Red Planet: Read, Write, Explore!

Lesson 2: Hanging Mars Out to Dry

Description of Lesson:
The purpose of this lesson is to introduce students to Mars' history through research and discussion. Students read about the history of Mars, Mars observing, and exploration with telescopes and robotic spacecraft. After learning about Mars, students consider how some aspects of our early understanding of Mars included fictitious ideas not based upon science (i.e. Lowell's observations of canals and speculation about a civilization). Students discuss the differences between science fiction and science fact. Students will illustrate a scene from Mars history with a paragraph description, and place their work along a clothesline in the classroom to create a timeline.

Background (See also "Background" from Lesson 1)**:**
The history of Mars is not completely understood. Our understanding of Mars will change as more missions like MAVEN visit the planet. MAVEN will help trace the history of Mars' atmosphere so we know how it has changed over time, and whether Mars was a more hospitable place billions of years ago.

The timeline seen below is our best understanding of Mars' history based upon the evidence we currently have. Some texts might have slightly different times due to different assumptions. Portions of Earth's timeline have also been included below. Note that "BYA" means "Billions of Years Ago" and "MYA" means "Millions of Years Ago."

About 4.5 BYA Mars and the Solar System form. The Sun is 30 percent less bright than it is today.

Between 4.3 and 4.1 BYA During this period, Mars is bombarded with large comets and asteroids. Some of the impacts are forceful enough to remove some of Mars' atmosphere, like when a big rock dropped into water creates a big splash.

4.1 BYA Volcanoes from the Tharsis region begin to explode and spew out gases. This replenishes Mars' atmosphere with carbon dioxide, water vapor, and other greenhouse gases.

4.0 BYA Mars had a strong global magnetic field, similar to Earth's. A magnetic field acts like a shield to incoming solar particles that stream out as a "solar wind into our Solar System. At this time, Mars loses its global magnetic field that protects it from the solar wind[1]. Some of Mars' upper atmosphere may

[1] In certain areas of the planet, remnants of the magnetic field still exist slightly below the surface in the form of magnetic rocks.

have been stripped away by the solar particles, which is something the MAVEN mission will explore. Other scenarios suggest that asteroid or comet impacts contributed to atmospheric loss.

3.8 to 3.5 BYA There is evidence Mars had flowing water in lakes, rivers, and possibly even oceans during this time. Although volcanoes continue to sporadically outgas, Mars' atmosphere is still being lost to space.

3.5 BYA As Mars continues to lose its protective atmosphere, the environment becomes drier and dustier. Lakes, oceans, and rivers dry up or freeze. Occasional catastrophic flooding occurs, but water is not sustained for long at the surface.

3.5 BYA The oldest fossilized bacteria discovered on Earth dates to this time.

3.3 to 2.9 BYA Lava flows occur on the surface and Olympus Mons grows through numerous eruptions. Although there is evidence of water occasionally flowing on the surface, the planet is now largely dry. Valles Marineris canyon (created by the surface "cracking," unlike the water-formed Grand Canyon on Earth), which is about the same width as the United States, begins forming during this time.

2.9 BYA to present Mars may experience occasional warm periods. Even today with the cold and dry conditions, springs have been occasionally observed seeping out of cliff faces.

1 BYA Multicellular life forms on Earth.

0.23 BYA (230 MYA) The first dinosaurs roam the Earth.

0.065 BYA (65 MYA) On Earth, the dinosaurs die out.

About 0.010 BYA (10 MYA) The youngest lava flows formed on the surface of Mars.

0.2 MYA (200,000 YA) On Earth, the first modern humans appear.

About 400 YA (1600 AD) Johannes Kepler uses observations of Mars to determine that the planets orbit the Sun in elliptical orbits.

About 400 YA (1608 AD) The telescope is invented.

About 115 YA (1894 AD) Percival Lowell observes Mars through a telescope in Arizona and draws images of canals created, as he believes, by an intelligent civilization.

About 115 YA (1895 AD) Edward Barnard observes Mars through a telescope in California. He finds no canals, but does see mountain ranges.

About 115 YA (1897 AD) H.G. Wells writes the novel, *War of the Worlds*, about a Martian invasion of Earth.

