optional) latex gloves (caution: check for allergies), sponges, rags, and brooms

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.

Advance Preparation

Sand layer preparation of tray

Final Tray Set up

a. If your pans have a pattern in the bottom, prepare the Stream Table: even out the surface with a thin layer of sand approximately 1 cm (0.4 in) deep before you lay the plastic cover over the top of this sand later.

b. Use a pair of scissors and make a straw-sized water drain hole in the short side in the middle of the bottom edge of the tray.

c. Cut a piece of thin plastic sheet several centimeters larger than the outside measurements of the tray. Lay the plastic over the thin layer of sand and make a hole in the plastic so that it lines up with the drain hole in the tray.

d. Add 3 cm (1.2 in) of ***very damp*** mixed fine-grained sand and fill ***no more*** than ⅓ the length of the tray away from the hole.

e. TEST: Make sure the drain and plastic liner holes line up and that the excess water from the runoff will flow into the catch bucket on the floor.

f. Use a serrated knife to slice several thin sections of florist foam so that Cadettes can adjust the tray to a slope of 10 degrees by placing the foam blocks under the end with the wet sand.

g. Optional: assign jobs from "Cooperative Group Responsibilities" (see separate pdf document).

5. Preparation for Activity #4

5.1. Read together *Background Evidence for an Atmosphere Over Time: Water Erosion* (see page 7)**.** Discuss and answer the following about the images:

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

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

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

Wind erosion often involves the movement of smaller particles.

Dunes are formed, and there is an absence of channels.

5.1.3. 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.

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

The appearances of the congromerate rocks on Earth and Mars are strikingly similar. The process involved in producing that type of rock on Earth involves swiftly moving water and, by analogy, suggests that Mars likely had sustained flowing water as well.

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

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

Scientists can use what they understand about the erosion processes on Earth to better explain what might have happened on a far-away planet like Mars. Scientists can also experiment with how alluvial fans are formed on Earth.

5.3. 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.

5.3.1. 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?

Moving water erodes the surface of planets by carrying solid material. Cadettes should feel the particles of sand moving and pushing against their fingers, imagining how the process might alter the planetary surface.

6. Go and Explore

6.1. 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.

6.2. 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.

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

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

6.4. **Group takes turns for steps 6.4–6.6:** 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.

6.5. 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?

No

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

Depending upon where Cadettes pour the water (in one place or across the entire end of the pan), shallow channels form and the particles travel from the top towards the open bottom area. Smaller particles typically move faster down the channel.

6.5.2. What types of surface features did you observe?

Slowly flowing water produces more meandering channels that are easily diverted by small rocks and other obstacles. Multiple small channels may appear.

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

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

Old channels are altered and incorporated into one newly formed deep channel. Small particles move down stream and into the open area of the Stream Table.

6.6.2. 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.)

One or more alluvial fans are observed in the video and in background images on pages 7-8.

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

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

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

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

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

Rocks divert the flow of water, creating new channels and slowing the particles down.

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

Varies with set-up.

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

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

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

6.8.2. Add the rock(s) as planned.

6.8.3. Sketch the Stream Table.

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

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

7. Cleanup

Everyone participates in cleanup.

7.1. Follow your adult leaders' directions.

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

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

7.4. Dispose of newspapers as directed.

8. 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:

8.1. Group Work:

8.1.1. 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

8.1.2. 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.")

This presence suggests that younger Mars had a thicker atmosphere and was warm enough to support liquid water on its surface, a big change from then to now.

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

If the atmosphere pressure is low, there is less gravity, and it is easier for the light water vapor to escape.

8.2. 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.

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

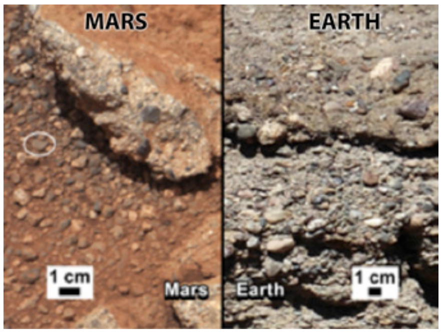
Start thinking about why the atmosphere and Global Warming are important to you. Activity #5 will help you understand Global Warming.

