Activity 7: Mars Imaginings – The Story

Adapted from *Imaginary Martians*, **DESTINATION: MARS**, NASA Johnson Space Center, 2002 (http://ares.jsc.nasa.gov/ares/education/program/destinationmars.cfm).

Overview

During this 45–60 minute activity, children ages 6 to 13 consider depictions of Mars from science fiction books and video clips. As a group, children discuss what they know about Mars and compare their ideas with the way Mars and imaginary Martians are presented in the science fiction works. They then use what they've learned to create their own Mars Science Fiction 'Movie Trailer' Zines. Optional: the children may also create a short story about life on Mars at home.

It is recommended that this activity is preceded by 2–3 of the previous activities so that the children will already have an understanding of what life needs and how Mars compares to Earth. This activity may be extended to serve as a tween and/or teen science fiction book club.

What's the Point?

- Earth and Mars have many differences and many similarities.
- Scientists have gained a great deal of information about Mars in recent years, and there is still much to learn.
- To discover how our understanding of Mars has changed over time as reflected in science fiction.
- To create a short 'Movie Trailer' Zine to allow them to use their imaginations and to capture what has been learned about Mars and possible life beyond Earth (to this point).

Tips for Engaging Girls in STEM:

- **Provide engaging informational and narrative texts.** This activity offers numerous science fiction book suggestions to engage the children.
- **Embed activities in interesting contexts.** For elementary aged children, use **fantasy** like save a planet from invasion, search for life on another planet, etc. to spark their interest and engage their imaginations. This activity heavily imbedded in fantasy and science fiction about Mars in order to spark interest and engage young imaginations.

Materials

For the group:

- 1 Whiteboard, large sheet of butcher paper, or poster paper
- Staplers (one per 4–6 children)
- A selection of **science fiction** books about Mars and Martians, such as the following (refer to the resources section for other suggestions)
  Suggested books:

  LIFE ON MARS: TALES FROM THE NEW FRONTIER
  Jonathan Strahan, Viking Juvenile, 2011, ISBN 0670012165
  Award–winning anthologist Jonathan Strahan has brought together thirteen original stories to explore the possibilities of traveling and living on Mars. For children ages 11 and up.

  MARS (CHAPTER 7)
  Ben Bova, Bantum Spectra, 1993, ISBN 055356241X
  Twenty–five astronauts of the international Mars mission set down on the harsh and unforgiving planet and soon face deadly meteor showers, subzero temperatures, and a mysterious virus. For children ages 10 and up.

  MESSAGES FROM MARS
  Andrew Schuerger and Loreen Leedy, Holiday House, 2006, ISBN 0823419541
  In the year 2106, junior astronauts and planetary scientists take a journey together to Mars and report their wealth of discoveries about the red planet to their friends back on Earth. A fun and informative read for children ages 8–13.

  OUT OF THE SILENT PLANET (CHAPTER 7)
  C.S. Lewis, Scribner, 2003, ISBN 0743234901
  Out of the Silent Planet begins the adventures of the remarkable Dr. Ransom. First published in 1943. For children ages 9 and up.

  RABBITS ON MARS (PICTURE BOOK)
  Jan Wahl and Kimberly Schaber, Lerner Publishing Group, 2003, ISBN 1575055112
  Tired of their hard life on Earth, where dogs chase them, winters are cold, and carrots scarce, three rabbit friends build a rocket ship and journey to Mars in hopes of finding a better life. For children ages 5 and up.

  RED PLANET
  Robert Heinlein, Del Rey, 2006, ISBN 0345493184
  Jim Marlow and his strange–looking Martian friend Willis were allowed to travel only so far. But one day Willis unwittingly tuned into a treacherous plot that threatened all the colonists on Mars, and it set Jim off on a terrifying adventure that could save—or destroy—them all! For ages children 10 and up.

Ricky Ricotta's Mighty Robot Vs. The Mecha–Monkeys from Mars
Dav Pilkey, Scholastic, Inc., 2002, ISBN 0439252962
Ricky Ricotta and his Mighty Robot are in big trouble. Now it's up to Ricky to rescue his robot and keep Major Monkey from menacing mankind. For children ages 4 and up.

Robot Wars
Sigmund Brouwer, Tyndale House Publishers, 2009, ISBN 1414323093
Set in an experimental community on Mars in the year 2039, The Robot Wars series features 14–year–old virtual reality specialist Tyce Sanders and is a repackaged and updated version of Mars Diaries. For children ages 10 and up.

The Day the Martians Came (Chapter 17)
Frederick Pohl, St. Martin's Paperbacks, 1989, ISBN 0312917813
Henry Steegman is hardly "Mr. Personality" aboard the Mars–bound Algonquin 9. For better or worse, the name Steegman will be immortalized by a discovery that will transform millions of lives. For ages 12 and up.

The Green Book
Jill Patton Walsh, Square Fish, 2012, ISBN 0312641222
Pattie and her family are among the last refugees to flee a dying Earth in an old spaceship. And when the group finally lands on the distant planet which is to be their new home, it seems that the four–year journey has been a success. But as they begin to settle this shiny new world, they discover that the colony is in serious jeopardy. For children ages 8 and up.

The Martian Chronicles
Ray Bradbury, Doubleday, 2001, ISBN 096501746X
Bradbury's Mars is a place of hope, dreams and metaphor – of crystal pillars and fossil seas – where a fine dust settles on the great, empty cities of a silently destroyed civilization. For ages 12 and up.

There's Nothing to Do on Mars (Picture book)
Chris Gall, Hachette Book Group, 2008, ISBN 0316166847
When Davey Martin's family moves to Mars, he discovers that there's nothing to do—at least until he and his robot dog Polaris learn to seize the spirit of adventure. For children ages 5 and up.

The Worst–case Scenario Ultimate Adventure #2: Mars! (You decide how to survive)
Hena Khan and David Borgenicht, Chronicle Books, 2011, ISBN 081187124X
Join the youngest crew of astronauts ever to make the trip to Mars! Faced with fearsome dangers and difficult decisions, your choices will determine your fate on the Red Planet. For children ages 9 and up.

YOU ARE THE FIRST KID ON MARS
Patrick O'Brien, Putnam Juvenile, 2009, ISBN 0399246347
Using the most up–to–date designs and theories of what it will take to establish a base on Mars, the reader is off on an incredible journey, over 35 million miles to the red planet. For children ages 5 and up.

Note: Please see the module Resources List for more book suggestions.

- Optional: A selection of **non–fiction** books about Mars, such as the following (please refer to the resources section for other suggestions), for reference and comparison.

Suggested Books:

MARS
Elaine Landau, Scholastic, Children's Press, 2008, ISBN 0531125602
Is there life on Mars? Nobody has ever found life on Mars, but some scientists think it's possible that there is – or once was – life on the red planet. For children ages 10–13.

PLANET MARS (SEE MORE READERS LEVEL 1)
Seymour Simon, Chronicle Books, 2006, ISBN 0811854043
Young readers view photographs of Mars from the Spirit and Opportunity rovers and receive up–to–date information in an easy to read format. For children ages 6–8.

MARS AND THE SEARCH FOR LIFE
Elaine Scott, Clarion Books, 2008, ISBN 0618766952
Despite the fondest desires of science fiction fans; everyone knows Mars isn't inhabited by little green men. But could there ever have been life there, in some form? And if so, what happened to it? And could life exist there again one day? For children ages 9 and up.

EXPLORING MARS
David J. Ward, Lerner Publications, 2006, ISBN–10: 0822559366
Ward provides a comprehensive introduction to Mars that includes discussion of Mars' surface features and water, life on Mars, and past and future missions to Mars. For children ages 9–12.

THE MIGHTY MARS ROVERS: THE INCREDIBLE ADVENTURES OF SPIRIT AND OPPORTUNITY
Elizabeth Rusch, Houghton Mifflin, 2012, ISBN 054747881X
This book tells the greatest space robot adventure of all time through the eyes—and heart—of Steven Squyres, professor of astronomy at Cornell University and lead scientist on the mission. For children ages 9 and up.

CARS ON MARS: ROVING THE RED PLANET
Alexandra Siy, Charlesbridge Publishing, 2011, ISBN 1570914621
Learn how scientists determined that there was once water on Mars and how the Earthbound NASA team resolved problems with the rovers from afar in order to prolong the mission, which continues today. For children ages 10 and up.
Note: Please see the module Resources List for more book suggestions.

- Optional: Copies of the *Extreme–O–File* activity pages for this activity
- Optional: Video camera to record the group movie trailer

For each child:
- 1 Pencil/pen
- Zine materials:
    - Zine template
    - Zine folding instructions

    Note: Both of these are available through http://smallsciencezines.blogspot.com/ *or other Internet sites*
- Art supplies, such as colored pencils, crayons, and markers
- Optional (Extension): 1 release form for the parent or guardian to sign (if the 'movie trailer' is to be filmed)
- Optional: 1 set of the *Extreme–O–File: The Story* activity pages
- Optional: 1 set of the *Life on Mars?* Trading Cards

For the Facilitator:
- Background information
- Shopping list
- 2–3 Markers or chalkboard and chalk to record the children's ideas
- 1 Computer/TV/Projector to show brief sci–fi video clips
- Connection to the internet

Preparation
- Review the activity procedures and background information
- Print copies of the Zine Template and folding directions
- Prepare an area large enough for the children to be comfortably seated as a group
- Prepare TV/Computer/Projector and load sci–fi movie clips. A selection could include:
    - 'Learning to Walk' – a clip from the movie "John Carter" (55sec) http://www.youtube.com/watch?v=xO67m2nkelw
    - 'Mars Best Friend' clip – John Carter (54sec) http://www.youtube.com/watch?v=xOBGjm2QfzE
    - 'John Carter' Official Movie Trailer (1:44) http://www.youtube.com/watch?v=_aWrKEWei7w

- 'Mars Needs Moms' Movie Trailer (2:32)
  http://www.youtube.com/watch?v=_aS5W___Ezk&feature=player_embedded
- 'Flight to Mars' 1951 Sci–Fi Trailer (2:13)
  http://www.youtube.com/watch?v=8m63WNclLpc

- Optional: Prepare to read — or arrange for a professional storyteller to read — selections of science fiction about Mars and Martians.
- Optional: Test out the video recorder if you plan to record the group 'movie trailer' at the close of the activity.
- Optional: Print copies of the *Extreme–O–File* activity pages.

Optional Extension: Feature one or more science fiction works about Mars as part of a tween and/or teen book club. Have the participants read and discuss each entire work of science fiction. Display several non–fiction books about Mars in a place where the children can page through them before and after the activity.

Activity

1. **Welcome the children and tell them that they will be exploring how life is depicted on Mars through books and video clips, which they will then use to create their own short Mars Science Fiction 'Movie Trailer' Zine.** Ignite their imaginations with a few questions before diving into the activity. Have them draw/write their ideas on a large sheet of butcher paper or poster board:

   - Have you ever dreamed or thought about going to Mars?
   - What do you think it is like on Mars?
   - What type of life forms (aliens) do you imagine when you think of Mars? *Draw it!*

   If appropriate, point back to the group definition of life developed during the *Searching for Life* activity, and remind them to keep it – and what they have learned about Mars – in mind as they work together to create a short science fiction "movie trailer" together.

2. **Introduce the children to the Mars science fiction books. Invite them to consider the descriptions of Mars and Martians in one or more science fiction works, either by listening to excerpts read to them or by reading individual works/excerpts themselves with a book club/small group.** Note the publication date of each work you feature, and ask the children to think about how our understanding of Mars has changed since that time. Explain that our understanding of Mars has changed over time as scientists continue to study Mars with telescopes, orbiting spacecraft, landers, and rovers. Often this change in our understanding is reflected (at least partially) in literature, such as the science fiction works.

- Why do you think that there are so many stories about Mars?
- What aspects of the author's description do you think are scientifically accurate?
- How do you think our understanding of Mars has changed since this work was written? How is our view of Mars different today?

Note: You may lead this in a story time fashion with the group, bringing in a professional storyteller, if available. Many librarians do their own storytelling – at least with younger children.

3. **Play 2–3 short video clips from sci–fi movies for the children.**

4. **Invite the children to use their imagination and create a Mars Sci–Fi 'Movie Trailer' Zine!** Introduce the Zine to them (show them an example). Explain that they will create miniature comic books to take home. Have them consider what others might want to know about life on Mars. Remind them to use a format similar to the movie trailer video clips that they watched in their drawings and text. Have them write and illustrate a concept on the Zine template. Optional: Invite them to use the *Life on Mars?* Trading Cards as inspiration for their trailers.