The following is a partial list of NASA missions. For a complete list, visit: http://mars.jpl.nasa.gov/programmissions/missions/

About 50 YA (1962-1971 AD) NASA successfully sends the missions Mariner 4, 6, 7, and 9 to photograph and return data from Mars. Mariner 9 is the first spacecraft to orbit another planet.

About 25 YA (1976 AD) The Viking landers 1 and 2 take soil samples of Mars to figure out if Mars ever had life. The results are inconclusive, so most scientists think that they did not detect life.

Recent Missions:

2004 AD The Mars Exploration Rovers, Spirit and Opportunity, begin roaming around Mars.

2008 AD The Phoenix lander digs into the soil near the north pole of Mars and digs up water ice!

2010 AD Spirit stops communicating with Earth. The original mission was expected to last only 90 days! As of 2012, Opportunity is still exploring craters.

2012 AD The Curiosity rover lands on Mars to study the rocks and soil, and search for signs of past habitable conditions, including the chemical building blocks of life.

Not Too Long Ago: You were born!

Present Day There is evidence that liquid water gullies are released from underground, but quickly evaporate in the dry, low-pressure environment of Mars. Otherwise, Mars is dry and dusty. Frozen water ice exists in the polar ice caps and underground. Mars' atmosphere is thin (about 100 times thinner than Earth's).

Future The MAVEN (Mars Atmosphere and Volatile EvoluioN) mission is scheduled to launch in the fall of 2013. MAVEN will piece together what exactly happened to Mars' atmosphere and will help scientists answer whether the solar wind stripped off some of Mars' atmosphere, and how much of it got carried away. This will fill in some of the missing picture in Mars' past.

Recommended additional materials:
The following site from the Lunar and Planetary Institute (LPI) has a timeline mural and downloadable timeline images and text: http://www.lpi.usra.edu/education/timeline/mural.shtml.

LPI's activity, "Time Travelers," has a timeline called "Master List of Events" and images on "Event Cards" that may help fill in some events for your students, but is focused on the history of Earth and Earth's moon.
http://www.lpi.usra.edu/education/explore/marvelMoon/activities/intro/timeTravelers/

Recommended additional activities:
Exploring the Earth's Magnetic Field activity III is a good way to demonstrate to students how the solar wind and Earth's magnetic field interact. Extend the learning by removing the bar magnet (from activity) to represent how Mars' atmosphere is not protected from the solar wind.
http://spacemath.gsfc.nasa.gov/NASADocs/magbook2002.pdf#page=10

Benchmarks for Science Literacy, Project 2061 (Grades 3-5)
The Nature of Science
- *Scientific Inquiry: Scientists do not pay much attention to claims about how something they know about works, unless the claims are backed up with evidence that can be confirmed, along with a logical argument. 1B/E4*

The Nature of Technology
- *Technology and Science: Technology enables scientists and others to observe things that are too small or too far away to be seen otherwise, and to study the motion of objects that are moving very rapidly or are hardly moving at all. 3A/E2*
- *Technology and Science: Measuring instruments can be used to gather accurate information for making scientific comparisons of objects and events, and for designing and constructing things that will work properly. 3A/E3*

Common Core for English Language Arts
Reading: Information Text
- *RI.3.7. Use information gained from illustrations (e.g., maps, photographs) and the words in a text to demonstrate understanding of the text (e.g., where, when, why, and how key events occur).*
- *RI.4.3. Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.*
- *RI.4.7. Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages), and explain how the information contributes to an understanding of the text in which it appears.*
- *RI.4.9. Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably.*
- *RI.5.9. Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably.*

Writing
- *W.3.2., 4.2, 5.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.*

- *W.3.3., 4.3, 5.3 Write narratives to develop real or imagined experiences or events using effective technique, descriptive details, and clear event sequences.*
- *W.3.7., 4.7, 5.7 Conduct short research projects that build knowledge about a topic.*
- *W.4.9., 5.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.*

Speaking and Listening
- *SL.3.2. Determine the main ideas and supporting details of a text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.*

Lesson Time: Three 45-minute periods

Choose one or more of the following books to read aloud:
- Ride, Sally and Tam O'Shaughnessy. 2006. *The Mystery of Mars*. San Diego: Sally Ride Science. (Grades 3 and up) pp 10-17, pp 8-9, 18-23, 30-41
- Scott, Elaine. 2008. *Mars and the Search for Life*. New York: Clarion Books. (Grades 5- 9) pp 1-25