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

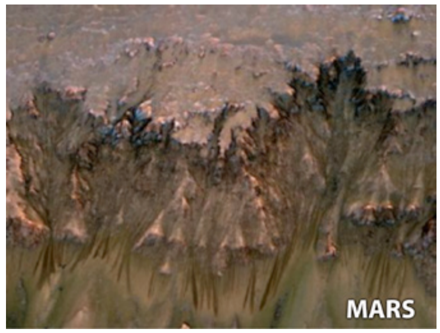


Image credit: NASA/JPL-Caltech/MSSS and PSI

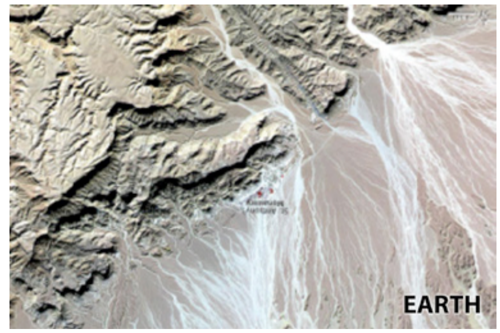
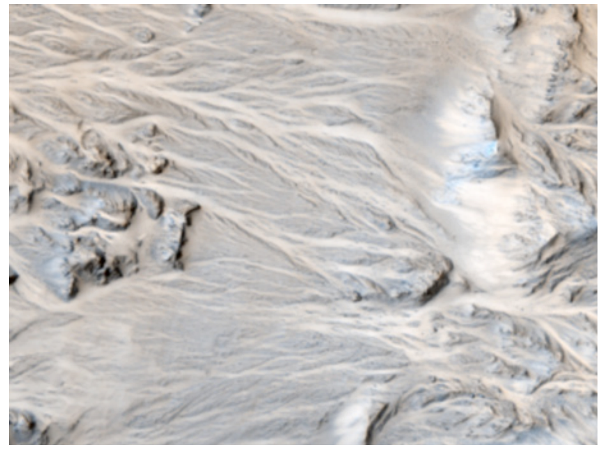
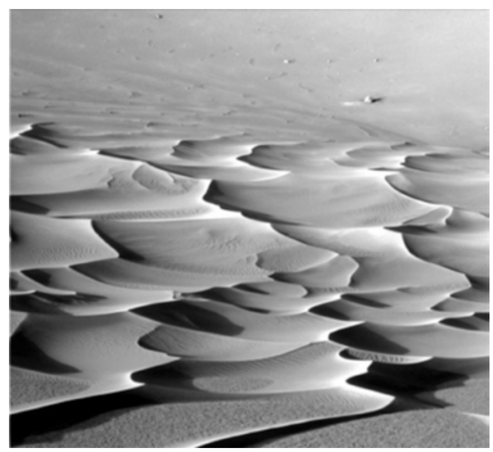
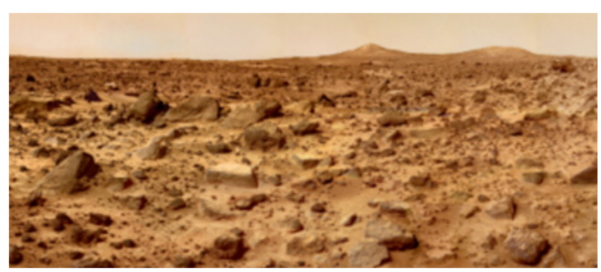


Image credit: NASA/JPL/ASTER

- 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.

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 *[Adult]*

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.

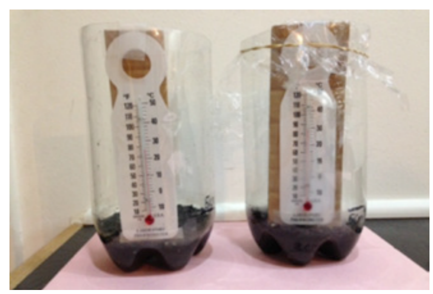
- [2] 2 liter (0.5 gal) clear soda bottles with labels removed and tops cut off. These are the **Atmosphere Model Chambers**. *Advance preparation required* (see page 2).
- [1] pair of scissors for constructing a set of **Atmosphere Model Chambers**
- [1] black permanent marker for constructing a set of **Atmosphere Model Chambers**
- [2] identical thermometers, one for each chamber; view on Amazon.com: http://tinyurl.com/lkrvzvq
- sufficient cardboard to prepare backing for each thermometer
- 5–10 cm (about 4 in) of clear tape to attach thermometers to cardboard and to inside of each chamber
- [1] piece of plastic wrap approximately 15 cm x 15 cm (6 x 6 in)
- [1] rubber band large enough to fit the circumference of chamber and secure plastic wrap
- chart of electromagnetic spectrum of light (EMS); print in advance
- 250-watt infrared heat lamp (bulb) in a fixture with hood. Lamp gets very hot — metal hood remains cool and is required for safety during experiment. Option: conduct outside on a sunny day.
- 500 ml (2.1 cups) dark, very moist soil (approximately 1 cup for each of two chambers)
- colored pencils in red, orange, yellow, green, violet, and blue
- [1] palm-sized piece of temperature-sensitive film available from Edmund Optics: http://tinyurl.com/o94kc6j (30 to 35 °C) or Amazon.com: http://tinyurl.com/nsbrxsp
- eye protection: safety glasses; view on Amazon.com: http://tinyurl.com/pjd8bp9

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.