   Things to keep in mind and to guide the children's effort (you may provide fiction and non–fiction books about Mars to help the children):
   - Were there any facts that you learned about Mars that that you would like to include in your fictional story? What did you find the most interesting about Mars?
   - What do you think it would be like to live on Mars? What is it like on Mars? How does it compare to the Earth?
     - What color is it? Red, orange, brown, etc.
     - Is it hot, cold, or both? Cold and dusty!
     - Is it smaller, larger, or about the same size as Earth? Smaller!
     - Is it closer or farther from the Sun than Earth? Farther!
     - What would it be like to live on Mars? Are there mountains? Rivers? Forests? No, it is soil and rock – very dusty.
     - Does it have more or less gravity than Earth? Less (~40% of the Earth's)
     - Is a Martian day longer, shorter or the same as an Earth day? Almost the same – Martian day, also known as a 'Sol' is only about 40 minutes longer than an Earth day.
     - Atmosphere, volcanos, craters, rivers, etc. take them back to the other activities they have undertaken.
   - The children outline the following in order to create their "movie trailer" Zine:
     1. <u>Introduction (Beginning)</u> – Who (main character), What, and Where (this is setting the scene for the story)
     2. <u>Problem/Challenge (Middle)</u> – What is going on? What challenge does the main character(s) face?
     3. <u>Concluding question (End)</u> – An intriguing open–ended question to peak people's curiosity and motivate them to want to see the movie. Why should they watch? What is the personal relevance?

- Have them follow the instructions to fold and staple their Zine into a booklet.
- Optional: Have the children complete the *Extreme–O–File: The Story* activity pages to help them in the process of creating their Zine.

5. **Invite the children to take their Zines home with them.** Encourage them to create a short story based on their Zine at home.

6. **Optional: Collect and photocopy the children's Zines for the library's collection.** Explain that you will add their photocopied creations to your library's collection (circulation) to share with the community.

   Optional: You may have the children complete this at home (on their own), if needed due to time constraints. However, this would prohibit you from featuring their stories in the library's circulation to share with your community.

In Conclusion

Summarize what was discovered about how life on Mars is depicted in sci–fi books and movies, how it compares to Earth, and how science fiction has reflected our (changing) understanding of the red planet over time.

Extension

Work as a group to create and film a Mars Sci–Fi 'Movie Trailer.'

- Collect signed video release forms from the parents/guardians of each child.
- Provide the group with various props and craft materials (i.e., boxes, sand, craft items (pompoms, craft sticks, pipe cleaners, construction paper, plastic/stuffed creatures or animals, fake plants/flowers, cans, tape, aluminum foil, Play–Doh®, etc.). Note: If you have conducted other activities within the *Explore: Life on Mars?* module, incorporate props and creations from those activities here, if available (i.e., Mars landscape, volcanos, creatures, etc.)
- Have the children brainstorm together, and then break the group into 3 smaller groups to create a "movie trailer" composed of 3 scenes:
  1) Introduction – Who, What, and Where (setting the scene)
  2) Problem/Challenge – What is going on? What challenge does the main character(s) face?
  3) Question – An intriguing open–ended question to peak people's curiosity and motivate them to want to see the movie. Why should they watch? What is the personal relevance?
- Optional: Partner with a local film group or college/university. Recruit film students/professionals to help in the creation, filming, and editing of the movie trailer for the group.

National Science Education Standards

Grades K–4

Science and Technology – Content Standard E

Understanding About Science and Technology

- People have always had questions about their world. Science is one way of answering questions and explaining the natural world.

Grades 5–8

Science and Technology – Content Standard D

Earth in the Solar System

- Earth is the third planet from the Sun in a system that includes the Moon, the Sun, eight other planets and their moons, and smaller objects, such as asteroid and comets.

Grades 5–8

Language Arts Focus

- Practice listening to and understanding nonfiction text.
- Understand scientific terms and descriptive scientific language
- Children use a variety of information resources to gather and synthesize information

Activity 1: Searching for Life

Adapted from "It's Alive!" from Destination: Mars, NASA Johnson Space Center, 2002 (http://solarsystem.nasa.gov/docs/destmarsLes5.pdf).

Overview

In this 45–60 minute indoor activity, children ages 8 to 13 discuss how life is defined and conduct a simple experiment, looking for signs of life in three different "soil" samples. The experiment introduces the children to the difficulty that scientists face in defining life. By observing the soil samples, the children try to determine if any contain signs of life and work to identify, refine, and create a set of characteristics that may be used to identify living versus non–living things. The activity concludes with the development of a group definition of life. This group definition will be important, and should be referred to as the children work through the subsequent module activities (if they are undertaken).

This activity compliments the later *Mars Engineering* activity and can be combined with a presentation by an astrobiologist, planetary scientist, or NASA Solar System Ambassador, if desired. It is highly recommended for this activity to be proceeded by the Ice Breaker activity.

What's the Point?

- When scientists look for life, the signs are not always easy to determine.
- Natural chemical reactions could be confused with evidence for life.
- There is no firm scientific definition of life, no **single** test that can prove its presence or absence, and no **single** characteristic that applies to all living things. For example, mountains may grow but are not alive. Fire can also grow, take in nutrients (oxygen and fuel), and give off waste products. However, fire is not considered to be a living thing. Scientists need to use **multiple** tests and characteristics to define life.
- Living things have certain recognizable properties.
- There are characteristics that almost all living things share.
- Scientists use a group definition of life to conduct their research, and *Explore: Life on Mars?* participants will likewise use a group definition to conduct activities in the module.
- One basic definition of life is that it does something, and that it keeps on doing it.

Tips for Engaging Girls in STEM:

- **Use group work and collaboration to help engage children.** Girls benefit from collaboration, especially when they can participate and communicate fairly. Girls are energized by the social part of science, working and learning together. This activity gives the children the opportunity to collaborate and work together in a fun and engaging social environment.
- **Encourage critical thinking.** Girls gain confidence and trust in their own reasoning when encouraged to think critically. This activity provides an opportunity for children to use their observational skills and think critically about identifying signs of life.
- **Expose girls to female role models who have achieved in math and science in order to promote positive beliefs regarding women's abilities.** If possible, have a female speaker share the science of astrobiology, and how scientists look for life in the universe. This activity also provides activity pages, scientist spotlight pages, and trading cards featuring female (and male) astrobiologists as an additional resource to connect children with careers in science and to challenge existing stereotypes of scientists.

Materials

For each pair of children:

- 3 (clean) Plastic cups (5–8 oz.), clear if available
- ¾ to 1 cup of Sand, enough to fill each cup ¼ full
- 3 teaspoons (tsp.) Sugar
- 1 teaspoon (tsp.) Instant active dry yeast
- 1 tablet of crushed (as finely as possible) Alka–Seltzer® or comparable fizzing tablets
- Hot water, enough to cover the sand in each cup (not hot enough to kill the yeast)
- 1 Pitcher, carafe, or other appropriate container for the hot water
- Optional: Library books related to the topic (suggested book list below)
- Optional: A variety of colorful Post–it® notes

For each child:

- 1 Pencil/pen
- 1 Copy of the *Extreme–O–File: Searching for Life* activity pages

For the facilitator:

- Background information
- Shopping list
- Flip chart, white board, or blackboard and appropriate writing utensils
- Permanent marker for writing on the cups

- Thermometer
- 3 Craft sticks or Spoons (for mixing cups A, B, and C)
- Container (large mug, cup, or pitcher) of water to fill all of the cups to cover the sand. You should use water that is between 105° – 115° F (check the temperature with the thermometer).
- Optional: Article on "Defining Life"

Preparation

- Review the activity procedures, activity pages, and background information.
- Prepare 1 set of 3 cups for each pair of children before the event/program: Each cup will contain sand and should be approximately ¼ full of sand. Each cup should also contain 1 tsp. of sugar.
    - Mark one cup "A." This cup should contain only the sand and sugar. Mix well using a craft stick or spoon.
    - Mark the second cup "B." Add 1 finely crushed tablet of Alka–Seltzer® or other comparable fizzing tablet to the sand and sugar. Mix well using a craft stick or spoon.
    - Mark the last cup "C." Add 1 tsp. instant active dry yeast to the sand and sugar. Mix well using a craft stick or spoon.

  Note: Make sure to use a different stirring stick/spoon for each type of cup (A, B, and C) to avoid cross–contamination.

- If possible, invite an astrobiologist, planetary scientist, or NASA Solar System Ambassador to present during the program/event. Consider the following tips for selecting a guest presenter and impacting persisting stereotypes:
    - Invite a female or representative of another underrepresented group.
    - Invite a dynamic, personable speaker to counteract the stereotype that scientists are solitary and boring.
- Make copies of *Extreme–O–File: Searching for Life* activity pages
- Optional: Select and set aside library books and resources related to the topic.
- Acquire a selection of books about astrobiology
  Suggested books:

  ALIEN LIFESEARCH
  David Jefferis, Crabtree, 1999, ISBN: 0–7787–0049–6
  This book presents the idea of life on other worlds showing evidence such as a meteorite that some scientists believe contains fossils of past life on Mars. It also includes sections on the origins of life, a look throughout the universe and designing an alien. For children ages 8–11.

  ARE WE ALONE? SCIENTISTS SEARCH FOR LIFE IN SPACE
  Gloria Skurzynski, National Geographic Children's Books, 2004, ISBN 079226567X
  Humans have always been fascinated with extraterrestrial life. Scientists look for it using telescopes, space missions, and planet explorations. They study extremophiles, organisms that live in extreme environments on Earth, in the

hopes that they will lead us to a better understanding of how life may exist in space. For children ages 10 and up.

ASTROBIOLOGIST (WEIRD CAREERS IN SCIENCE)
Mary Firestone, Chelsea House Publishing, 2006, ISBN 0791089711
See how scientists from many different fields are all working to determine if there may be life beyond Earth. For children ages 10 and up.

IS THERE LIFE IN OUTER SPACE?
Isaac Asimov and Richard Hantula, Gareth Stevens Publishing, 2005, ISBN 0836839501
This book transports young astronomers into a realm of speculation, hypothesis, and conjecture about the possibility of life in outer space. For children ages 8 and up.

LIFE IN OUTER SPACE
Kim McDonald, Raintree, 2001, ISBN: 0–7398–2223–3
Topics covered include: what is astrobiology, life's raw materials, extreme biology and searching for ET. Good images are included. Great book for children ages 7–12.

LIFE ON OTHER PLANETS
Rhonda Donald, Children's Press, 2004. ISBN 0531163741
A comprehensive look at the question of whether there is life on other planets, from the imaginative visions of fantasy novels and science fiction movies to the facts revealed by today's cutting–edge technology. For children ages 9 – 14.

MARS AND THE SEARCH FOR LIFE
Elaine Scott, Clarion Books, 2008, ISBN 0618766952
Mars is a desolate, hostile world, with unbearably cold temperatures, no atmosphere to speak of, and violent dust storms – could there ever have been life there, in some form? For children ages 9 and up.

THE SEARCH FOR EXTRATERRESTRIAL LIFE
Don Nardo, Lucent Books, 2006, ISBN 1590188322
Scientists have long suspected that the human race is not alone in the universe. This fascinating volume explores the scientific probabilities of extraterrestrial life and current scientific efforts to find it. For children ages 12 and up.

Note: Please see the module Resources List for more book suggestions.

Activity

Divide the children into small groups of 2–3 children each.

1. **Welcome and introduce the topic/module.** Explain to the children that in this activity, they are going to discuss how we define life and conduct an experiment to test for the signs of life (much like a rover on Mars may do) – creating a group definition of life to use in later activities. Having a clear definition is important for scientists, too. In order for a rover, like the Curiosity rover on Mars, to find signs of life, scientists need to have a clear understanding of what to look for – how to identify living versus non–living!

2. **Ask the children what the characteristics of life are.** Invite the children to work in their small groups and then to share their answers and examples. Write their responses on the White Board/Poster/Chalk Board. *Optional: You may write their responses on colorful Post–It® notes and post them on a poster or wall.*

   As a group, you should work to create an initial definition for life together that they will use as they move on to complete more of the *Explore: Life on Mars?* activities. Optional: Have the children record their definition (set of characteristics) on their Extreme–O–File activity page. *Note: If you have previously conducted the Ice Breaker activity, you should incorporate the characteristics compiled during that activity here and add to them/refine them.*

   - What are some examples of living things? Cat, dog, tree, flowers, grass, many possible answers here
   - What are some examples of non–living things? Car, TV, table, many possible answers here
   - What tells you that something is alive (i.e., characteristics of living things)? How can you tell that it is alive? It moves, breathes, eats, reproduces, it responds to changes in its environment, many possible answers here.
     - <u>Living example</u>: A cat needs to be fed and watered, provided shelter. It can breathe, move on its own, reproduce, and respond to its environment (make choices).
     - <u>Non–living example</u>: A car “eats” or consumes a fuel (gas), and its engine need to “breathe” (i.e., take in fresh air and release used air – exhaust), but it is not alive. It cannot reproduce, move on its own (needs an operator), or respond to its environment (make decisions).
     - One (single) characteristic cannot be used to distinguish between living and nonliving. We need to develop more tests (questions) that we can use together to determine the presence of life. Scientists also have to do this!

3. **Invite the children to conduct an experiment searching for signs of life in three different “alien” samples, based on the characteristics they defined.** Pass each small group the 3 prepared cups A, B, and C, and a copy of the *Extreme–O–File: Searching for Life* activity page.