Choose one or more of the following books as a classroom resource:
- Murray, Stuart. 2004. *Eyewitness Mars*. London: DK Publishing, Inc. (Grades 3 and up) pp 8-15, 18-24, 26-46, 52-57
- Ride, Sally and Tam O'Shaughnessy. 2006. *The Mystery of Mars*. San Diego: Sally Ride Science. (Grades 2 and up)

Additional books to have on hand (optional):
- Asimov, Isaac. 2002. *Mars*. New York: Prometheus Books. (Grades 4 and up)
- Scott, Elaine. 2008. *Mars and the Search for Life*. New York: Clarion Books. (Grades 5-9)

Materials:
- One or more of the books listed to read aloud
- One or more of the classroom resource books
- Clothesline or thin rope to cross longest wall of classroom end to end
- Index cards (any size)
- Clothespins
- Masking tape
- Magic tape or double stick tape
- Black non-toxic marker
- Paper for student artwork (cardstock, construction paper, etc.)
- Colored pencils, markers, or crayons
- Computer and projector for displaying the video, "Questions for the MAVEN Mission to Mars," which is available on the MAVEN website (YouTube): http://lasp.colorado.edu/home/maven/multimedia/videos/ . If YouTube is not supported, the video is called "MAVEN Teaser," and is available from

NASA:
http://www.nasa.gov/multimedia/videogallery/index.html?collection_id=14742

- For Grade 5 students, also display, "MAVEN: Exploring the Upper Atmosphere of Mars," available from the same websites. From NASA, it is under the "Related Videos" tab.

Procedure:

- Label index cards to mark off time on the clothesline from 4.5 billion years ago to the present. See Figure 1 for suggested times for the timeline.
- Hang clothesline fairly taut along the longest wall of the classroom.
- Place labeled index cards along the clothesline using clothespins. See Figure 1 for a suggested configuration.
- Read one or more of the books listed to the class. While you are reading, highlight note-taking skills by requesting students record three important ideas.
- Have students read the included article, "The MAVEN Mission: Climate Detective."
- View the video, "Questions for the MAVEN Mission to Mars."
- For Grade 5, view the video, "MAVEN: Exploring the Upper Atmosphere of Mars."
- Have available one or more of the classroom resource books.
- Using the reading materials, have students choose a historical event. Ideally, no student should share an event. It could be a geologic or human event and can be about Earth or Mars.
- Students will write a paragraph description and drawing of their event. Students can begin on Day 1, with time to write and revise on Day 2 and Day 3.
    - Encourage students to do additional research in the library or online (with guidance).
    - Discuss the writing and illustrations with students as they work and address any misconceptions students may have.
    - Allow time for revision.
- On Day 3, students will place their drawing and writing along the clothesline in the appropriate spot using clothespins. Students may need assistance placing it in the correct spot. Certain events may share the same time period, and may need to share space on the timeline (or be close to one another).
- Encourage and allow time for students to read and reflect on the timeline and on the work of their classmates.

Example Discussion Questions (allow for open discussion):

- Looking at the distance on the timeline, how much space is there between when you were born and when the dinosaurs were around?
  A: There is a lot of space, and a long time between these events.
- How much space is there between when the dinosaurs were around and when Mars and Earth were formed? Is it more or less distant than the distance between your birth date and the dinosaurs?

A: There is even more distance between the dinosaurs and when the planets formed. It was a very long time ago.

- What is the difference between Mars science fiction and science fact?
- Can you think of some examples of Mars science fiction that you have seen or read?
- How do we get information about Mars, and why did early astronomers not know what the surface was like? A: *Today, we send space missions to Mars to collect data. Some of the missions orbit the planet and some land on the ground to collect samples of the surface. Telescopes cannot make out many details of the surface. Before the telescope, we only observed the planet with our eyes.*
- Why do you think Percival Lowell believed intelligent beings lived on Mars? A: *An Italian astronomer saw dark areas of Mars that he labeled "canali" which is translated as "channels" in English. Many people misinterpreted this to mean, "canals," which are waterways built, on Earth, by humans. Lowell saw lines on the planet that he thought were canals used to transport water from the poles to "intelligent civilizations" on the planet. It's unclear why Lowell saw lines on the surface, but he may have seen dark features on the planet that he thought were canals.*
- Was Lowell doing good science? What is good science? A: *Lowell came up with a conclusion about canals on Mars based upon what he saw, and he stated that intelligent beings lived on Mars without having enough evidence. Science requires a lot of evidence before ideas are stated as fact.*
- Could Mars ever have had life? Do we know for sure? How could we find out? A: *Mars could have had life, but it would most likely have been bacterial life like microorganisms, and not intelligent life. We would look for fossils or chemical tracers for life using ground-based missions in order to find out.*