Advance Preparation



Atmosphere Model Chambers — one set up per group of 4–6 Cadettes.

a. Remove labels from [2] 2 liter (0.5 gal) clear, colorless soda bottles.

b. Measure about 20 cm (8 in) from the bottom of the bottle and, using black marker, draw a circle to guide you in cutting off the top of the bottle.

c. Use the sharp point of a knife or scissors to make an initial incision, and then with scissors completely remove the curved portion of the bottle so that you have a cylindrical container about 20 cm (8 in) tall.

d. Prepare two thermometers: Cut out cardboard backing to protect thermometers from the heat effects of the infrared heat lamp. Amount and shape of cardboard will depend on your choice of thermometer.

e. Use transparent tape to attach thermometer to cardboard. *Do not place tape over the bulb of the thermometer*.
Note: Thermometers may have two temperature scales: Celsius (°C) and Fahrenheit (°F). In this case, scientists would use (°C). The expected difference between the control and experimental values is roughly 3°C (or ~6°F). To avoid confusion, you may select one scale and cover the other set of numbers with opaque tape.

f. Final **Atmosphere Model Chambers** will look like the image at bottom right.
Left Chamber: *Control* — open atmosphere allows for heat flow and no condensation.
Right Chamber: *Experiment* — closed atmosphere traps heat, and condensation will occur.
Cadettes will add soil, place thermometers, cover with plastic wrap and attach rubber bands as part of the experimental design.

g. Before Cadettes begin, help them choose a Timekeeper. (see separate "Cooperative Group Responsibilities" pdf document).

h. Optional: assign other jobs from "Cooperative Group Responsibilities" (see separate pdf document).

5. Get Ready

5.1. Read together *Background Exploring Light and the Greenhouse Effect* (see page 8)**.** Direct team members to talk amongst themselves and answer the following:

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

Visible

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!)

Blue light

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?

Thin high clouds reflect less sunlight than low-level puffy big clouds.

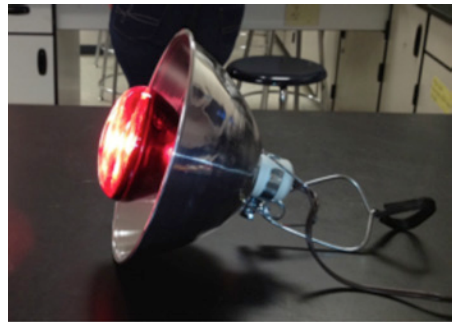
Big low clouds return more heat energy to the Earth's surface.

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 8.

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?

Red

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

Infrared to visible red light.

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.

More

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.)

More

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

Agree

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:

Purple-blue

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

Purple, blue, green, yellow, orange, red

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

Yes

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?

Yes. Red or orange on the edges toward blue in the middle.

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

The warmest part of the hand that touches the film. The fleshy part of the fingertips and the palm generate more heat.

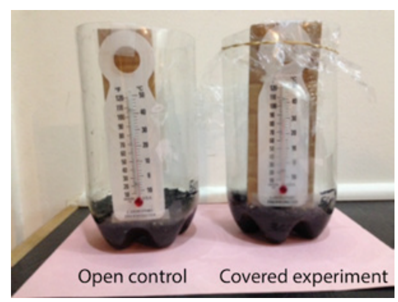
7. Explore: Part II

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.

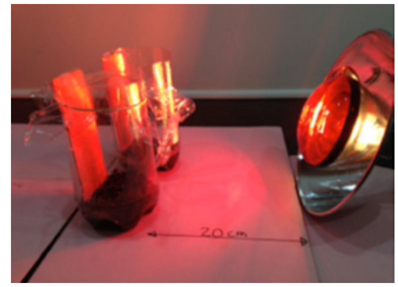
7.3.2. Check the temperatures on both thermometers. Keep thermometers in the shade and wait until both are the same temperature.

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.

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.

We have completed the table below with *SAMPLE data* (in *italics*).

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	*70*	*70*
(A) + 5 minutes = (B)	T = 5	*81*	*81*
(B) + 5 minutes = (C)	T = 10	*84*	*condensation is observed* *86*
(C) + 5 minutes = (D)	T = 15	*87*	*more condensation* *89*
(D) + 5 minutes = (E)	T = 20	*88*	*water dripping on sides* *94**

* 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?

Experiment

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:

Experiment bottle reached a higher temperature and condensation is observed on sides. Water vapor is trapped inside the experiment bottle by the plastic top.

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?

Our atmosphere is a large and complex system, so experiments and measurements concerning it are difficult. For instance, measuring average temperatures is tricky and temperature is important to the water cycle and cloud formation.

8.3.2. What was the greenhouse gas we studied?

We studied water vapor.

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

The plastic wrap represented a closed system like a planet's atmosphere that traps heat.

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

It represented the Sun's energy.

8.3.5. Was this a good model for an atmosphere?

One way to study the greenhouse effect and global warming is to build models and test theories and ideas about climate change by experimenting with the model. However, this model has limitations.

Scientists think something is trapping heat in the Earth's atmosphere, causing the temperature to go up. However, it is not a SOLID barrier like plastic.

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?

Greenhouse gases trap heat in one way or another, increasing the temperature of Earth's surface. However, greenhouse gases are not equal in their effects, because the gases cycle through the Earth's system in different ways than water.

Background Information

What are the percentages of gases contributing to the greenhouse gas effect?

Water vapor	50%
Clouds	25% (Clouds are water droplets — condensed water vapor. View *Unscramble the Clouds* activity: http://tinyurl.com/m79kedp)
CO_2	20%
Other gases	Remainder.

So why are scientists not more concerned about water vapor, since it is the most predominant greenhouse gas? That is related to how long the greenhouse gas remains in the atmosphere. For water, the average is just a few days. The rapid turnover of water means that if human activity WERE directly adding or removing lots of water vapor, there would be no slow build-up of water vapor, unlike what is happening with carbon dioxide. Reference article: http://tinyurl.com/lz98zoc

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.

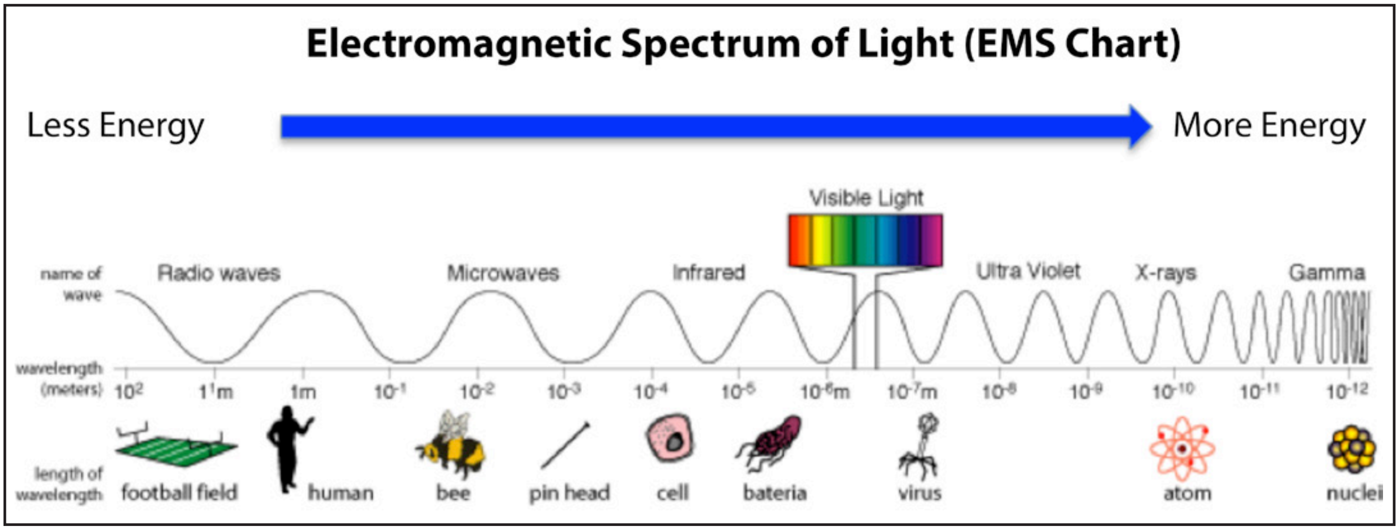


Image credit: NASA

The Greenhouse Gas Effect and Light Energy

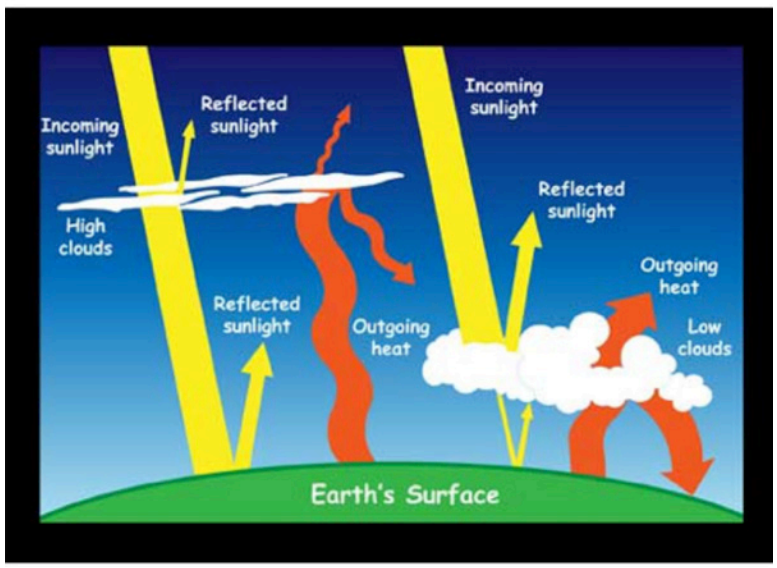


Image credit: NASA

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*.

Activity #6
Steps Along the Journey: Global Warming

1. Introduction

In this activity, you will begin your *Breathe: It's Your Planet — Love It! A Leadership Journey* Air Care Team Plan in which Cadettes discover, connect, and take action.

2. Materials

- Print pages 2–7 for each Cadette.
- Upon completion of this, the final activity in the series, please complete the GGTM User Survey at https://www.surveymonkey.com/s/8FZHB6M. The participation patches will be shipped to you for your troop.

3. Breathe

Troop Leader:

3.1. Get out your book: *Breathe: It's Your Planet — Love It! A Leadership Journey*, a copy of the questions and answers from GGTM Activity #1: The Goldilocks Question, and GGTM Activity #5: The Greenhouse Effect.

3.2. It is time to ***link*** what you have learned to your *Breathe* awards along the journey.

3.3. You are now **AWARE** of the world's air quality and **ALERT** to global warming and ready to **AFFIRM** support for a plan of action with your Air Care Team (ACT).

3.4. Where do you go from here? How do we know what we know about global warming? Why do we care about global warming? As leaders, what are the next steps to inspire and educate others?

3.5. Read the Introduction instructions below.

Now that we have finished all the activities, we are going to work on completing some of the steps in two of the Breathe Journey awards: Aware and Alert. As you have worked your way through the GGTM activities, you have learned about atmospheres and land formations, their importance, and why they are the way they are. Girls will apply the knowledge they gained to the Journey work!

In the grid on the following pages, you will see the steps in both the Aware and Alert awards in the first column. In the second column, you will see which GGTM activity completed the step or what still needs to be completed. Now, let's use what we have learned to complete the remainder of the steps. This is where the girls and their troop will be able to develop their plan for the Air Care Team.

The Girls Go to Mars activities do not fully complete the journey, but they help you complete a significant portion of it. As you can see, some of the steps in both the awards need to be completed outside of the GGTM activities, for example the Air Log (step 1, Aware Award). By completing GGTM, you are also choosing global warming as your air issue to act on together.

We hope you enjoyed the GGTM activities and find the Breathe correlations helpful in completing the Journey.

4. REVIEW and BACKGROUND

From *Terrestrial Planet Atmospheres: Reading Chapter 10*: http://tinyurl.com/ltjk2d6

What Do We Know?

The Greenhouse Gas Effect and Light Energy

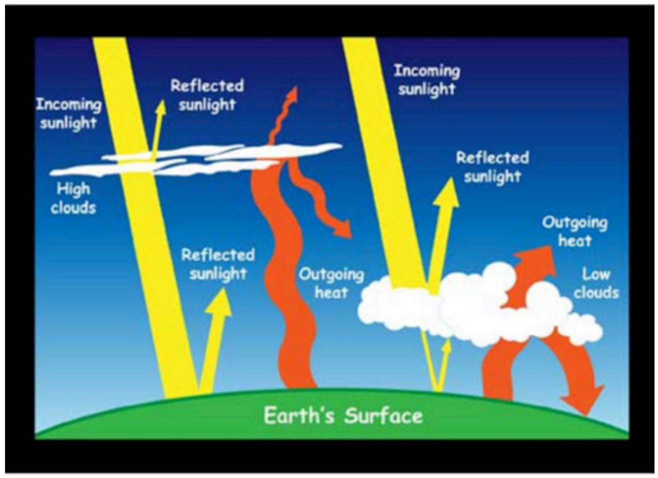


Image Credit: NASA

Girls Discover:

Activity #5: Water vapor and CO_2 absorb infrared energy and increase the temperature of the air!

"Earth's atmosphere absorbs the sun's hot, ultraviolet** rays and helps reduce temperature extremes between night and day. Essentially, it serves as a 'blanket' for Earth, protecting life on the planet." *Breathe. It's Your Planet—Love It!* 33.

Absorbed by land, oceans, and vegetation at the surface of the Earth, visible light** is changed into heat and comes back out in the form of infrared** energy.

**refer to: Activity #5, Electromagnetic Spectrum Chart

Girls Discover:

Too Hot, Too Cold, or Just Right? The Goldilocks Question again!

Review what you learned in Activity #2.

Atmospheric Gas	 **Venus**	 **Earth**	 **Mars**
Carbon Dioxide (CO_2)	96.5%	0.03%	95%
Nitrogen (N_2)	3.5%	78%	2.7%
Oxygen (O_2)	Trace	21%	0.13%
Argon (Ar)	0.007%	0.9%	1.6%
Methane (CH_4)	0	0.002%	0

Using that information and information in the table above:

1. What is the planet with MOST dense atmosphere?

2. Which is warmer, Earth or Mars?

3. Why is Mars so very cold?

Girls Connect:

Evidence of Global Warming: Earth

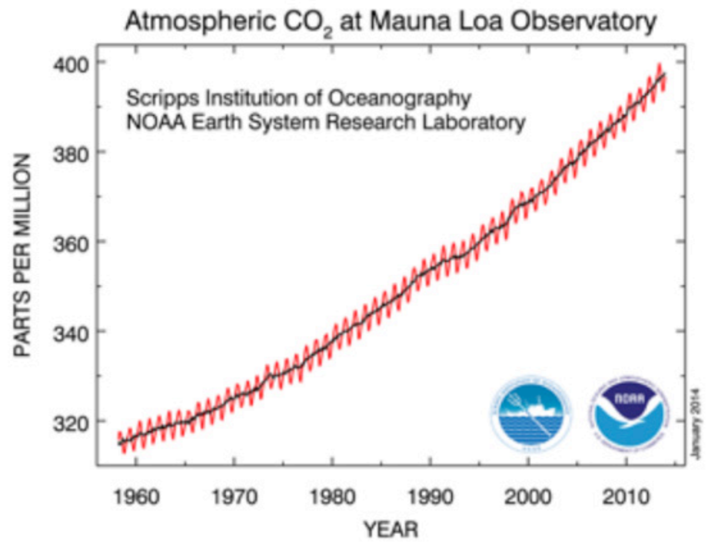


Image Credit: ESRL/NOAA

"Over time, those greenhouse gases have been on the rise, leading to gradual warming of Earth's temperatures, both on land and in the oceans. This temperature rise, and the various climate changes resulting from it, is known as global warming or climate change." *Breathe. It's Your Planet—Love It!* 33.

Look at the graph above and describe the relationship between the levels of CO_2 and what you have learned about temperature change over the past 50 years.

Girls Connect:

Natural and Human Sources of Carbon Dioxide

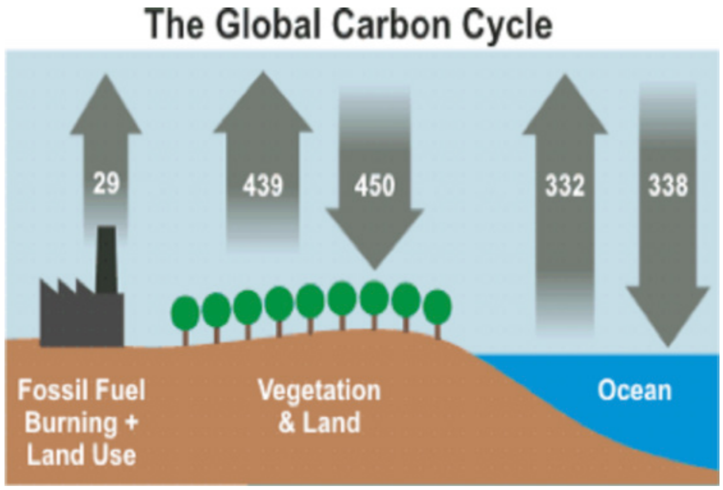


image Credit: Intergovernmental Panel on Climate Change

Do the math! The numbers on the arrows represent gigatons (a really big number!) per year of CO_2.

Total the up↑ arrows =

Total the down↓ arrows =

1. Are the amounts for the up and down arrows equal?

   Are we in "balance"?

   If not, which total (up or down) is larger?

2. Open your *Breathe* book to page 35 and read, "The Fossil in Fossil Fuels." There are natural and human sources of increasing amounts of CO_2 in our atmosphere. Natural sources, like volcanoes, we cannot change.

   Human sources of CO_2 released into our atmosphere we can change!

Girls Take Action:

What can we do to help?

Recall: Plants use CO_2 from the atmosphere as part of a process called photosynthesis.

5. "Breathe" Awards Along the Journey

Get together with your troop and start to make a plan! Look at the Background for ideas.

AWARE

Step	Activity Description	Completion Date
1. Keep an air log…	You will do this independently in your troop meetings.	
2. Identify two experts who can guide you to greater air AWAREness.	Today I talked to scientists; I watched videos where geologists, engineers and astronomers talked about Mars and other planets.	
3. Increase your AWAREness about the issues that impact Earth's air.	In Activity #5 The Greenhouse Effect, you investigated how water vapor, one of several greenhouse gases, increases the temperature of Earth's air. Look at some evidence for global warming. Read some background information.	
4. Decide the most important, personal reason you care about Earth's air. Explain why this reason matters to you and why it should matter to others. Share with your sister Cadettes.	**Complete your statement here:**	

ALERT

Step	Meeting Date:
1. With your Cadette team, choose global warming as your air issue to act on together. Write a statement that explains why it's important to educate and inspire others on this issue.	Write a statement:
2. Decide whom to educate and inspire — this is your Air Care Team (ACT)! What group of people will join you? Parents? Teachers? Other Cadettes? Brownies?	Air Care Team plan:

ALERT

Step	Planning
3. Decide what you will ask your Air Care Team to do. What is your action plan to educate and inspire? (Brainstorm: **Girls Take Action** What Can We Do to Help Better Our Communities?)	Write a plan of action:
4. Decide how to reach your Air Care Team (ACT) to inspire them to act on your air issue.	How to reach your Team:
5. Educate and inspire!	Feel the rewards…. Happens outside our workshop time.

AFFIRM

Step	Take Action and Monitor Progress
1. Gather proof of progress. 2. Share the impact. 3. Reflect on efforts. 4. Affirm commitment.	Long-term goals that happen after the planning and action has started.

Answer Key

Girls Discover:

Too Hot, Too Cold, or Just Right? The Goldilocks Question again!

Review what you learned in Activity #2.

Using that information and information in the table above:

1. Planet with MOST Dense atmosphere?

   Venus

2. Which is warmer, Earth or Mars?

   Earth

3. Why is Mars so very cold?

   Mars receives just less than half the energy from the sun that Earth does. Mars has higher percentage of carbon dioxide, a greenhouse gas, yet it is much colder. Mars was once warmer. The loss of atmosphere has played a role in the climate change on Mars.

Girls Connect:

Evidence of Global Warming: Earth

"Over time, those greenhouse gases have been on the rise, leading to gradual warming of Earth's temperatures, both on land and in the oceans. This temperature rise, and the various climate changes resulting from it, is known as global warming or climate change." *Breathe. It's Your Planet—Love It!* 33.

Look at the graph above and describe the relationship between the levels of CO_2 and what you have learned about temperature change over the past 50 years.

The level of CO_2 has risen, and so has the temperature. The greenhouse gas is trapping heat, and global warming is occurring.

Girls Connect:

Natural and Human Sources of Carbon Dioxide

Do the math! The numbers on the arrows represent gigatons (a really big number!) per year of CO_2.

Total the up🡩 arrows =

800

Total the down🡫 arrows =

788

1. Are the amounts for the up and down arrows equal?

   No

   Are we in "balance"?

   No

   If not, which total (up or down) is larger?

   Up. More CO_2 is going into the atmosphere than comes out of the atmosphere.

Girls Go To Mars
Additional Resources

Directions

Each activity is accompanied by a list of resources linked to the internet. Sources are evaluated for appropriate science content and grade level. Note: website addresses (URLs) change over time and the original resource link can often be located by entering the exact title of the resource in the search box on your internet browser.

Overview

Resource Title/Source	Summary	Group	Link	Notes/Type of Resource
Programs & Missions *NASA Mars Exploration*	Overview, science, people — including women in STEM and their personal reflections	All	http://tinyurl.com/2eaaz3v	Images; article; career
MAVEN Science *Mars Atmosphere and Volatile Evolution Mission*	Three primary science questions, how scientist will use the data from the spacecraft, related links	All	http://tinyurl.com/n22ksob	Images; article
The Outer Planets: Lessons & Activities *Laboratory for Atmospheric and Space Physics (LASP)*	Lessons for grades 6–8: Comparing Planets — Looking Inside Planets: Enrichment activity comparing physical properties of planets in our Solar System	Cadettes	http://tinyurl.com/ka3ccmv	Images; article
Mars: Mysteries & Marvels of the Red Planet *Sky & Telescope*	Special Edition of *Sky and Telescope* magazine contains articles, maps, photos, and art	Adults	http://tinyurl.com/k5xnfkr	Images; article (cost: $10)
Making a Comet Model *Pacific Science Center*	Demonstrate the composition of a comet using dry ice and common ingredients to make a nucleus that will release jets of gas and sublimate over time. Excellent introduction to solid carbon dioxide.	Adults	http://tinyurl.com/pf2kkmm	Activity (print as pdf)

Activity 1: The Goldilocks Question: Just Right, Too Cold, or Too Hot?

Resource Title/Source	Summary	Group	Link	Notes/Type of Resource
A Solar System Model Builder's Guide *Windows to the Universe*	General information about the Solar System and its formation. Scroll and click on various options such as: "The Solar System" and "What is a Planet?"	All	http://tinyurl.com/l7oaw97	Images; article
A Simulated Voyage through the Solar System *Exploring Earth*	Animation shows each planet's average distance from the Sun and conveys a sense of how much time it would take to reach Pluto	All	http://tinyurl.com/2psfmz	Animation
Build a Solar System *Exploratorium*	Make a scale model of the Solar System and learn the real definition of "space." Be sure to scroll down to the links at the bottom of the page. Go to: TheNinePlanets.org and the ProportionalPlanets.org links.	Adults	http://tinyurl.com/22bug	Activity
The Dynamic Earth *National Museum of Natural History*	Explore the dynamic forces that formed and are continually reforming the Earth and our Solar System. Select: The Solar System: take the tour of "The Big Picture."	All	http://tinyurl.com/yxymyf	Activity (print as pdf) or multimedia

Activity 2: It's All About the Atmosphere

Resource Title/Source	Summary	Group	Link	Notes/Type of Resource
Mars Climate, Now and In the Past *Windows to the Universe*	Tour that explores the history of Mars' climate in text and images	All	http://tinyurl.com/mkux8o6	Images; article
How Rocky Planets Get Their Atmospheres *Astrobiology Magazine*	Available in Spanish and English, a brief article with images that offers clues about the sources of early atmospheres on Mars and other rocky planets	Adult	http://tinyurl.com/kztyt58	Article
Mars, Earth & Venus *Terrestrial Planet Atmospheres*	General principles of planetary atmospheres covering characteristics, greenhouse effect, sources, and losses of gases	Adult	http://tinyurl.com/ltjk2d6	Images; article

Activity #2 Extension: Women STEM

Resource Title/Source	Summary	Group	Link	Notes/Type of Resource
Women @ NASA *NASA*	Women in STEM — their stories, jobs, and career paths	Cadettes	http://women.nasa.gov/	Image; article; career
Dream of a Green Career *NASA Climate Kids*	Descriptions of careers for people interested in working in the environment, including suggested interview questions	Cadettes	http://tinyurl.com/mp7qhqj	Careers
Making the Grade: A Focus on Helping Women Excel in STEM Majors *California Polytechnic State University, San Luis Obispo*	12-minute video with believable female role models, containing wisdom and rich insights from successful STEM students and grads who offer concrete advice about dealing with confidence issues, peers, social support, and more	All	http://tinyurl.com/ks8l8h8	Video; review of research

Activity #3: How Do Atmospheres Change Over Time? The Role of Magnetosphere and Solar Wind

Resource Title/Source	Summary	Group	Link	Notes/Type of Resource
Earth's Magnetosphere *LASP*	Brief introduction to properties of Earth's magnetosphere	All	http://tinyurl.com/m9wpth8	Images; article
The Solar Wind Tunnel *LASP*	Uses a computer simulation to demonstrate how solar wind interacts with planetary magnetospheres	All	http://tinyurl.com/mckebo7	Multimedia — interactive
Measuring Mars: The MAVEN Magnetometer *NASA*	Video with accompanying text discussing global magnetic fields on Earth compared to Mars	All	http://tinyurl.com/kwkoxnn	Multimedia; article

Activity #4: Evidence for an Atmosphere on Mars Over Time: Water Surface Features

Resource Title/Source	Summary	Group	Link	Notes/Type of Resource
Water on Mars *Phoenix Mars Mission*	Overview of evidence for water on Mars, past and present, including historical perspective; current images with helpful text: links to habitability and biology	All	http://tinyurl.com/moohfqe	Multimedia; article
Planets and Moons: Water on Mars *ESA Kids Our Universe*	European Space Agency's website covering a wide range of topics from the story of the Universe; includes short current topics such as water on Mars with links to other Martian surface features	All	http://tinyurl.com/koqp9zk	Images; article
Study: Water Could Be Flowing on Mars Now *CNN*	Current review of evidence for past and present	All	http://tinyurl.com/pf4f67q	Images; article
Is There Really Water on Mars? *How Stuff Works*	Historical review up to 2008 findings related to scientific evidence for water on Mars; includes Phoenix Mars Lander, a look at geological evidence, and an introduction to MAVEN mission questions	All	http://tinyurl.com/m57gr9o	Images; article

Activity 5: How Do Atmospheres Change Over Time? The Greenhouse Effect

Resource Title/Source	Summary	Group	Link	Notes/Type of Resource
Climate Kids *NASA*	Engaging up-to-date presentation of the big questions about weather and climate, the greenhouse effect, and recycling	All	http://climatekids.nasa.gov/	Multimedia
Climate Change Compendium *LASP*	A standards-based compendium of activities regarding climate change, many with links to relevant websites	Adult; Cadettes	http://tinyurl.com/km4auk4	Activities
Causes of Climate Change *Environmental Protection Agency*	Extensive review of the causes of climate change	Adult	http://tinyurl.com/9xb7d9o	Images; article
Exploring Invisible Light, Science Behind the Scenes *SETI Institute*	Detailed instructions for IR Film activity and explanation of IR film	Adult	http://seti.org/ggtm	Activity and background science

Activity #6: Steps Along the Journey: Global Warming

Resource Title/Source	Summary	Group	Link	Notes/Type of Resource
Climate Kids *NASA*	Engaging up-to-date presentation of the big questions about weather & climate, the greenhouse effect and recycling	All	http://climatekids.nasa.gov/	Multimedia
Make Stuff *NASA Climate Kids*	Simple project suggestions for your Breathe Journey and help with the science behind the community action plans	Cadettes	http://tinyurl.com/l4p3fbv	Multimedia
Global Greenhouse Gas Reference Network *National Oceanic & Atmospheric Administration*	Trends in Atmospheric Carbon Dioxide: Animation of time history of atmospheric carbon dioxide from 800,000 years ago until January 2012	All	http://tinyurl.com/4c7fxoz	Animation
Dream of a Green Career *NASA Climate Kids*	Descriptions of careers for people interested in the environment, including suggested interview questions	Cadettes	http://tinyurl.com/mp7qhqj	Careers
Bottle Column Investigations *Bottle Biology*	Use 2-liter plastic soda bottles to study decomposition and fermentation as recycling projects; learn how nature recycles garbage all the time in a landfill	Cadettes	http://tinyurl.com/m25swz3	Activities; images

Cooperative Group Responsibilities

Decide in a way that makes you most comfortable…. You may want badges!

TEAM LEADER

Read directions and check for clarifications with your group

Plan work timeline

Lead discussions and make sure every member has a chance to speak

Check data sheets for completion

Organize group for report-out

Help with cleanup

DATA COLLECTOR — everyone's role

Record information in your Investigator's Journal

Ask questions when something isn't clear

Help with cleanup

ENCOURAGER — everyone's role

Praise and affirm

Positive communication

Help with cleanup

MATERIALS MANAGER

Collect and return all materials as directed by your adult leader

You are the only one who can retrieve materials and supplies

Make sure everyone has access to materials

Help with cleanup

TIME KEEPER

Keep your eye on the clock, stopwatch or cell phone alarm

Remind the group about tasks and time remaining

Keep the group eyes on the finish time and budget for report-out preparation

Help with cleanup