- Examine your samples – look and even smell the samples (do not taste them). Fill in the first observation on your observation page.
- Do you detect any visible evidence of life? *No – Unless they recognize the yeast, there won't be any true evidence of life yet.*

4. **Invite the children to add hot water to their samples.** Pass around the hot water to the children and ask them to add the water to each cup, filling it up halfway (to completely cover the sand and leave some water on top). Alternatively, fill the cups to the appropriate level for them. *Note: Caution them to be careful while handling the hot water.*

   - What do you notice? Invite them to make observations and record their observations (optional).

After a few minutes...

- **Ask the children what they see, smell, and feel. Invite them to share what they've seen.** They should comment that the second cup, B, is showing a reaction with bubbling.

5. **Discuss the definition of life with the children, while the water continues to react with the materials in the cups.** Discuss the scientific perspective on life, and consider how life might be different on other planets. Encourage all ideas, and write their responses on the flip chart/white board.
   - How can you tell living things apart from nonliving things (recall the Ice Breaker Activity if applicable)? *If it moves, breathes, eats, reproduces, learns, uses energy, is made of cells, grows, evolves, respond to changes in the environment, produces waste, etc.*

Facilitator's Note: Share that scientists do not agree on exactly how to define life; it is a difficult subject. Machines can be built to make other machines, computers can be programmed to learn, and cars also need fuel and use energy and move. ***One of the most basic definitions that may be applied is that life does something and keeps on doing it (while living).***

6. **Observe any further changes in the "alien" samples.** Ask the children to observe their three cups again and record their last observations.
   - What do you see, smell, and feel? *Invite them to share the changes that they've observed. [Cup B should no longer be reacting. Cup C may be warmer to the touch than the other cups, and should have a layer of foam on top, and a yeast/dough smell.]*
   - What is the evidence of life? Are any of the cups showing something happening and continuing to happen? [*The quick reaction in Cup B is a chemical reaction, not an indication of life. Cup C is demonstrating a sustained reaction.]*

Describe the ingredients for each cup, and for each cup, ask whether the sample contained life. Describe the yeast sample last. Let the children know that yeast is a fungus that was growing, using the sugar and giving off carbon dioxide, which created the foam. While they could not see the yeast itself (it is microscopic), they were able to observe signs of life, such as the foam and gas bubbles. They may have also noticed that the cup was getting warmer – another sign of life from the yeast. Scientists suspect that any life present on Mars would have been (or is) microscopic (i.e., too small to see with the human eye). Thus, scientists need to observe for signs of life much like the children have just done!

Revisit the group definition/set of the characteristics of life. Do you have any changes or additions to make to your definition? If so, add/change as needed. Have the children record it their findings in their *Extreme–O–File* activity pages.

Facilitator's Note: Studying (unicellular) yeast cells, such as those in the experimental cup C, has provided many scientific advances in biology over the years. Yeast has even made it into space to study the effects of microgravity. In fact, researchers today are using yeast to help understand the development of multicellular life forms that exist on Earth today, alongside the unicellular forms. By understanding how life developed on Earth, they hope to understand how life may have developed beyond our planet.

For more information about how yeast is being used to study the origin of life, please visit: http://astrobio.net/components/com_news/newsPrintDetail.php?id=4477

In Conclusion

Ask the children whether it was difficult to identify the soil sample with life? If so, why? Which of their senses were most useful as they were observing? Note that scientists use instruments to make observations. For example, they can use instruments that measure the chemical composition of air as their form "smell" on another planet (like Mars). Did the children use their noses and notice any differences between the "soil" samples during the activity?

Summarize the experiment and its results. How did this experiment affect and help you to create your group definition of life?

Share that, while at first it might seem like determining if something is alive or not is easy, defining life is actually much more difficult than many people realize. Optional: Have the children record the group definition in their activity pages.

Revisit your refined group definition. Explain how an experiment may be used in missions (such as their rovers) to search for signs of life in other places, such as Mars. By refining our understanding of life, we are better able to look for it elsewhere! This is what astrobiology strives to do!

Defining life is not a simple task and even scientists do not completely agree on all of the characteristics that should be used to do so. Tell the children that they will refine their group definition as they continue to explore the possibilities of life on Mars in the later activities.

Correlations to National Science Standards

Grades K–4

Science as Inquiry – Content Standard A

Understandings about Scientific Inquiry

- Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.
- Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations.

Life Science – Content Standard C

The Characteristics of Organisms

- Organisms have basic needs. For example, animals need air, water, and food; plants require air, water, nutrients, and light.

Grades 5–8

Life Science – Content Standard C

Regulation and Behavior

- All organisms must be able to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment.

Searching for Life

Extreme-O-File Activity Pages

Name: ____________________________

Searching for Life

Group Definition of Life (Characteristics of living things):

____

____

____

____

1. **Compare the three cups of material before adding the hot water. Observe without touching or tasting any of the samples (smelling is okay, as is touching the outside of the cup). Circle the words you would use to describe each cup and draw each in the cup-shaped space below. Do any show any signs of life?**

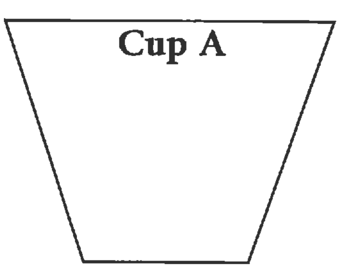
Cup A

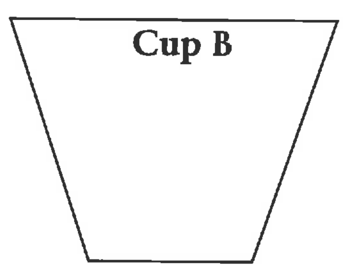
growing	slushy	foamy	warm	cold	moving
shrinking	bubbly	smelly	(add your own description)		

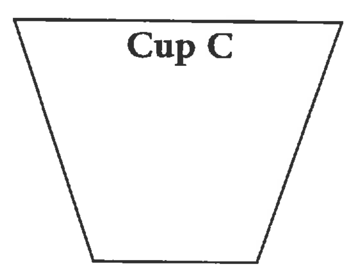
Cup B

growing	slushy	foamy	warm	cold	moving
shrinking	bubbly	smelly	(add your own description)		

growing	slushy	foamy	warm	cold	moving
shrinking	bubbly	smelly	(add your own description)		







2. After hot water is added:
Observe without touching or tasting any of the samples (CAUTION: the water may be very hot). **Write down and draw your observations for each cup below. Do any show any signs of life?**

Cup A	Cup B	Cup C

3. Final analysis: Wait at least 5 minutes after adding the hot water. Observe without touching or tasting any of the samples (smelling is okay, as is touching the outside of the cup). **Write down and draw your observations for each cup. Do any show any signs of life?** Circle the cup **with the evidence for life.**

Cup A	Cup B	Cup C

Group Definition of Life (Refined from this activity):

____

____

____

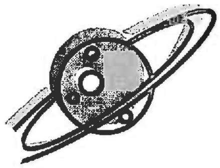
____

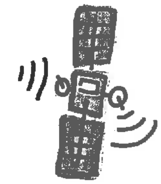
Strange New Planet

Draw the features you see on the planet at each stage of exploration.

Telescope on Earth	Telescope in space
Space Probe	Orbiter

Lander	Sample Return Mission





Strange New Planet

Adapted from *Mars Activities: Teacher Resources and Classroom Activities* (http://mars.jpl.nasa.gov/classroom/pdfs/MSIP-MarsActivities.pdf), a Mars Education Program product from the Jet Propulsion Laboratory and Arizona State University.

Overview

Children ages 10 to 13 work in teams to collect data and plan missions to explore unknown worlds! The facilitator creates three "planets" out of clay decorated with craft items ahead of time. In this 45-minute activity, the planets are unveiled and teams send observers armed with "viewers" (paper towel tubes) to study them. The observers first view the planets from a distance to simulate observations by groundbased telescopes, then have opportunities to study them from increasingly closer distances during flybys and orbits. The teams use their collected information to plan lander and sample return missions.

What's the Point?

- Space missions are scientific investigations that involve observing and describing planets and moons. Sample return missions allow scientists to collect and analyze specimens.
- Space scientists use technology, such as telescopes and robotic spacecraft, to help them make better observations. Robotic spacecraft may fly by or orbit a planet, or they may investigate the surface (landers and sample return missions).
- Scientists plan exploration missions based on previous scientific knowledge and investigations. Different kinds of investigations answer different kinds of questions.
- Scientists and engineers often work in teams with different individuals doing different things that contribute to the results. The team members work together to gather and analyze data, and they use that data to plan future investigations.

Materials

For the group:

- Modeling clay, Play-Doh©, Styrofoam© balls, plastic balls, balloons, or rounded fruit (pumpkins, oranges, grapes, etc.) (enough to make 3 "planets" with additional for "moons," if desired)
- Craft and food materials:
  - Planet surface features: small stickers, sequins, candy, marbles, cotton balls, felt, toothpicks, pasta, beads (use your imagination!)

    - "Life": butterfly stickers or cloves
    - Scents (optional): scent stickers, spices such as cloves, vinegar, perfume, or other scents
- 1 (2' × 3') dark-colored cloth
- Glue or tape
- Toothpicks
- 1 pedestal or stool
- A space large enough for the children to observe the "planets" from varying distances of 30 feet to less; children should be able to circle the "planets" from a distance of 2 to 5 feet
- 5 sheets of poster paper
- 2-4 markers of different colors
- Optional: a computer, projector, and access to the following websites:
    - NASA's Solar System Exploration Timeline allows site visitors to scroll along an interactive display of "robotic firsts," beginning with Sputnik 1 in 1957 and extending into the future. Appropriate for ages 8 and up. http://solarsystem.nasa.gov/external/timeline.cfm
    - NASA's Eyes on the Solar System combines video game technology and NASA data to create an environment for users to ride along with NASA spacecraft and explore the cosmos. Appropriate for ages 8 and up. http://eyes.nasa.gov/

For each team of three to four children:

- 2 cardboard or rolled paper tubes
- 2 (5" × 5") blue cellophane squares
- 2 rubber bands
- Masking tape
- 1 set of *Our Solar System* (NASA educational product number LS-2001-08-002-HQ, http://solarsystem.nasa.gov/multimedia/download-detail.cfm?DL_ID=262) lithographs, preferably in color
- Books about the exploration of the bodies in the solar system (optional)
- Paper
- Pencils or pens

Preparation

- Create three "planets" using the craft and food materials. Decorate the planets with beads, stickers, sequins, candy, marbles, scents (optional), etc., to make the object interesting to observe. Some of these materials should be placed discreetly so that they are not obvious upon brief or distant inspection. Some suggestions for features are to create cotton-ball "clouds," carve channels, add moons by attaching grapes with toothpicks, affix small stickers or embed other objects into the planet, and apply scent sparingly to a small area. To one planet, attach something that depicts life or is alive, e.g., butterfly stickers or cloves.

- Prepare a large, open area with the planets elevated at the center on a pedestal or stool. Drape the dark-colored cloth over the planets. Allow enough room for the children to observe the planets from an initial distance of about 30 feet. Leave a clear path around the planets for the children to walk in a complete circle ("orbit") around them from a distance of about 2 feet.
- If desired, make two viewer tubes for each team ahead of time. Attach the blue cellophane squares to one of the ends with a rubber band (this will be removed by the children after their initial observations).
- Gather information sources about the exploration of our solar system. You may wish to include books about the planets, dwarf planets, moons, asteroids, and comets that discuss the history of their exploration. NASA's *Our Solar System* lithograph set and NASA websites are sources of information about the various missions.
- Hang the sheets of poster paper around the room. Draw a line down (or across) each piece, so that it is divided in half. Label one section Mercury, one Venus, and continue for the rest of the planets on the remaining four sheets. Include one section for Earth's Moon. The moons of other planets can be grouped with that planet.

Activity

1. Brief participants on their mission: to explore strange new planets.

- How do scientists explore planets? *Astronomers look at planets through telescopes on the ground (like in observatories) or in orbit around Earth (like the Hubble Space Telescope). NASA and other agencies send robotic spacecraft to fly by, orbit, or land on other planets and moons. Only one other body in our solar system has been visited by humans — the Moon!*

Explain that in this activity, the children will work in teams to remotely explore strange, *new* planets, report the data they gathered, and then form questions they can help answer with the next exploration step. Each stage of the exploration provides progressively more detailed information. Team members will either serve as observers who study the planets and collect information or as mission control scientists on Earth. The roles will switch at each stage of exploration so that all team members have the opportunity to serve in both roles.

2. Divide the children into teams of three to four and allow each member to select a role to play (or assign one) for the initial step. Arrange the teams at one end or side of the room — this is mission control. Provide two viewer tubes to each team for the two observers. If the tubes were not assembled beforehand, instruct the children on how to assemble them. Provide paper and pens or pencils to the mission control scientists.

Provide the mission control scientists of each team with the books, lithographs, and posters to discover examples of historic telescopic observations and flyby, orbiter, lander, rover, and sample return missions. Prompt them to note which planets and moons have been visited by these different types of missions; at the close of the activity, they will have the opportunity to share what they learned about the exploration of our solar system.

3. Pre-Launch Reconnaissance: Invite the observers to study the planets from Earth-based telescopes. Have the observers stand 30 feet away from the covered planets while the mission control scientists remain seated. Instruct the observers to place their tubes at one of their eyes and the scientists to turn away from the covered planets. Emphasize that the planets may only be viewed through the viewers.

- What does the blue cellophane represent? *Earth's atmosphere.*
- How does Earth's atmosphere affect your ability to see detail? *Makes it harder.*

Remove the cloth covering the planets. Teams observe the planets using their viewers for one minute. Replace the cloth. Invite the observers to report back to Mission Control their observations of color, shape, texture, and position. Invite the children to make drawings of their discoveries and note questions they would like to pursue. Allow time for the teams to discuss the observations and plan a closer inspection of the planets.

Have the teams repeat their observations from the distance of 30 feet for one minute with the cellophane removed from their "telescopes." Allow the observers to update Mission Control and have the teams record any new observations.

- Were their observations different? In what way? *Without the cellophane — "Earth's atmosphere" — details could be seen more clearly.*
- How might scientists minimize — or remove — the affect of Earth's atmosphere? *They could put telescopes on high mountains or completely above the atmosphere.*
- Do we have any telescopes that are above Earth's atmosphere? *Yes, the Hubble Space Telescope!*

4. Mission 1 — The Flyby: Invite two new observers from each team to walk quickly past the "front" side (the side they just viewed from a distance) of the planets at a distance of 5 feet. Ask them to place the tubes at their eyes.

Uncover the planets but leave one side draped under the cloth. Invite the observers to file past. Teams then reconvene at the side of the room (Mission Control) with their backs to the planet while the other teams conduct their flyby. Replace the cloth over the planets once all the flybys have taken place. Allow the teams time to discuss what data they gathered and what they will look for on the next orbit mission.

5. **Mission 2 — The Orbiter: Invite the observers to walk around the planets in a circle (orbit) at a distance of 2 feet.** (The children should rotate roles so that other team members again have a chance to observe.) They observe distinguishing features through their viewers and record their data back at Mission Control. Invite the teams to use the information to plan the next mission.

- Where would your team like to send a lander? What one location out of the three planets would you choose? What features will you examine?

6. **Mission 3 — The Lander: Invite one member of each team to approach their landing site and mark it with masking tape.** Emphasize that only one planet may be visited — missions of exploration are expensive! Invite the new observers to observe the landing site with the viewers. Instruct them to keep the field of view constant by aligning their viewers with the tape located inside and at the top of their viewers. After observing for five minutes, the observers return to Mission Control to record their findings and plan a sample return mission.

- Based on what you learned from your explorations, what one sample will your team collect?

Sample return missions are very expensive and must be carefully informed by all the previous mission data.

- What questions will you be able to answer based on that sample?

7. **Mission 4 — Sample Return: Invite the observers (again, rotate roles) to collect *one* sample (a tiny pinch) from *one* planet.** Have the observers bring the samples to their Earth laboratories for examination.

Invite the teams to share their interpretations of the characteristics of each planet, based on their observations.

Invite the children to share what they learned about the missions across our solar system. Record their findings for each planet and its moons on the appropriate sheet of poster paper. Note that they will not necessarily know about all the missions in the short amount of time available, but they will have a sense of past and present exploration.

- Are there any missions happening around or on other planets or moons right now? Which planets or moons? What kinds of missions? *Lots of satellites are orbiting Earth, and Earth's Moon. Mars currently has orbiters and rovers, and recently a lander has been active. A mission is on the way to Pluto (New Horizons). Another is orbiting Saturn (Cassini). One is orbiting Mercury (MESSENGER).*

- Which planets and moons have been visited by flybys?
- By orbiters?
- By landers?
- By human missions?
- Which planets have been studied by the most missions — and why? *Earth, Earth's Moon, Mars*
- The least — and why? *Uranus, Neptune, and Pluto*
- Where would they like to see a mission travel? What kind of mission? Why to that planet and why that kind of mission?

Conclusion
Unveil the planets and invite the children to look at them (without their viewers).

- What did you first observe through the viewers? How did the blue cellophane affect what you saw?
- What surprised you when you were able to remove the cellophane and take a closer look (fly by)?
- Did the orbiting mission reveal anything surprising on the "back sides" of the planets?
- Were there any indications of life on the planets? What were the clues?
- What was the role of Mission Control scientists?
- How did your drawings — your scientific understanding — change as you learned more?
- How did you decide what to observe next?
- Would you like to be a scientist or engineer sending missions to other planets?

Standards
Correlations to National Science Standards

Grades K-4
Understandings About Scientific Inquiry

- Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.
- Scientists use different kinds of investigations depending on the questions they are trying to answer. Types of investigations include describing objects.
- Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations.

Science and Technology — Content Standard E
Understandings About Science and Technology

- Scientists and engineers often work in teams with different individuals doing different things that contribute to the results. This understanding focuses primarily on teams working together and secondarily on the combination of scientist and engineer teams.
- Tools help scientists make better observations, measurements, and equipment for investigations. They help scientists see, measure, and do things that they could not otherwise see, measure, and do.

Grades 5-8

Physical Science — Content Standard B

Science as Inquiry

- Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects; some involve collecting specimens; some involve seeking more information; some involve discovery of new objects.
- Current scientific knowledge and understanding guide scientific investigations.
- Technology used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations.

Geologic Scene Investigators: Part 1 – Scratching the Surface
Crater Creations
from *Explore*: Mars Inside and Out

Overview
In the 30-45 minute *Crater Creations* activity, teams of children ages 8-13, experiment to create impact craters and examine the associated features. The children observe images of Martian craters and explore how the mass, shape, velocity, and angle of impactors affects the size and shape of the crater.

This activity has been modified from *Impact Craters*, an activity in Exploring the Moon: a Teacher's Guide with activities for Earth and Space Sciences, NASA Education Product EG-1997-10-116-HQ by J. Taylor and L. Martel (http://www.spacegrant.hawaii.edu/class_acts/EP-306.html).

What's the Point?
- Impact craters are caused when an impactor collides with a planet.
- A crater's size and features depend on the mass, velocity, and incoming angle of the impactor.
- Impact craters provide insights into the age and geology of a planet's surface.
- Models – such as the children are using here - can be tools for understanding the natural world
- Geologists use features on Earth to help them understand how similar features may have formed on other planets, like Mars

Materials
For each child:
- One GSI Journal *Mars Inside and Out* or One GSI Journal *Part 1: Scratching the Surface*
- One pencil

For each team of 4-8 children:
- A large pan or box such as a dish pan, aluminum baking pan, or copy paper box lid, (larger pans allow children to drop more impactors before having to re-smooth or resurface)
- Enough sand, sugar, rice, or oatmeal to fill the pan about 4 inches
- Enough flour to make a 1" to 2" deep layer
- 1 heaping cup of powdered cocoa
- A sifter
- A large trash bag or piece of cloth or plastic to place under the crater box
- Several objects that can be used as impactors, such as large and small marbles, golf balls, rocks, bouncy balls, and ball bearings. Use your imagination!
- Ruler
- Paper and pencil
- Images of craters from the *Setting the Scene* activity
- Safety glasses

For the Facilitator:

- Background Information

Preparation

- Prepare an area large enough to accommodate the crater boxes for the number of teams participating. Allow several feet between each box.
- Prepare the appropriate number of crater boxes
  - Fill a pan 4 inches deep with sand, sugar, rice, or oatmeal
  - Add a 1 to 2 inch layer of flour
  - With the sifter, sprinkle a thin layer of powdered cocoa on top of the flour (just enough to cover the flour)
  - Provide several impactors, a ruler, and images of craters beside each box

Activity

1. Introduce the activity by asking the children what they think will happen when an impactor – a heavy object – is dropped into one of the boxes.

2. Divide the children into groups of 3 to 5 and have each group stand by a box. Invite them to begin experimenting by having them select one impactor to drop and determining from what height they will drop it (encourage them to not throw their impactor). What do they think will happen? Have each teams drop their impactor one at a time.

- What do they observe?
- Does the feature that was created look like any of the features they observed on the surface of Mars or Earth?
- Which features? *Craters – roughly circular depressions on the surface of a planet.*
- How are they similar? Different? *Some similarities include the circular shape and depression, and the material that is excavated from the crater and forms a rim – the ejecta. Some differences include the fact that the impactor is still present in the model. Long bright streaks – rays - probably extend out from the crater they created; these also occur in some places on Mars and the Moon..*

After each crater creation, ask them to carefully remove their impactor, to make the crater clearly visible (in reality, impactors are completely - or almost completely - obliterated upon impact; any remains of the impactor are called "meteorites").

3. Now, taking turns, let the children experiment with creating craters! Have each group conduct an experiment by changing one variable to see how it affects impact crater size. Experiments could explore different impactor sizes, weights, distances dropped, or angles of impact. For example, one group could drop the same impactor from different heights (modeling different velocities of the incoming impactors), and another group could experiment by dropping different sized impactors from the same height. If the children want to experiment with angles of impact they will need to throw the impactors at the box; caution should be used to make sure no one is standing on the opposite side of the box in case the impactor misses. Invite the children to predict what will happen in their experiment. Have the children measure the width and depth of each impact crater formed in their experiment.

- What did the groups observe?
- How did the weight of objects affect the size and depth of the crater you created?
- How did the size of the object affect the size and depth of the crater?
- How did dropping or throwing the impactors from different heights affect the size and depth of the craters they formed?

In Conclusion

Have the children reflect on what they observed and the images from Mars and Earth. Invite them to record what they learned in their *GSI Journal*s.

- What features did the children create in their models? *Impact craters.*
- Do similarly shaped features occur on Mars or Earth? *Yes, both.*
- How are they different? *The craters on Mars are much, much larger.*
- How do the children think the craters on Mars and Earth formed? *By large impactors – asteroids or comets - striking the Earth and Mars.*
- Scientists have not actually seen any large asteroids or comets hit Mars, but they think the large craters on Mars - and on other planets and moons - were created by them. Scientists have observed very small asteroids hitting Earth and several pieces of Comet Shoemaker-Levy struck Jupiter. When the children see "shooting stars" – more accurately called "meteors" – they are seeing tiny dust to sand-sized "asteroids" that are streaking toward Earth's surface. They are too small to make craters or leave any meteorites to collect.
- What evidence might scientists have to make them think impactors created these craters? *Scientists experiment with models – like the children did – to determine what type of feature an impactor might leave behind. They also have other evidence from some craters on Earth – like fragments of the asteroid (meteorites), or alterations to the rocks and minerals at the impact site caused by the impactor striking the ground at high speed.*

Invite the children to reflect on what they learned during all of their different investigations.

- How might observations on Earth help scientists interpret what they see on other planets? *Scientists study features – like volcanos – on Earth to understand their shape and size, what they are made of, and how they form. On Earth, this information can be used to predict where volcanos may form, and when they may erupt. By understanding volcanos on Earth, scientists can interpret what they see on other planets. If they see a feature that is similar in shape and detail to volcanos on Earth, even if the volcano is not erupting, they can interpret that it is a volcano – and this tells them about the history of the planet.*
- How might relying on Earth observations not be a good model for scientists to use when studying other planets? *Other planets may have characteristics that*

are not the same as on Earth. Titan, the large moon of Saturn, has features that look like river channels, but these were carved by liquid methane – not water!

If things might be different, why not stop trying to understand other planets until we can go there? First, what's the fun of that? And second, it may be a long time until we get there! Planetary geology is about creating a picture of what it is like on a planet and how it has changed over time. Geologists use every piece of evidence they can – images from telescopes and spacecraft, information from rovers – to help them paint this picture. As they get more information, they alter the picture to fit the evidence. By studying what is available, scientists can help to identify the important questions that we should address in future robotic and human missions! And by understanding how planets change – and why – we can better understand how Earth has and will change. Learning about the history of water on Mars can tell us more about our own future.

National Science Education Standards
Grades K-4
Science as Inquiry - Content Standard A
Understanding About Scientific Inquiry

- Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.
- Scientists use different kinds of investigations depending on the questions they are trying to answer. Types of investigations include describing objects, events, and organisms; classifying them; and doing a fair test (experimenting).
- Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations.

Earth and Space Science - Content Standard D
Changes in the Earth and Sky

- The surface of the Earth changes. Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes - and impacts!

Science and Technology - Content Standard E
Understanding About Science and Technology

- People have always had questions about their world. Science is one way of answering questions and explaining the natural world.
- Scientists and engineers often work in teams with different individuals doing different things that contribute to the results. This understanding focuses primarily on *teams working together* and secondarily, on the combination of scientist and engineer teams.

History and Nature of Science - Content Standard G
Science as a Human Endeavor

- Although men and women using scientific inquiry have learned much about objects, events, and phenomena in nature, much more remains to be understood. Science will never be finished.

Grades 5-8
Science as Inquiry - Content Standard A
Abilities Necessary to Do Scientific Inquiry

- Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models.
- Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances.
- Science advances through legitimate skepticism. Asking questions and querying other scientists' explanations is part of scientific inquiry. Scientists evaluate the explanations proposed by other scientists by examining evidence, comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations.

Earth and Space Science- Content Standard D
Structure of the Earth System

- Land forms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruption, and deposition of sediment, while destructive forces include weathering and erosion.

Earth's History

- The earth processes we see today, including erosion, movement of lithospheric plates, and changes in atmospheric composition, are similar to those that occurred in the past. Earth history is also influenced by occasional catastrophes, such as the impact of an asteroid or comet.

History and Nature of Science- Content Standard G
Nature of Science
Science as a Human Endeavor

- Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science, there is much experimental and observational confirmation. Those ideas are not likely to change greatly in the future. Scientists do and have changed their ideas about nature when they encounter new experimental evidence that does not match their existing explanations.
- It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists. Evaluation includes reviewing the experimental procedures, examining the evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations. Although scientists may disagree about explanations of phenomena, about interpretations of data, or about the value of rival theories, they do agree that questioning, response to criticism, and open communication are integral to the process of science. As scientific knowledge evolves, major disagreements are eventually resolved through such interactions between scientists.

Mars from Above: Mars Match

Adapted from *Astrobiology: Science Learning Activities for Afterschool Educator Resource Guide*. Walker, Education Department of the American Museum of Natural History; and *Setting the Scene, Scratching the Surface* unit of **Explore! Mars: Inside and Out**, Lunar and Planetary Institute, 2007 (http://www.lpi.usra.edu/explore/mars/activities_part1.shtml).

Overview

Mars Match, a 15 minute activity for children ages 8–13, engages children in an exploration of Mars' surface features by comparing and contrasting them with surface features on Earth. The children form teams of "planetary investigators" to examine images of volcanos, channels, and craters on Earth and Mars. The teams then use what they've learned to match the appropriate Mars feature cards to their Earth counterparts. The teams conclude by considering how scientists view these features from space, and what that may mean for our search for life beyond Earth.

What's the Point?

- Mars has many surface features similar to those on Earth, including volcanos, stream channels, and impact craters.
- There are differences in features on Mars and Earth. Mars has fewer volcanos than Earth, but they are much larger. Mars has many more visible craters than Earth. Mars does not have liquid water on its surface today, but features that look like stream channels on Earth suggest it had flowing water in the past.
- Surface features of planets look quite different from space than they when viewing them from the surface. It is important to understand how the images were taken in order to properly interpret them.
- Scientists must learn to identify these features from space using their observational skills since it is not always possible to send imagers to the surface.

Tips for Engaging Girls in STEM:

- **Use group work and collaboration to help engage children.** Girls benefit from collaboration, especially when they can participate and communicate fairly. Girls are energized by the social part of science, working and learning together. This activity gives the children the opportunity to collaborate and work together in a fun and engaging social environment.
- **Encourage critical thinking.** Girls gain confidence and trust in their own reasoning when encouraged to think critically. This activity provides an opportunity for children to use imagery to think critically about what it is like on Mars (what we can observe) and what that can tell us about its past and potential to support life – now or in the past.

Materials

For each team of 3–4 children:

- 1 set of Mars Cards depicting Mar's geologic features, printed on cardstock (cut)
- 1 set of Full page print outs of Earth Image Placemats depicting Earth's geologic features, printed on cardstock if available
- Optional: Sheet protectors for the geologic features placemats

For each child:

- 1 Pencil/pen
- Optional: 1 set of *Extreme–O–File: Mars from Above* activity pages
- Optional: Clipboard

For the facilitator:

- Background information
- Shopping list
- 1 Flashlight
- 1 Empty soup bowl
- 1 copy of the Mars Match Image Descriptions

Preparation

- Review the activity procedures and corresponding resources
- Prepare an area large enough for the children to be seated and working together in small teams. The children may be more comfortable working on the floor for this activity.
- Print enough sets of Mars Cards to accommodate the expected number of teams of 3–4 that undertake the activity at any one time
- Print enough sets of Earth Image Placemat pages to accommodate the expected number of teams of 3–4 that undertake the activity at any one time
- Review the images
- Optional: Print one copy of the *Mars from Above* activity pages for each child

Activity

1. **Distribute a pencil to each child and the optional *Extreme–O–File: Mars from Above activity pages (if needed)*, and invite them to become *planetary investigators!*** The planets they will investigate are Mars and Earth. They will begin their investigation by making observations and asking questions, sorting the geologic features from Mars into groups, and sharing their observations with the whole group.

2. **Team Up!** Divide the children into teams of 3–4 children each. Give each team a set of Mars Cards. Explain to them how the images were taken so that they understand that they are looking down on these features from space – just like the orbiting

spacecraft that took the images! Make sure to point out that some cards have a sun–shaped symbol to indicate the direction of the sunlight. They should think about where they see shadows in relation to the direction of sunlight to help interpret the images.

Facilitator's Note: If the children have difficulty understanding the perspective of the images, you can use the bowl and flashlight to help make sure that they understand the perspective from which the images were taken.

1) Flip the bowl upside down and place it on a surface. Invite the children to look at the bowl from the side. Does it look like a hill or mountain from this viewing angle?

2) Next, invite the children to look at the bowl or hill from above. They are now looking at the bowl much the same way that the spacecraft looked at Mars when taking images.

How does the "hill" look to the children now? Is it different than viewing from the surface? Yes! Looking down on features, it is not easy to tell what is sticking up from the surface, like a hill/mountain, versus what is dipping in below the surface, like a crater/hole. By using the flashlight to simulate sunlight hitting the bowl (our geologic feature), we can observe where shadows occur. This can help us to determine the relief of the topography – whether it is sticking up or dipping below the surface. Notice for features sticking above the surface, like a hill/mountain, the shadow lies **outside** of the feature, opposite the direction of the sunlight. For holes or depressions in a surface, the shadow will lie **inside** of the feature, opposite of the direction of sunlight.

3. **Invite each team to examine their Mars Cards images and sort/organize them by the types of features they observe.** They should try to create 3–5 groups.

- How many different features are there? How many different groups did they have?
  - Ask them to describe their features.
    - What are their shapes?
    - Are they above ground level? Below?
    - Can you tell how big they are?
- Do you recognize any of the features? What are they? *Craters, volcanos, stream channels!* If the children do not have a name for the different features, invite

them to create a descriptive name (for example, craters might be called "circular holes").

- Optional: Have the children complete the questions on their *Extreme–O–File* activity page.

Facilitator's Note: If the children have difficulty distinguishing between volcanos and craters in the images, ask them to observe where the shadows fall. Craters are circular depressions in the ground. If the sunlight is striking the crater at an angle in the image, the "bowl" will have a shadow "inside" of the circular feature. Volcanos are mountains above the landscape, and they often cast shadows on the ground "outside" of the circular feature. You can illustrate this by moving the beam of a flashlight across a bowl when it is placed right–side–up on a surface (crater) compared to turning the bowl upside down on the surface (volcano) and repeating the sweep of the flashlight beam. Have the children imagine that the flashlight beam is the sunlight and ask them to look for where the shadows occur for the crater (upright bowl) compared to where the shadows occur for the mountain (inverted bowl).

4. **Briefly discuss the observations and summarize the group findings.**

   - How many different types of features are there?
   - For any one type of feature, how are the different examples the same? Different?
   - Compare your features with a nearby team. Are there any similarities? Differences?

5. **Challenge the teams to apply what they've learned by playing Mars Match.** Give each team a set of Earth Image Placemats. Each team should work together to match each Mars card to one Earth Image Placemat, placing the card in the shaded box on the placemat. They should continue until each card has been matched and placed onto a corresponding Earth feature. Once completed, the team should read about the Earth features, how they form, and discuss what that may mean for the matching Mars features. *Note: Some of the Earth images also have a sun icon indicating the direction from which the sun is shining (as appropriate).*

   - What created the Earth features? How did they form?
   - What could this mean for the Mars geologic features? How do you think that they formed?

6. **Invite each team to compare and contrast the features they observed.**

   - Are there similar features on Earth and Mars? What are they?
   - Are there different features?
   - Can you name the features? *Craters, Volcanos, and Stream Channels!* (*Terminology can be reinforced in the remaining hands–on activities.*)

Facilitator's Note: Mars has fewer volcanos than Earth, but they are much larger. Mars has many more craters than Earth. Mars does not have liquid water on its surface today, but features that look like stream channels on its surface, similar to those seen on Earth, suggest it had flowing water in the past.

In Conclusion

Summarize that Mars and Earth have been shaped by similar processes, and that we can find volcanos, stream channels, and impact craters on both planets. Encourage the children to take part in the other *Mars from Above* activities (stations) to discover more about how these features formed, how we view them from space, and what that may mean for our search for life beyond Earth.

National Science Education Standards

Grades K–4

Science as Inquiry – Content Standard A

Understanding about Scientific Inquiry

- Scientists use different kinds of investigations depending on the questions they are trying to answer. Types of investigations include describing objects, events, and organisms; classifying them; and doing a fair test (experimenting).

Earth and Space Science – Content Standard D

Changes in the Earth and Sky

- The surface of the Earth changes. Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.

Science and Technology – Content Standard E

Understanding About Science and Technology

- People have always had questions about their world. Science is one way of answering questions and explaining the natural world.
- Scientists and engineers often work in teams with different individuals doing different things that contribute to the results.

Grades 5–8

Science as Inquiry – Content Standard A

Abilities Necessary to Do Scientific Inquiry

- Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models.

Earth and Space Science– Content Standard D

Structure of the Earth System

- Land forms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruption, and deposition of sediment, while destructive forces include weathering and erosion.
- Water covers the majority of the earth's surface.

Mars from Above: Mars Match

Mars Image Descriptions

1. Mars – Volcano
A three-dimensional view of Olympus Mons, the tallest volcano on Mars, created by using elevational data and planetary imagery. The volcano forms a gently sloped "cone" on the surface of Mars. Olympus Mons rises 22 kilometers (13 miles) above the surface of Mars and is 500 kilometers (310 miles) wide
at its base.
Image courtesy of NASA:
http://www.esa.int/SPECIALS/Mars_Express/SEM2K1W4QWD_0.html

2. Mars – Channels
Satellite image of river channels on Mars. The branching – dendritic - pattern was produced by flowing water carving ribbon-like channels into the land. No liquid water is present on the surface of Mars today, so these channels were formed by flowing water in the past. The image is about 200 kilometers
(124 miles) across.
Image courtesy of the Lunar and Planetary Institute:
http://www.lpi.usra.edu/publications/slidesets/redplanet2/slide_26.html

3. Mars – Craters
Spacecraft image of a large circular depression – crater - created when an impactor struck the surface of
Mars. This is an unnamed crater in Tyrrhena Terra. A couple of smaller craters can be seen above the large crater in the image. The sunlight is coming from the left side of the image; shining on the right side of the crater and leaving the left portion of the crater in shadow.
THEMIS image courtesy of NASA/Jet Propulsion Laboratory/Arizona State University:
http://image.mars.asu.edu/convert?format=jpeg&image=/mars/images/special/themis/iotd/V25983003.png

4. Mars – Volcano
Infra-red spacecraft image over the small-dome shaped Hecate Tholus volcano on Mars. The sunlight is coming from the left side of the image; shining on the left side of the volcano and leaving the right side in shadow.
THEMIS image courtesy of NASA/Jet Propulsion Laboratory/Arizona State University:
http://themis.asu.edu/zoom-20040820A

5. Mars - Channels
Spacecraft image of channels carved into the surface of Mars. The channels merge together toward the bottom right of the image. No liquid water is present today, so these

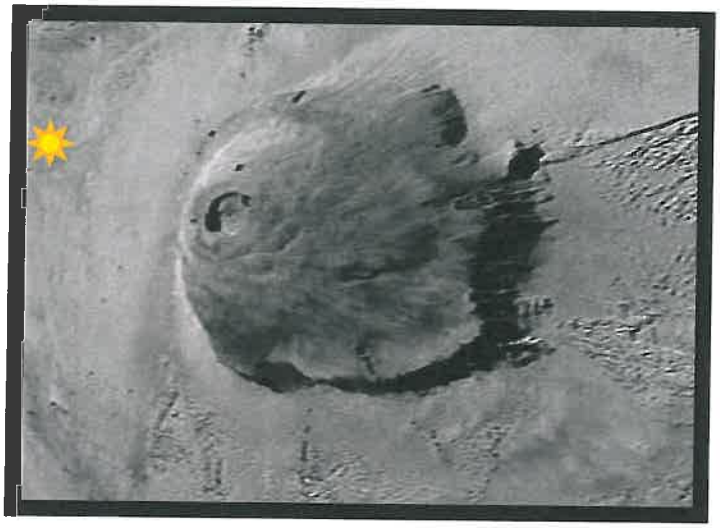
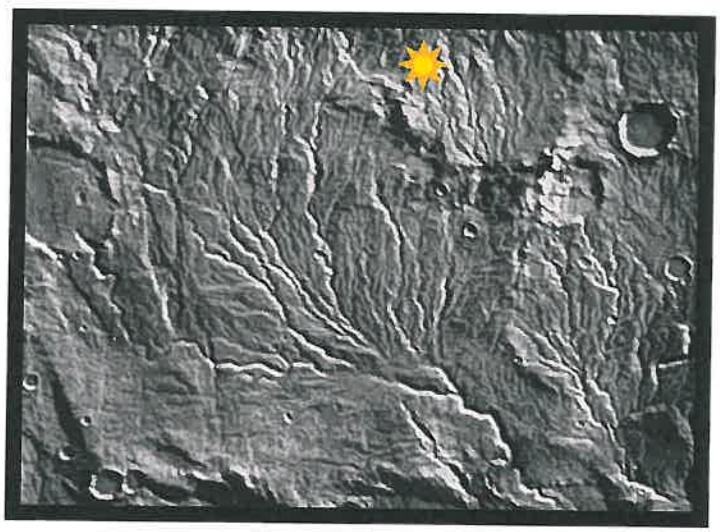
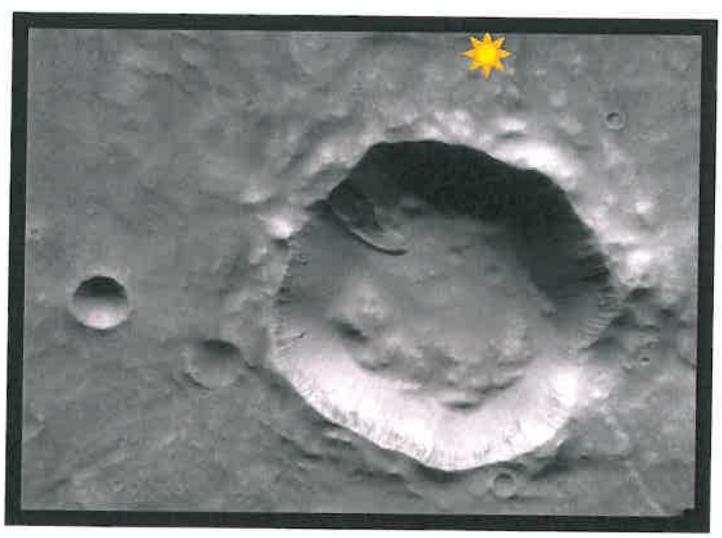
ribbon-like channels were cut by flowing water in the past. The sunlight is coming from the upper right side of the image.
Image courtesy of the European Space Agency / DLR / FU Berlin (G. Neukum): http://www.esa.int/esa-mmg/mmg.pl?b=b&type=I&mission=Mars%20Express&single=y&start=91&size=b

6. Mars – Craters
Spacecraft image of a circular depression on the surface of Mars created by an impactor striking the planet. The material thrown from the crater (ejecta) forms a rough, irregular surface around the crater. The crater is approximately 6 kilometers (3.7 miles) across. The sunlight is coming from the left side of the image; shining on the right side of the crater and leaving the left portion of the crater in shadow.
THEMIS image courtesy of NASA/Jet Propulsion Laboratory/Arizona State University: http://themis.asu.edu/zoom-20060818a

7. Mars – Volcanos
A small volcano rises above the surface of Mars, Uranius Tholus, in this spacecraft image. Smaller impact craters dot the surface around the volcano, and on the volcano, too! The large, flat bottomed, circular depression in the center (on the top) of the volcano is a caldera, the location from which lava flows. The sunlight is coming from the right side of the image; shining on the right side of the volcano and leaving the left side in shadow.
Image courtesy of NASA: http://erc.arc.nasa.gov/MarsVolc/TharsisTholi.htm

8. Mars – Channels
Spacecraft image above ribbon-like channels cut into the surface of Mars. Unlike the dendritic patterns observed on other images, these channels are wider and have many branches braided together, with tear-drop islands separating the channels. These are interpreted to have been carved by fast flowing water flooding across the surface.
Image courtesy of NASA: http://jules.unavco.org/Voyager/Docs/ImageGallery/mars_channels

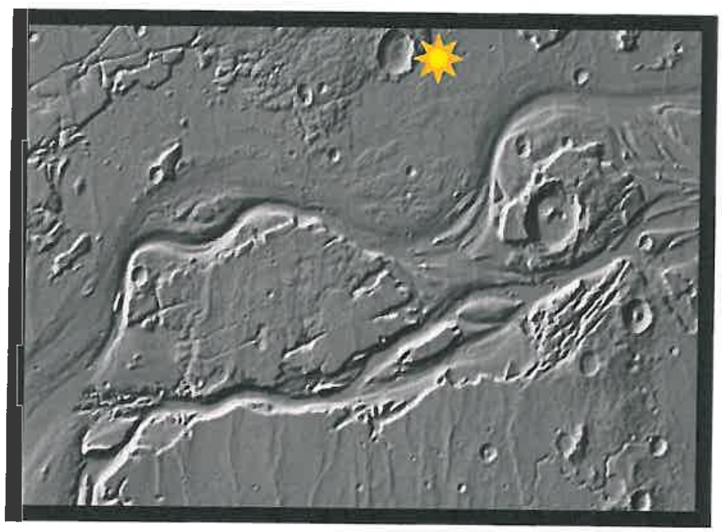
9. Mars – Craters
Spacecraft image of a circular depressions located in the northern lowlands on the surface of Mars created by impactors striking the planet. The material thrown from the crater (ejecta) forms a rough, irregular surface around the crater. The ejecta surrounding the crater at the top of the image is still readily visible, whereas the ejecta surrounding the crater at the bottom of the frame is "disappearing" into the background plains. The sunlight is coming from the left side of the image; shining on the right side of the crater and leaving the left portion of the crater in shadow.
THEMIS image courtesy of NASA/Jet Propulsion Laboratory/Arizona State University:
http://themis.asu.edu/node/5936

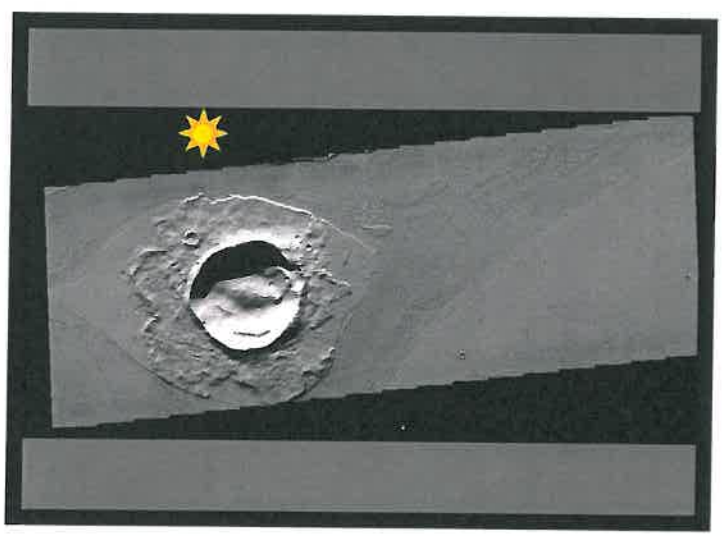





EXPLORE: LIFE ON MARS?
MARS MATCH
1

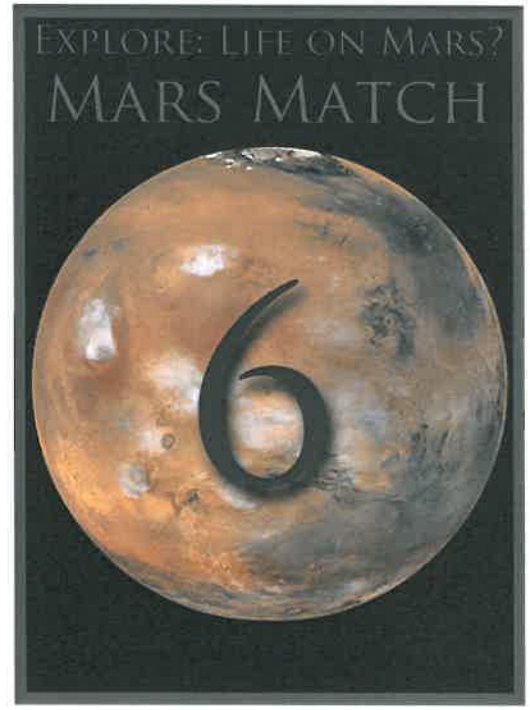

EXPLORE: LIFE ON MARS?
MARS MATCH
2

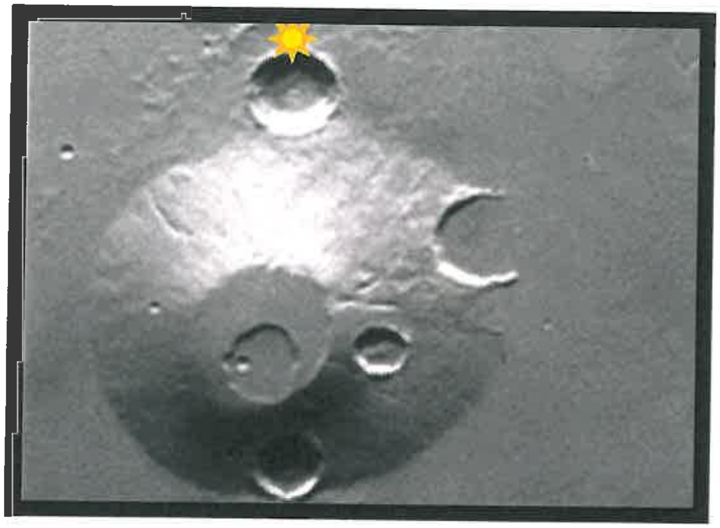

EXPLORE: LIFE ON MARS?
MARS MATCH
3

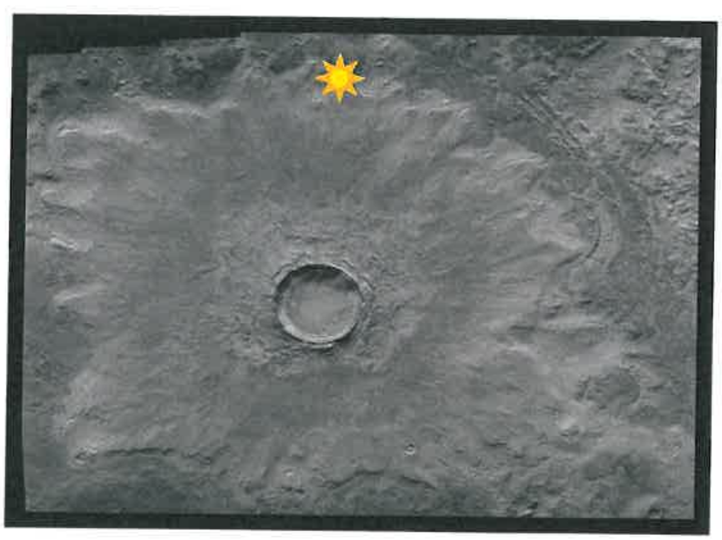





EXPLORE: LIFE ON MARS?
MARS MATCH
4

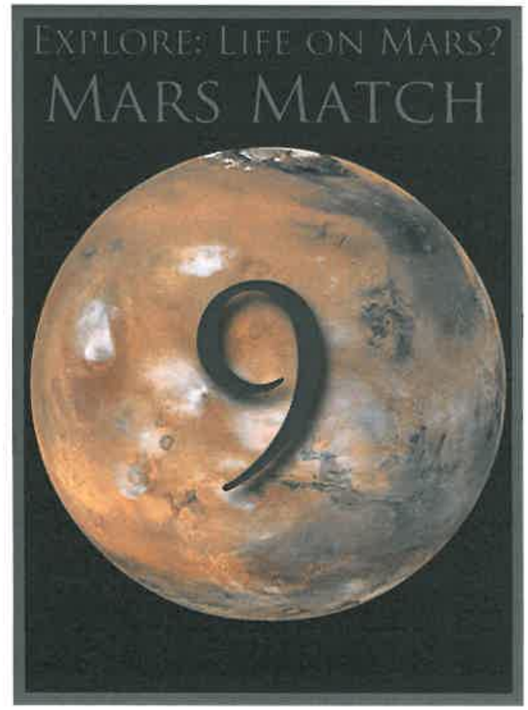
EXPLORE: LIFE ON MARS?
MARS MATCH
5

EXPLORE: LIFE ON MARS?
MARS MATCH
6






EXPLORE: LIFE ON MARS?
MARS MATCH
7


EXPLORE: LIFE ON MARS?
MARS MATCH
8


EXPLORE: LIFE ON MARS?
MARS MATCH
9

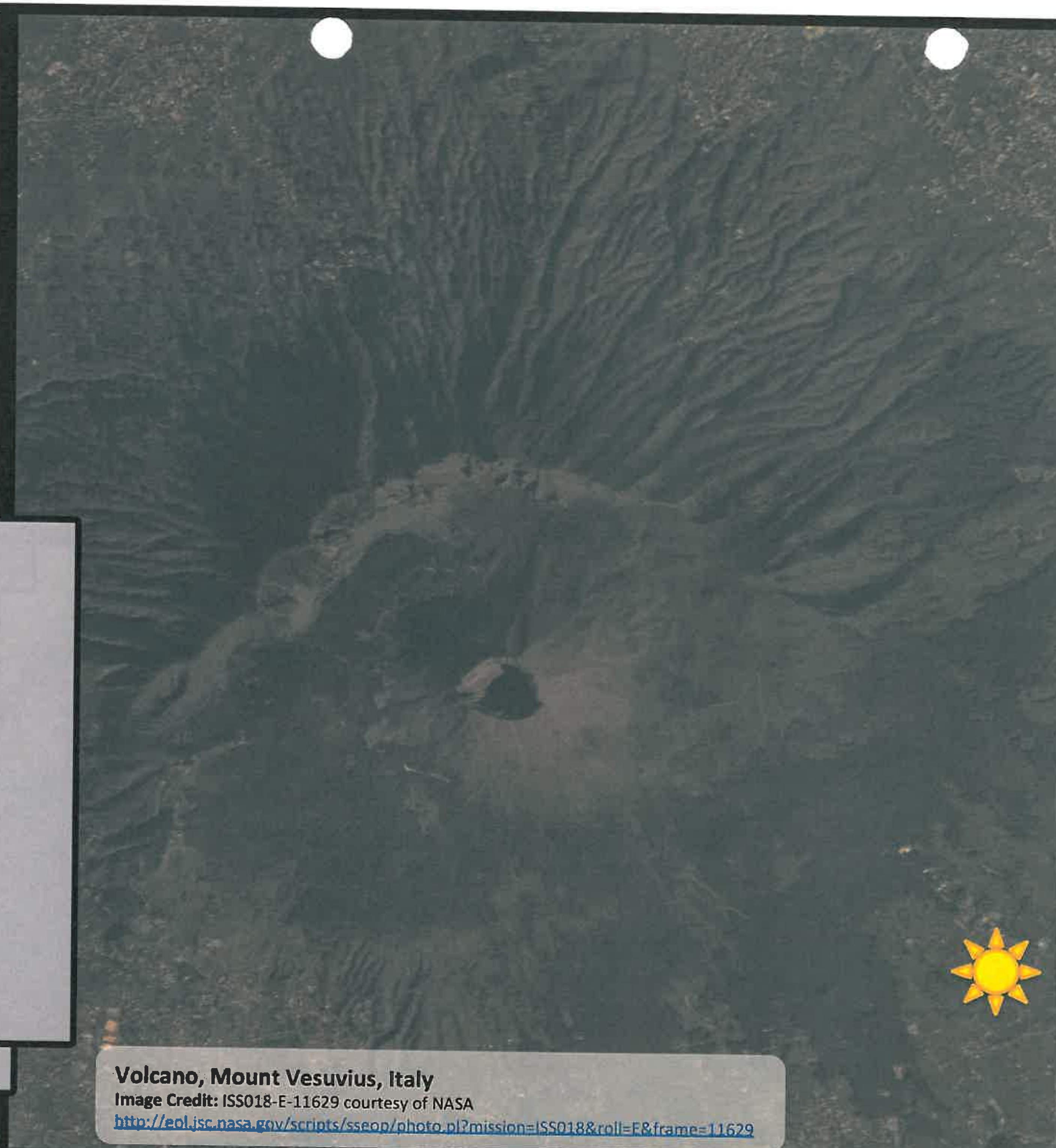
Earth Imag[illegible] cemat #1

This image shows a view of a volcano on Earth, as viewed looking down from the International Space Station (orbiting the Earth). The sunlight is shining from the lower right-hand side of the image.

A volcano is a mountain or hill formed by the accumulation (build up) of molten rock, known as magma, from the interior of a planet or moon.

On Earth, magma is typically produced at depths of 50 to 60 miles below the surface. Since liquid magma is less dense than solid rock, it is pushed out of (erupted through) cracks in the Earth's surface.

Place your matching Mars Cards here



Volcano, Mount Vesuvius, Italy

Image Credit: ISS018-E-11629 courtesy of NASA

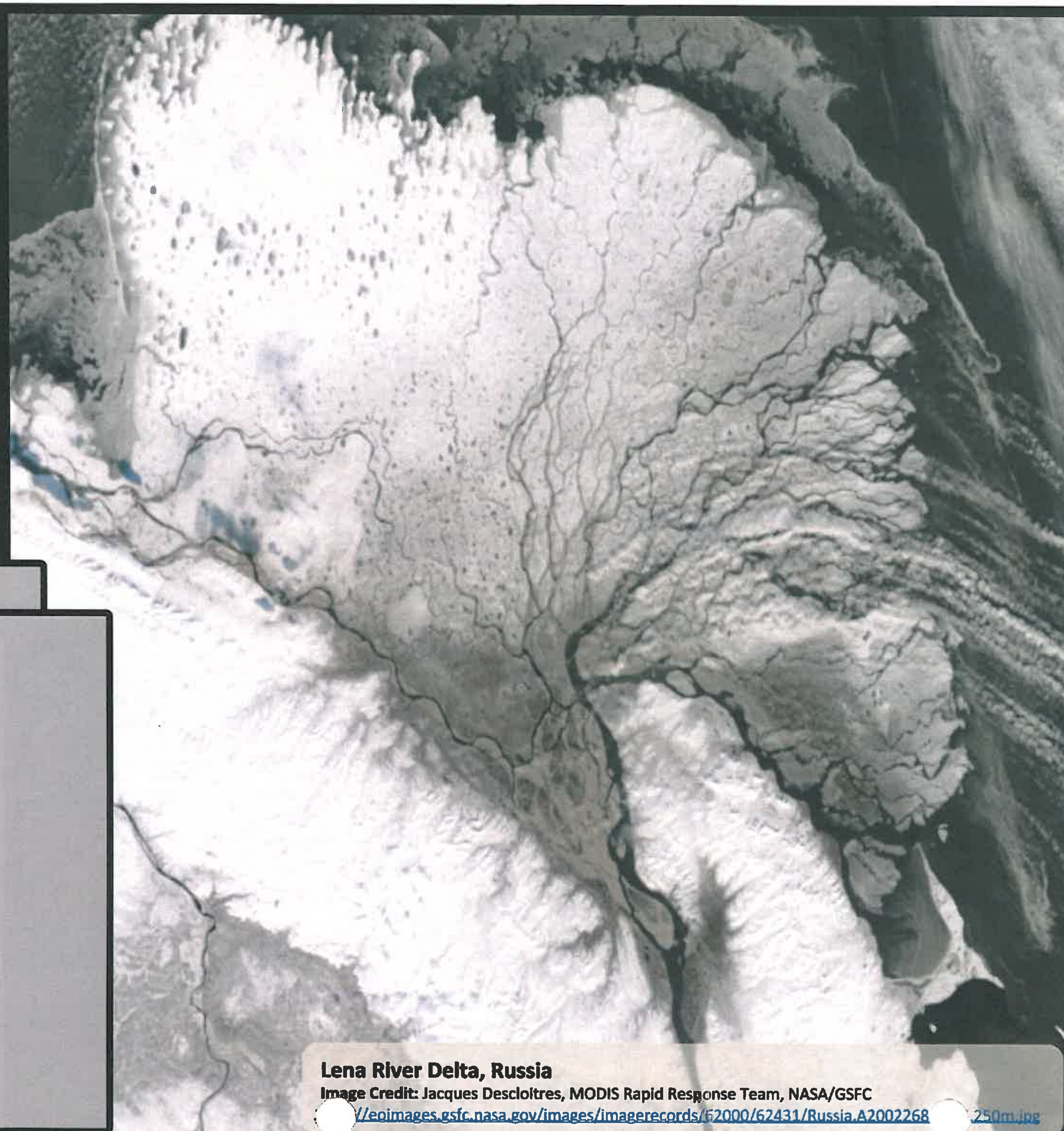
http://eol.jsc.nasa.gov/scripts/sseop/photo.pl?mission=ISS018&roll=E&frame=11629

Earth Image Placemat #2

This image shows a view of a river delta on Earth, as viewed looking down from the International Space Station (orbiting the Earth).

The river and stream channels making up the delta are clearly visible in the snowy landscape and are formed by water flowing downhill over the land, eroding (sweeping away) the dirt and rock beneath. As the river empties into a larger body of water (like an ocean or large lake), the dirt and rock (sediment) is deposited - creating a triangular deposit . This deposit causes the larger stream channel to break into many smaller ribbon-like channels.

Place your matching Mars Cards here



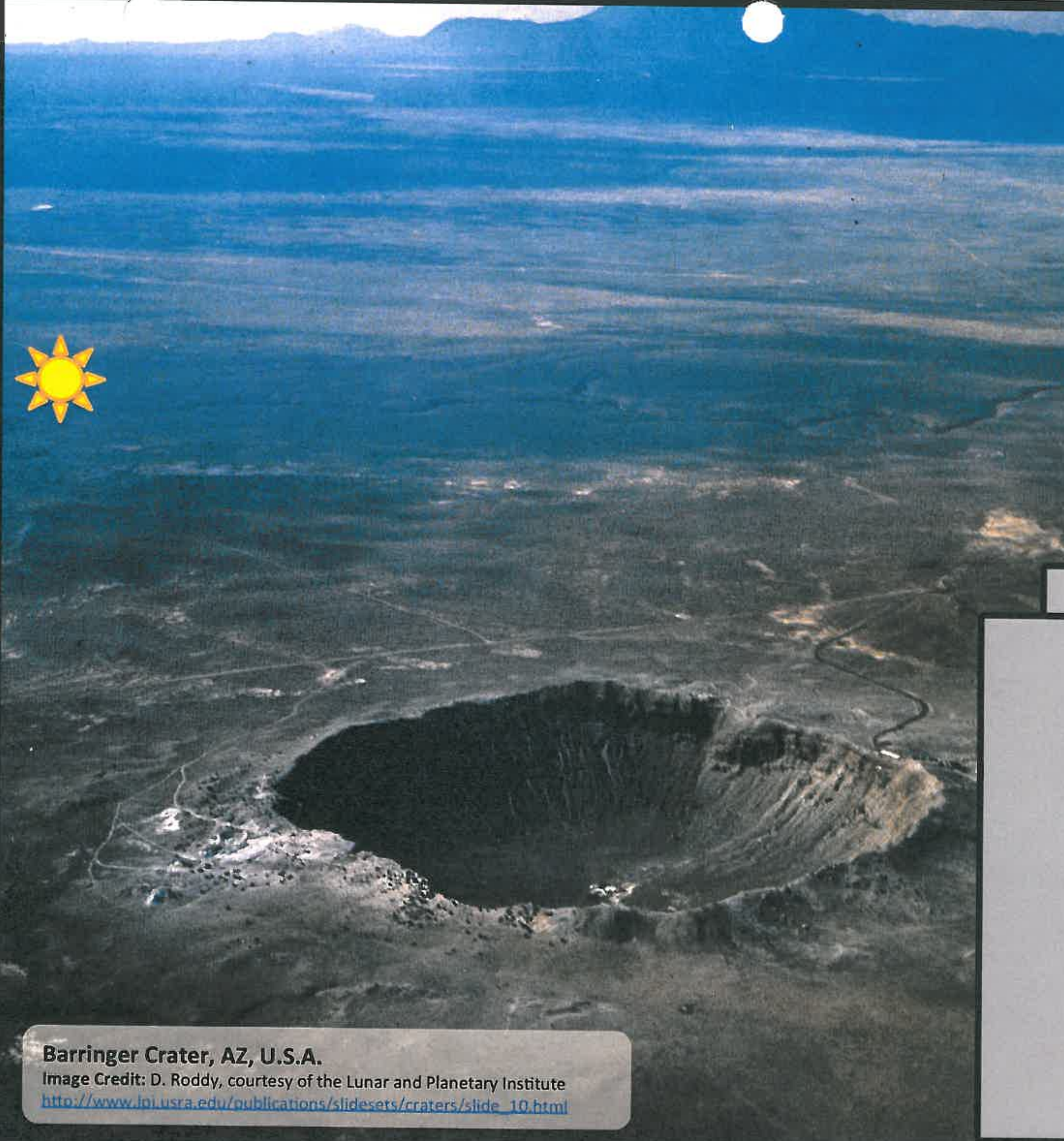
Lena River Delta, Russia
Image Credit: Jacques Descloitres, MODIS Rapid Response Team, NASA/GSFC
…//eoimages.gsfc.nasa.gov/images/imagerecords/62000/62431/Russia.A2002268…250m.jpg

Earth Image Placemat #3

This image was taken from an airplane looking across at Barringer Crater. The sunlight is shining from the left-hand side of the image.

The crater was created by the impact of a meteorite that struck Arizona about 50,000 years ago. This is a small crater, 1.2 kilometers across (0.75 miles) and 419 m deep (1300 feet).

The crater has a circular outline with a raised rim, and a deep, bowl-shaped shape.



Barringer Crater, AZ, U.S.A.
Image Credit: D. Roddy, courtesy of the Lunar and Planetary Institute
http://www.lpi.usra.edu/publications/slidesets/craters/slide_10.html

Place your matching Mars Cards here

Mars from Above: Carving Channels

Adapted from selected activities from *Mapping Mars*, **DESTINATION: MARS**, NASA Johnson Space Center, 2002 (http://ares.jsc.nasa.gov/ares/education/program/destinationmars.cfm), and the *Scratching the Surface* unit of **EXPLORE! MARS: INSIDE AND OUT**, Lunar and Planetary Institute, 2007 (http://www.lpi.usra.edu/explore/mars/activities_part1.shtml).

Overview

Carving Channels is a 15 minute activity in which children ages 8 to 13 create channel features with flowing water, comparing their observations to real images of Mars and Earth taken by satellites/orbiters. Their observations of the ways in which flowing water alters the surrounding terrain are used as clues to draw conclusions about Mars' geologic past and its ability to support life, as well as how scientists view these features from space.

What's the Point?

- Channels are surface features carved by a flowing liquid, like water.
- The types of features formed by flowing water indicate slope of the terrain.
- The presence of channels on a planet or moon is evidence that liquid once flowed on its surface and suggests that it possessed an atmospheric pressure high enough that the water was stable as a liquid at the surface (i.e., it would not boil off instantly).
- Scientists are interested in knowing if water is – or was – present on other planets and moons because all life as we know it requires water. If there is or was water, life might be – or have been – present.
- Models – such as the children are using here – can be tools for understanding the natural world.
- Geologists use features on Earth to help them understand how similar features may have formed on other planets, like Mars.

Tips for Engaging Girls in STEM:

- **Use group work and collaboration to help engage children.** Girls benefit from collaboration, especially when they can participate and communicate fairly. This activity gives the children the opportunity to collaborate and work together in a fun and engaging social environment.
- **Encourage critical thinking.** Girls gain confidence and trust in their own reasoning when encouraged to think critically. This activity provides an opportunity for children to use imagery to think critically about what it is like on Mars (what we can observe) and what that can tell us about its past and potential to support life – now or in the past.

- **Provide opportunities for developing spatial skills.** Spatial skills are not innate and can be improved with training and experience. This activity provides an opportunity for children to think three-dimensionally, by creating a model and drawing to represent their ideas.

Materials

The following materials are for this activity conducted as stations.

For each Station: The following materials will serve approximately 8 children working in teams of 3–4. Two "stream tables" are recommended (one per team) for this station, as listed below:

- 10 pounds of clean Playground sand
- 4 to 5 (1 to 3 inch) Rocks (2" diameter or less)
- 4 to 6 (2–liter) Bottles, without lids, filled with water
- Access to water to refill the bottles as needed
- 2 Plastic wallpaper trays (from home improvement or hardware stores) or other long narrow plastic container such as plastic window planter boxes.
- 4 Standard bricks (foam floral/craft bricks may be used if desired)
- 2 (5 gallon or larger) Trash cans or buckets (rectangular shaped is best)
- 2 Large Trash bags to line the buckets or trash cans
- 1 set of Full page Earth Image Placemats (stream channel images only) from the Mars Match activity
- 1 set of Mars Cards (channel images only) from the Mars Match activity
- Optional (Recommended): 5 pounds of Pesticide–free diatomaceous earth (from a home improvement or pool supply store), gloves, and a mask. The diatomaceous earth will aid in creating well–defined channels
- Optional: 1–2 bottles of Craft sand, any color (24 oz. – readily available at hobby or department stores) may be used in place of diatomaceous earth

Facilitator's Note: Sand and diatomaceous earth can be dried out and reused!

Caution: Diatomaceous earth poses an inhalant hazard and can cause eye irritation if handled improperly. If you choose to use it in your stream tables, set up the stream tables beforehand and keep the diatomaceous earth moist or covered to keep it from becoming airborne in the presence of children. Use caution when working with the diatomaceous earth and setting up the tables. You may use a mask to protect yourself. It is also a good idea to wear gloves when handling this material as it may dry hands significantly.

For each child:

- Pencil or pen
- Optional: 1 set *of Extreme–O–File: Mars from Above* activity pages
- Optional: Clipboard
- Optional: 1 set of Life on Mars? Trading Cards

For the facilitator:

- Background information
- Shopping list
- Scissors or other tool to poke holes though thin plastic trays

Preparation

- Review the activity procedures, activity pages, and background information
- Prepare the stream tables:
  - Poke 3 pea–sized holes on the bottom of each narrow plastic tray, about 1 inch from the end. Punch holes only in one end of the trays.
  - Place the trays so that the children can easily group around them.
  - Tray 1: Pour two to three inches of sand into the tray, keeping it away from the end with holes so that the water can drain.
    - Partially bury 2 or 3 rocks in the sand, so that the upper 2/3 of the rocks are exposed
    - On top of the sand, pour 2 inches of diatomaceous earth OR 1 inch of craft sand
    - Add a thin layer of regular sand across the surface of the diatomaceous earth/craft sand
    - For the top layer, sprinkle just enough diatomaceous earth/craft sand to cover the sand
    - Dampen the sand
  - Tray 2: Pour two to three inches of sand into the tray, keeping it away from the end with holes so that the water can drain. Have the sand along the edges be a little higher than in the center so that water will flow down the center.
    - Bury 2 or 3 rocks in the sand
    - Dampen the sand
  - Position each plastic tray so that the end with the holes hangs over the table edge about 6 inches
  - Place a lined trash can or bucket under the part of the tray that extends over the edge to catch excess water as it drains from the tray
  - Place 2–3 bricks under the other end of the wallpaper tray #1 with the diatomaceous earth/craft sand, so it is tilted about 20 degrees. You may want to recruit help with positioning the trays on the bricks.
  - Place one brick under tray #2 with the sand only, so that it is tilted about 5 degrees.
  - Fill two, 2–liter bottles with water and place them beside the trays.
  - Place copies of the Mars/Earth channel images (from Mars Cards and Earth Placemat set) near the stream tables. You may wish to laminate or put these images into page protectors to protect them from the water during the activity.

Activity

1. **Consider the images of channels on Mars and Earth.** Explain that these images were taken by spacecraft looking down on the planets.

    - What do the features look like? *Rivers, streams, etc.*
    - How might channels have formed on Earth? *Water*
    - What do you think created the channels on Mars?

Facilitator's Note: Early Mars was wetter and warmer. Several lines of scientific evidence support this claim. Images obtained by Mars orbiters have revealed that the ancient Southern Highlands are covered by dendritic drainage patterns – networks of stream channels, or "valley networks" that erode into the highland craters. While there are some differences, these features are generally similar to the networks of gently meandering river channels on Earth. The valley networks on Mars are interpreted to have formed slowly, and thus they require a time in Martian history when flowing liquid water was stable at or near the surface of the planet. Chemical measurements made from orbit reveal the presence of clay associated with some of these channels; the formation of clay requires that water was present at some time. Additional evidence for liquid water was found by the Mars Exploration Rovers. They documented structures in the rocks that are created by flowing water, and minerals formed in salty, acidic water.

2. **Point out that the trays and their contents are called *stream tables,* and they contain sand (and possibly diatomaceous earth).**

    - What do you notice about the way in which the trays are positioned? The trays are positioned at an angle; one tray at a steeper angle than the other.
    - Which way does fluid, like water, flow? Water – or any fluid – flows downhill.
    - What do you predict will happen when you pour water onto the surface at the top of the tray? The water will flow downhill. It will create channel features much like the ones they observed in the images of Earth and Mars.
    - Do you think the features in the steeply dipping tray will differ from the features in the tray tilted 5 degrees? If so, in what way(s)? Answers may vary, but may include that in the tray with a low slope, the water will travel more slowly. The size of the material may also cause a difference. Perhaps the sand will drain more.
    - What do you think will happen when the water meets an obstacle, like a buried rock? *Answers will vary, but may include that the water will stop, or go around the obstacle.*

3. **Invite the children to create their own channels**! Invite the children to take turns holding a water bottle at the high end of the tray and slowly pouring water, *gently* and *steadily*, into each tray.

    - What features do you observe?

- Observe what happens along the stream edges. Can you detect sand building out some parts of the meanders and eroding others?
- Optional: Draw your observations and complete the questions on your *Extreme–O–File: Mars from Above* activity page for the *Carving Channels* activity.
- Do the channels you created look anything like those in the images of Mars and/or Earth? What is the same? What is different? Try to match a one of the images to your channels.
- What happens if you increase the flow rate of the water? Do the features change?
- How do the features in the stream table with the lower tilt compare to the one with the higher tilt?

4. **Discuss what the model means in terms of Earth and Mars.** Explain that both Mars and Earth have features that look like meandering channels (look at the Mars Match Cards and Earth Image Placemats). Mars also has some features that look like the braided channels and teardrop–shaped islands. We know that features like these are formed by water on Earth. This means that it is likely that the channels that we see on Mars were also caused by flowing water. Using these observations, we can recreate an image of what Mars was like in the past!

In Conclusion

Have the children reflect on what they observed and the images from Mars and Earth. Optional: Invite them to record what they learned and to finish completing the questions in their *Extreme–O–Files: Carving Channels* activity pages (if they have not already).

- What caused the channels in the stream tables to form? Water flowing across the surface cut into the surface and carried some of the material away.
- Do you observe flowing water in the images of Earth's channels? What do you conclude about how Earth's channels formed? Flowing water carved Earth's channels.
- Do you observe water flowing in the channels on Mars? No. What do you conclude about how those channels formed? Water carved the channels but the water is no longer there.

Facilitator's Note: You may want to bring the children's attention to the fact that the water is no longer present in the channels in the stream table, but the channels are still there – the channel offers evidence that water flowed across the surface in the past. It is also possible that another fluid – other than water – carved the channels. Although there is other evidence on Mars that water is the most likely option – water exists as ice caps near the poles and is suspected to exist in the soil as well.

- If you observe channels on a planet, based on your model, what do you conclude about how those channels formed? *Water – or another fluid! – created the channels.*

- What does this tell you about that planet? *Water was once present.*
- What do the channels on Mars tell us about the history of Mars? *Mars once had flowing water that carved the channels, but there is no evidence of water on the surface today.*
- Why might scientists be interested in water on other planets? *All life as we know it needs water. If water is – or was – present, there may be – or have been – life!*

Summarize that Mars and Earth have been shaped by similar processes, and that we can find stream channels on both planets.

National Science Education Standards

Grades K–4

Science as Inquiry – Content Standard A

Understanding about Scientific Inquiry

- Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.
- Scientists use different kinds of investigations depending on the questions they are trying to answer. Types of investigations include describing objects, events, and organisms; classifying them; and doing a fair test (experimenting).
- Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations.

Earth and Space Science – Content Standard D

Changes in the Earth and Sky

- The surface of the Earth changes. Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.

Science and Technology – Content Standard E

Understanding About Science and Technology

- People have always had questions about their world. Science is one way of answering questions and explaining the natural world.
- Scientists and engineers often work in teams with different individuals doing different things that contribute to the results.

History and Nature of Science – Content Standard G

Science as a Human Endeavor

- Although men and women using scientific inquiry have learned much about objects, events, and phenomena in nature, much more remains to be understood. Science will never be finished.

Grades 5–8

Science as Inquiry – Content Standard A

Abilities Necessary to Do Scientific Inquiry

- Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models.
- Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances.

- Science advances through legitimate skepticism. Asking questions and querying other scientists' explanations is part of scientific inquiry. Scientists evaluate the explanations proposed by other scientists by examining evidence, comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations.

Earth and Space Science– Content Standard D
Structure of the Earth System

- Land forms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruption, and deposition of sediment, while destructive forces include weathering and erosion.
- Water covers the majority of the earth's surface.

Earth's History

- The earth processes we see today, including erosion, movement of lithospheric plates, and changes in atmospheric composition, are similar to those that occurred in the past. Earth history is also influenced by occasional catastrophes, such as the impact of an asteroid or comet.

History and Nature of Science– Content Standard G
Nature of Science
Science as a Human Endeavor

- Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science, there is much experimental and observational confirmation. Those ideas are not likely to change greatly in the future. Scientists do and have changed their ideas about nature when they encounter new experimental evidence that does not match their existing explanations.
- It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists. Evaluation includes reviewing the experimental procedures, examining the evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations. Although scientists may disagree about explanations of phenomena, about interpretations of data, or about the value of rival theories, they do agree that questioning, response to criticism, and open communication are integral to the process of science. As scientific knowledge evolves, major disagreements are eventually resolved through such interactions between scientists.