Extension activity (Grade 5): Listen to a recording of Orson Well's 1938 radio broadcast of "War of the Worlds" (typically available on YouTube). Discuss how some members of the public were convinced that it was an actual news bulletin and panicked during the broadcast.

Extension activity (Grades 4-5): Have students research Mars mythology from the Greeks, Romans, Hindus, and/or Maya, write a short report, and orally present their research to the class.

Extension activity (Grades 3-5): Discuss popular fiction about Mars with students. From Lesson 1, you might discuss the book, *Max Goes to Mars,* as an example. Have students draw and illustrate a fictitious story about Mars. Encourage students to use creativity as well as ideas from the timeline in their stories.

Dispelling Preconceptions: Students often have trouble understanding the nature of time, and the concept of billions of years may be overwhelming or difficult to grasp. Consider creating separate timelines for Earth and Mars in this activity. Encourage students to place other events on the Earth timeline as well as the ones listed, including events from history. This could evolve into a

longer-term project. Additionally, if students are learning about place value in math, consider pairing a lesson about "*How big is a billion?*" with this lesson.

References used to create lesson:

Baker, Victor R. 2001. "Water and the Martian landscape." *Nature* 412: 228-236.

Jakosky, Bruce M. and Roger J. Phillips. 2001. "Mars' volatile and climate history." *Nature* 412: 237-244.

Stevenson, David J. 2001. "Mars' core and magnetism." *Nature* 412: 214-219.

Phoenix Mission website. Accessed June 5, 2012: http://phoenix.lpl.arizona.edu/.

NASA JPL Mars Mission website. Accessed June 12, 2012: http://mars.jpl.nasa.gov/programmissions/missions/.

Private conversation with Dr. Bruce Jakosky.

Private conversation with Dr. David Brain.

Private conversation with Dr. Brian Hynek.

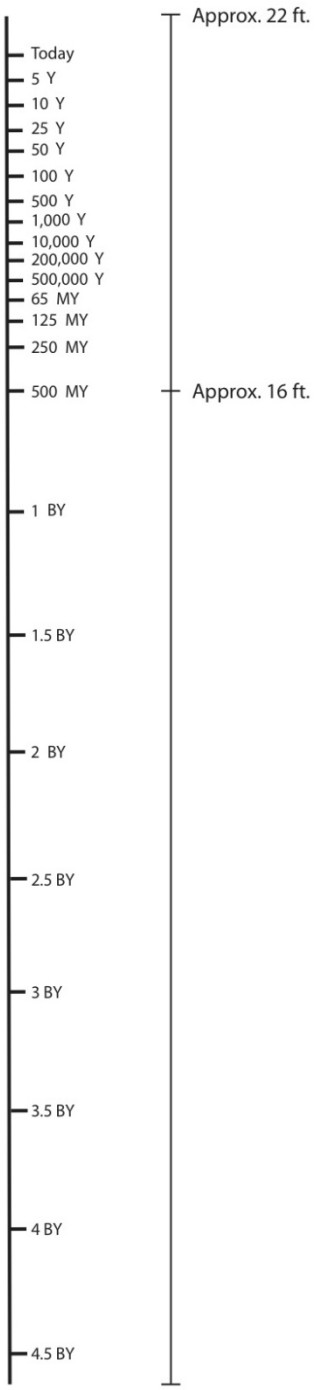

Figure 1:
It is nearly impossible to create a geologic timeline to scale in a school since such vast quantities of time are represented. It is more important to demonstrate that events in the last 500,000 years are very close to one another on the timeline and are far from the beginning of the Solar System. A suggested layout is shown to the left.

Not to scale

My Name:

My chosen time on the timeline:

Describe your historical event: