Mars and Earth

Science Learning Activities for Afterschool

Participants ages 5-12

EDUCATOR RESOURCE GUIDE

Credits & Acknowledgements

Original Activity Sources

The activities in this collection were not adapted from individual existing NASA resources. However, they were heavily influenced and inspired by the Mars Education Program's Mars Curriculum Modules for grades 4 through 12, which can be found online.
http://mars.jpl.nasa.gov/classroom/resources.html

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Preface

Mars and Earth: Science Learning Activities for Afterschool was produced by the American Museum of Natural History (AMNH) as part of an 18 month study and demonstration project funded by NASA. The demonstration project collected a wide range of existing NASA and AMNH educational resources developed for formal school settings. It drew on AMNH's experience to adapt the materials for community-based afterschool program staff working with participants aged 5-12. Materials were tested in afterschool programs operated by the local affiliate of a national youth-serving organization, an independent community-based organization, and a public school. Afterschool participants and staff were engaged as co-researchers with the AMNH staff. Observations were conducted by the AMNH staff, interviews were conducted with the afterschool staff and participants, and written data was collected from instructors in the form of weekly summary sheets and from participants in the form of science journals.

The key findings from the demonstration project were:

- Young people are highly interested in what the universe is like and how it has developed over time.
- The most powerful part of the learning experience in the demonstration project was the opportunity for participants to express their ideas and opinions, and to learn to build explanations from evidence.
- Afterschool staff with youth development training have a set of skills that are applicable to leading inquiry and discussion-based science learning experiences.

Mars & Earth: Science Learning Activities for Afterschool is one of three prototype curriculum packets produced by the project. *Mars & Earth* varies from the other two prototype packets produced under the grant (*Astrobiology* and *Sun as a Star*) in that it is not an adaptation of individual existing NASA activities. This packet makes use of a prototype instructional model developed and piloted during the second year of our project. Activities were developed to explore and illustrate the instructional model, rather than adapted directly from specific existing NASA resources. However, the activities were heavily influenced and inspired by the Mars Education Program's Mars Curriculum Modules for grades 4 through 12, which can be found online.
http://mars.jpl.nasa.gov/classroom/resources.html

The complete report on the demonstration project and the scan of the field that accompanied it, *NASA and Afterschool Programs: Connecting to the Future* can be downloaded from the NASA Informal Education web portal.
http://education.nasa.gov/divisions/informal/overview/R_NASA_and_Afterschool_Programs.html

Introduction

The *Mars and Earth* unit consists of nine sequential Activities, most of which may be completed in about one hour. The Activities are targeted for the elementary school level.

Navigating Through the Activities

The format is geared towards helping the instructor navigate efficiently through each hour-long Activity. The headings contain brief but pertinent information.

- **The Overview** gives you a quick summary of the Activity and the estimated time for completing the lesson.

- **The Big Ideas** relate to the nature of science and how scientists think and work. They present concepts about conducting an investigation and take you and your group through the same series of steps that scientists follow.

- **Connections** help you make sense of the flow of the unit by relating the topic of the Activity to those that come before or after it. You may use this section to introduce an Activity and to help participants connect to what they have already done or will be doing in subsequent activities.

- **The Materials** section lists everything you will need to use that day. In many cases, the materials are commonly available supplies. Most images listed are provided either as handouts or online. There are some items you will need to gather yourself, and these are clearly outlined. Be sure to preview the Materials section in advance. Please see the complete Materials list for the entire unit on page 6.

- **The Preparation** section lets you know what you need to get ready ahead of time.

- **The Activity** is presented in a step-by-step style. The main objective in each step comes first, in bold print as a visual cue. A brief paragraph explains the step in more detail and also provides questions and prompts to use with participants.

Overview

In this unit, participants are engaged in acquiring content knowledge while also using the process skills that are key to conducting scientific investigations. In each Activity, they are introduced to a big idea related to the nature of science, and then have an opportunity to put that idea into practice.

Science is about asking questions. **Activity 1** introduces the central question of the unit: What can we learn from images of other planets? Participants compare and contrast images of Earth and Mars and then experiment with lenses to understand more about the instruments used to make the images.

Science is about collecting data and using evidence to answer questions. In **Activity 2**, participants will be doing exactly what scientists do when analyzing images from spacecraft – comparing what they see in satellite images to what they already know.

Scientists use evidence from satellite images to build explanations. In **Activity 3**, participants apply what they have learned about viewing and interpreting satellite images of Earth to begin analyzing satellite images of Mars. Then they brainstorm a list of forces or events that could have caused some of these features to form on Mars.

Scientists rely on laboratory experiments and modeling to better understand and test their ideas. In **Activities 4**, **5**, and **6** participants conduct a series of experiments using models. They test their ideas by attempting to recreate features that might have been caused by wind, flowing water, or the impact of a falling object.

A model is different from the real thing but can be used to learn something about the real thing. Through discussions in **Activity 7**, participants explore the limits of the models they created, develop a list of their own questions about Mars, and speculate on ways they might find their own answers.

An important part of research is learning what others have discovered, and communicating what you have learned. In **Activity 8**, participants make use of a variety of resources to find out what is known about Mars and hold a science conference to share new information and new questions.

Scientists use skills they have learned and apply them to new situations. In the culminating activity, **Activity 9**, participants apply what they have learned about how to interpret images of Earth and Mars to interpret images of other planets. Then they select one planet on which to base the story of an imaginary voyage. They create comic strips to tell the tale.

Materials

For Activity 1

For each group of 3 to 4 participants:
- 3 images each from the Earth and Mars image sets
- a collection of large and small lenses (American Science Surplus sells large lenses at 10 for $3.50, small lenses at 10 for $2.00. Sold online at http://www.sciplus.com/).

For the group:
- 1 piece of paper with small print (to hang as a viewing target for lens experiments)
- 2 sheets of large chart paper and markers

For Activity 2

For each participant:
- 1 sheet of drawing paper
- 1 pencil

For the group:
- 1 set of Earth Images
- several large sheets of paper

For Activity 3

For each participant:
- 1 sheet of paper
- 1 metric ruler (for grades 4 and above)

For the group:
- 1 set of Earth Images
- 1 set of Mars Images
- 2 sheets of chart paper and markers

For Activity 4

For each group of 3 to 4 participants:
- 1 lightweight plastic tray about 1 m long and 10 cm wide (purchase wall paper trays from a paint store for about $1.00 each)
- sand to cover surface of tray to a depth of at least 5 cm
- clear plastic wrap to cover tray
- tape
- 1 drinking straw
- 1 set of Mars Images

For Activity 5

For each group of 3 to 4 participants:
- 1 lightweight plastic tray about 1 m long and 10 cm wide (purchase wall paper trays from a paint store for about $1.00 each)
- damp sand to cover surface of tray to a depth of at least 2 cm
- jug of water
- several blocks (to raise one end of the tray)
- 1 protractor (for grade 4 and above)
- several large and small paper cups
- 1 bucket (for collecting excess sandy water)
- 1 set of Mars Images
- newspapers to place under trays (optional)
- clean up supplies such as rags, sponges, whisk brooms

For Activity 6

For each group of 3 to 4 participants:
- 1 lightweight plastic tray about 1 m long and 10 cm wide (purchase wall paper trays from a paint store for about $1.00 each)
- sand to cover surface of tray to a depth of about 5 cm
- jug of water (optional)
- several objects in a variety of sizes and shapes to use as "impactors", such as ball bearings, marbles, golf balls, tennis balls, rocks, acorns, coins, blocks
- 1 set of Mars Images

Materials - cont'd

For Activity 7

For the group:
- 1 set of Mars Images
- chart paper and markers

For Activity 8

For the group:
- chart labeled "Our Questions About Mars" (generated in Activity 7)
- a variety of books, videos, and CD-ROMs about Mars (See Resources on page 35 for a detailed list of suggestions)
- access to computers, if possible
- chart paper and markers

For Activity 9

For each group of 3 to 4 participants:
- 1 set of NASA Solar System Lithographs (these can be found online at http://teachspacescience.org)
- drawing materials such as large sheets of paper, colored pencils or pens, markers, rulers
- sample comic strips (optional)

1. What Can We Learn From Images?

Overview

The activity introduces the central question of the unit: What can we learn from images of other planets? Participants compare and contrast images of Earth and Mars and then experiment with lenses to understand more about the instruments used to make the pictures.

TIME:
- 45 minutes to examine images (Steps 1-4)
- 45 minutes to experiment with lenses (Steps 5-6)

Big Ideas

- Science is about asking questions and collecting data in order to answer questions.
- Our data will consist of images of Earth and Mars.

Connections

The opening activity gives participants their first experience looking at images of the Earth and Mars.

Materials

For each group of 3 to 4 participants:
- 3 images each from the Earth and Mars Image sets
- a collection of large and small lenses (sold in groups of ten online at: http://www.sciplus.com/)

For the group:
- 1 piece of paper with small print (to hang as a viewing target for lens experiments)
- 2 sheets of large chart paper and markers

Preparation

1. Label one sheet of chart paper "Mars and Earth are similar because...". Label the other sheet "Mars and Earth are different because...".

2. Divide the participants into groups of three or four.

Activity

1. Introduce the unit.

Tell participants that over the next few weeks they will be investigating the question "What can we learn from images of other planets?" Ask:

- What are images?
- What do you think they might show us about other planets?

Explain that images are pictures. Participants will be looking at images of Earth and Mars which were taken with special instruments.

2. Compare and contrast images of Earth and Mars.

Distribute the images of Earth and Mars to each group. Ask them to compare and contrast the images to look for ways in which Mars is the same as Earth and ways in which Mars is different from Earth.

3. Record data on similarities and differences.

Hang up the two sheets of chart paper you have prepared and ask participants to share their findings on similarities and differences. Record their ideas on the two charts.

4. Discuss the technology behind the images.

Open a discussion on how scientists use technology to help them learn about other planets and make better observations. Ask:

- How do you think scientists made these images?
- What kinds of technology might they use to observe planets that are very far from Earth?

Explain that one of the key tools that scientists use to study objects in space is the telescope. A telescope can make far off objects look closer and faint objects appear brighter.

The images of Earth and Mars that participants just examined were taken using telescopes mounted in satellites. These are small, unmanned spacecraft in orbit around Earth and Mars.

The telescope itself is a tube-shaped device with lenses positioned inside.

1. What Can We Learn From Images? - Activity

5. Experiment with lenses.

Distribute a box of lenses to each group and hang up the piece of paper with small print. Challenge participants to find a way to use the lenses to read the small print from a distance.

Allow participants time to experiment. If necessary, suggest that they try using two lenses in combination, one in front of the other, held at different distances from their eyes.

6. Communicate findings.

After participants have found a successful combination of lenses, call the group back together to report on their findings. Ask:

- What did you notice about the lenses?
- What combination of lenses gave you the best image of the text on the wall?

Explain to participants that telescopes are constructed using either a combination of lenses like these or a lens together with a mirror. Throughout activities that they do, they will be looking at images that have been taken using telescopes.

2. What Are Satellite Images?

Overview

Participants create maps of the room and discuss the perspectives in their drawings. Then they look at satellite images to help them realize that these are taken from above the Earth.

Participants brainstorm a list of features that might be recognizable in satellite photos, search the Earth Images for these features, and place the images in categories depicting these features.

TIME:
• 1 hour

Connections

Before we can study and interpret images of other planets, we need to understand what we see in satellite images of our own planet.

Big Ideas

• Science is about collecting data and using evidence to answer questions. Participants will be doing what scientists do when analyzing images from spacecraft – comparing what they see in the images to what they already know.

• Satellite images are taken from space, and therefore give us images of the Earth from far above its surface.

• Major features, such as rivers, oceans, mountains, and cities are recognizable on satellite images.

Materials

For each participant:
• 1 sheet of drawing paper
• 1 pencil

For the group:
• 1 set of Earth Images
• several large sheets of paper

Preparation

No advanced preparation beyond the gathering of materials necessary for this activity.

2. What Are Satellite Images?

Activity

1. Draw a picture of the room.

Ask participants to draw a picture of the room. They may draw it any way they like.

As participants are working, walk around and look at their pictures. Check on the number of different perspectives they have chosen. Some may have drawn the room from eye level, others from above (like a map).

2. Share the drawings to point out different perspectives.

Invite participants to share their drawings. Pick out several pictures drawn from different perspectives and ask:

• Where would you need to be standing in order to draw the room from this point of view?

Note: If no one has drawn the room from above, ask participants to try to draw the room as if they were looking down on it from the ceiling.

Ask:
• What details in the room are represented in these pictures?

3. Recognize the point of view in satellite images.

Group participants into teams of three or four, and distribute one set of Earth Images to each team. Let them look at the images briefly and then ask:

• Where would you need to be standing in order to see the Earth from this point of view?

Explain that these images were taken from space, looking down on the Earth from space. They are similar to the drawings participants did when they made maps of the room as if they were looking down on it from the ceiling.

2. What Are Satellite Images? - Activity

4. Brainstorm a list of features that might be visible in satellite photos.

Ask participants to brainstorm a list of features they would expect to see in satellite photos of the Earth. They might mention features such rivers, mountains, oceans, cities, and forests.

Record each idea on a separate sheet of paper. Hang the sheets of paper with the feature names around the room..

5. Work in groups to identify features in the satellite images.

Ask each group to observe all of the Earth Images closely and decide if an images includes one of the features they named in the brainstorming session. Then have them place the image showing that feature under the paper (which you have hung around the room) with the name of that feature.

6. Discuss the findings.

Have participants discuss their choices and give reasons for their placements. Encourage rich and detailed descriptions. Ask, for example:

- Why do you think this image shows a river? How does it look? What shape is it? Can you trace its flow?

Recognize that there may be disagreement, and that some features may be incorrectly identified. Provide guidance, and ask participants to give more evidence and to reconsider their identifications based on the evidence.

3. What Do Satellite Images Tell Us About Mars?

Overview

Participants compare satellite images of Mars and Earth to look for similar features. Then they brainstorm a list of forces or events that could have caused some of these features to form on Mars.

TIME:
• 45 minutes

Big Ideas

• Science is about collecting data and using evidence to answer questions. Participants will be doing what scientists do when analyzing images from spacecraft -- comparing what they see in the images to what they already know.

• Scientists use evidence from satellite images to build explanations.

Connections

Participants apply what they have learned about viewing and interpreting satellite images of Earth to begin analyzing satellite images of Mars.

Materials

For each participant:
• 1 science journal
• 1 metric ruler (for grades 4 and above)

For the group:
• 1 set of Earth Images
• 1 set of Mars Images
• 2 sheets of chart paper and markers

Preparation

Each participant will need a science journal to record thoughts, observations, and findings over the next few weeks. There are a number of ways to create journals if you are not providing ready-made ones. For example:

• Have participants make folders from construction paper. They can then insert loose leaf paper (both lined and drawing paper) into the folders.

• Fold sheets of large paper in half. Either staple the sheets together or punch holes and tie the sheets together with string or yarn.

3. What Do Satellite Images Tell Us About Mars?

Activity

1. Scientists compare satellite images of Mars to images of the Earth.

Have participants share their ideas about how scientists use images to study Mars. Ask:

- What do you think that scientists did when they first saw images of Mars? How did they try to figure out what they were seeing?

Explain that scientists interpret images of Mars by comparing and contrasting them to more familiar things that they already know about, such as features and areas of the Earth.

2. Now participants will use the same technique that space scientists use to interpret images.

Distribute the Earth Image set and the Mars Image set to groups of three or four participants. Tell them to:

- Compare the two sets of images and look for similarities. When they find two images that have similar features, they should write down the number of the Mars image and the number of the Earth image in their science journals.

- Write about and/or draw (depending on grade level) what is similar in the two images.

Extension for grades 4 and above:
- Notice the scale bar in the corner of each picture. Calculate the size of the feature in each image: Use the ruler to measure the size of the feature in centimeters and then multiply that number by the number of kilometers or miles represented by each centimeter (as shown on the scale bar.)

3. Discuss findings.

Hold a discussion about how participants were able to interpret features on Mars. Record their responses on a sheet of chart paper. Ask:

- What features did you find on Mars that look similar to those on Earth?
- What differences did you observe?

3. What Do Satellite Images Tell Us About Mars? - Activity

4. Speculate on what might have caused those features to form on Mars.

Ask participants to look at the Mars images again and share their ideas of how and why they think those features might have formed on the surface of the planet. They might mention such forces as wind, water, earthquakes, or volcanoes. Record their ideas on another sheet of chart paper.

Let participants know that in upcoming activities they will be trying to recreate some of these features using three different methods.

4. Did Wind Create Features On Mars?

Overview

Participants use trays of sand and straws to attempt to recreate surface features of images of Mars.

TIME:
- 1 hour

Connections

By modeling the effects of wind on a planet's surface, participants test their ideas about how some of the features on Mars might have been produced.

Big Ideas

- Scientists rely on laboratory experiments and modeling to better understand and test their ideas.
- A model is different from the real thing but can be used to learn something about the real thing.
- Similar investigations rarely come out exactly the same.

Materials

For each group of three to four participants:
- 1 lightweight plastic tray about 1 m long and 10 cm wide (purchase wall paper trays from a paint store for about $1.00 each)
- sand to cover surface of tray to a depth of at least 5 cm
- clear plastic wrap to cover tray
- tape
- 1 drinking straw each
- 1 set of Mars Images

For each participant:
- 1 science journal

Preparation

1. Prepare the trays for the simulation:
   - Cover the bottom of each tray with a layer of sand at least 5 cm deep.
   - Cover the top of each tray with clear plastic wrap, and tape the wrap to the sides of the tray to make sure it will not come off during the activity.
   - Poke a hole in the plastic wrap at one end of the tray. It needs to be large enough for participants to stick in a straw and blow air across the surface of the sand. The plastic wrap is a safety measure, meant to keep the sand in the container and prevent it from blowing into participants' eyes.

2. Place the trays and straws at work stations around the room.

4. Did Wind Create Features On Mars?

Activity

1. Review the set of Mars Images.

Distribute the Mars Images to groups of three or four participants. Ask them to choose two images from the set that have features they think might have been formed by wind. Have them give reasons for their selections.

2. Explain modeling.

Explain that although scientists can't go to Mars to find out if their ideas are correct, they can test their ideas in laboratory simulations. They use models to see if they can get results similar to what they observe in the satellite images of Mars.

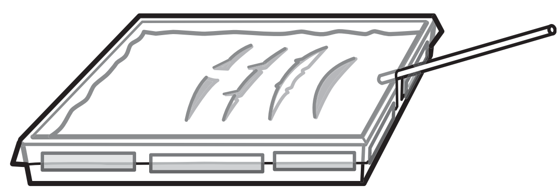
Now participants will test their ideas about features formed by wind by trying to recreate surface formations similar to the ones they have selected from the Mars Images.

3. Introduce the model and the testing procedures.

Gather participants around one tray set-up and explain that they will use the model to try to recreate some of the features they see on the surface of Mars. Demonstrate the following, and invite participants to comment on the results:

- Stick a straw in the hole of the plastic wrap and blow gently across the surface. What happens? What kind of feature results? Is it similar to any of the features in the images of Mars?

- Change the angle or the direction of the straw. How is the effect different?



Set the appropriate safety rules. Emphasize that the plastic wrap should stay on the tray at all times.

4. Explore the effects of wind. Record the results.

Allow participants as much time as possible to explore the effects of wind on the sandy surface.

Remind them that they need to keep track of what they did to create features and that it is important to record their results in their science journals. Younger participants may draw before and after pictures of their trays. Older ones may add written descriptions as well.

4. Did Wind Create Features On Mars? - Activity

5. Report on results.

Debrief the group on what they found out about the effects of wind. Use some of these prompts for the discussion:

- What did you do to try to recreate the features in the Mars images?
- What happened? What kinds of features were you able to recreate?
- Why do you think you could model some kinds of features but not others? Give reasons.

Let participants know that they will continue to explore modeling in upcoming sessions.

REMINDER:
Store the trays and the sand in a safe place. They will be used again in the next activity.

5. Did Water Create Features On Mars?

Overview

Participants use trays of sand and cups of water to attempt to recreate surface features seen in images of Mars.

TIME:
• 1 hour

Connections

Participants continue to tests their ideas about the surface of Mars by using water to create features.

Big Ideas

• Scientists rely on laboratory experiments and modeling to better understand and test their ideas.

• A model is different from the real thing but can be used to learn something about the real thing.

• Similar investigations rarely come out exactly the same.

Materials

For each group of three to four participants:
• 1 lightweight plastic tray about 1 m long and 10 cm wide (purchase wall paper trays from a paint store for about $1.00 each)
• damp sand to cover surface of tray to a depth of at least 2 cm
• jug of water
• several blocks (to raise one end of the tray)
• 1 protractor (for grade 4 and above)
• several large and small paper cups
• 1 bucket (for collecting excess sandy water)
• 1 set of Mars Images
• newspapers to place under trays (optional)
• clean up supplies such as rags, sponges, whisk brooms

For each participant
• 1 science journal

Preparation

1. Set up the trays of sand:
• Dampen the sand.
• Cover the bottom of each tray with a layer of sand about 2 cm deep.

2. Place the trays, blocks, buckets, jugs of water, cups, and clean up supplies at work stations around the room.

5. Did Water Create Features On Mars?

Activity

1. Review the set of Mars Images.

Distribute the Mars Images to groups of three or four participants. Ask them to choose two images from the set that have features they think might have been formed by flowing water. Have them give reasons for their selections.

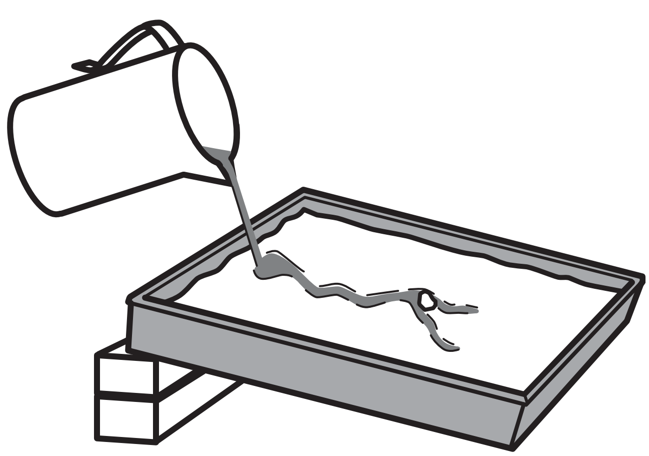
Next, participants will test their ideas about features formed by flowing water by trying to recreate surface formations similar to the ones they have selected from the Mars Images.

2. Introduce the model and the testing procedures.

Gather participants around one tray set-up and explain that they will use the model to try to recreate some of the features they see on the surface of Mars. Demonstrate the following, and invite participants to comment on the results:

- Put several blocks under one end of the tray. Slowly and carefully, pour a cup of water into the higher end of the tray. What happens to the sand?
- Change the angle of the tray by adding or removing blocks. For 4th grade and above, demonstrate using a protractor to measure the angle of the tray. What effect does changing the angle have on the water flow? On the feature?
- Show participants how to remove excess water from the bottom of the tray by using a cup to scoop most of the water out into the collection bucket. NOTE: Sandy water will clog drains, so plan to collect all this water and dispose of it outside.

Set the appropriate safety rules. Also mention that these are messy experiments, so it is important for participants to work carefully.



5. Did Water Create Features On Mars? - Activity

3. Review the set of Mars Images.

Allow participants as much time as possible to explore the effects of flowing water on the sandy surface.

Remind them that they need to keep track of what they did to create features and that it is important to record their results. Younger participants may draw before and after pictures of their trays. Older ones may add written descriptions as well.

4. Report on results.

Debrief the group on what they found out about the effects of flowing water. Use some of these prompts for the discussion:

- What did you do to try to recreate the features in the Mars images? Did you manipulate the amount or the speed of the water? The angle of the tray?
- What happened? What kinds of features were you able to recreate with flowing water?
- Why do you think you could model some kinds of features but not others? Give reasons.

Let participants know that they will continue to explore modeling in the next session.

REMINDER:
Store the trays and the sand in a safe place. They will be used again in the next activity. Let the sand air dry.

6. Did Impacts Create Features On Mars?

Overview

Participants use trays of sand and a variety of solid objects to model the effects of "impactors" on the surface.

TIME:
- 1 hour

Connections

Participants conclude their modeling of features on the surface of Mars by experimenting with objects that make impact when landing.

Big Ideas

- Scientists rely on laboratory experiments and modeling to better understand and test their ideas.
- A model is different from the real thing but can be used to learn something about the real thing.
- Similar investigations rarely come out exactly the same.

Materials

For each group of three to four participants:
- 1 lightweight plastic tray about 1 m long and 10 cm wide (purchase wall paper trays from a paint store for about $1.00 each)
- sand to cover surface of tray to a depth of about 5 cm
- jar of water (optional)
- several objects in a variety of sizes and shapes to use as "impactors", such as ball bearings, marbles, golf balls, tennis balls, rocks, acorns, coins, blocks
- 1 set of Mars Images

For each participant:
- 1 science journal

Preparation

1. Set up the trays of sand:
- Cover the bottom of each tray with a layer of sand about 5 cm deep.

2. Place the trays, an assortment of "impactors", and a jar of water (optional) at work stations around the room.

6. Did Impacts Create Features On Mars?

Activity

1. Review the set of Mars Images.

Distribute the Mars Images to groups of three or four participants. Ask them to choose two images from the set that have features they think might have been formed by the impact of a falling object. Have them give reasons for their selections.

Ask what the group knows about meteors, sometimes called falling stars. Then explain that meteors are not really falling stars, but are pieces of rock that hit the Earth's atmosphere (the air surrounding the Earth). Usually the rock burns up before it hits the Earth. If a very large piece enters the Earth's atmosphere, it may fall all the way to the ground before it burns up completely. This doesn't happen very often now, but it did happen more a very long time ago. This kind of impact can change the planet's surface.

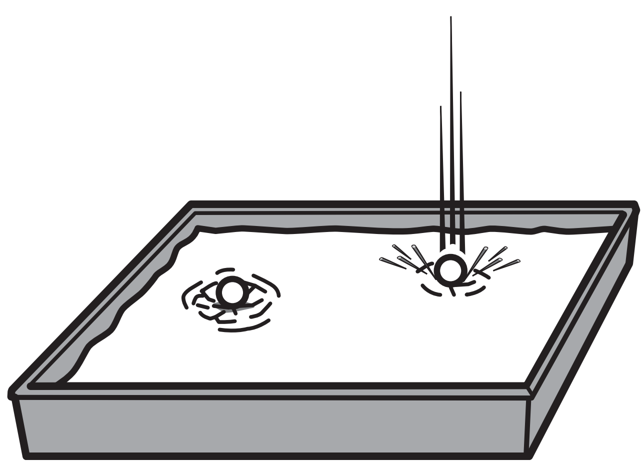
Next, participants will test their ideas about features formed by "impactors" by trying to recreate surface formations similar to the ones they have selected from the Mars Images.

2. Introduce the model and the testing procedures.

Gather participants around one tray set-up and explain that they will use the model to try to recreate some of the features they see on the surface of Mars. Demonstrate the following, and invite participants to comment on the results:

- Drop one of the objects from varying heights. How are the craters that formed different? What would happen if you dropped a lighter or heavier object? An object with a different shape?

Set the appropriate safety rules. These might include the caution that only dropping objects is allowed; no throwing.



6. Did Impacts Create Features On Mars? - Activity

3. Introduce the model and the testing procedures.

Allow participants as much time as possible to explore the effects of a variety of "impactors" on the sandy surface.

Remind participants that they need to keep track of what they did to create features and that it is important to record their results. Younger participants may draw before and after pictures of their trays. Older ones may add written descriptions as well.

NOTE:

After participants have experimented with dry sand, you can also suggest that they add enough water to make it just damp. Water adds a little more surface strength to the sand, and this results in slightly different crater features. This is a bit messier and takes more time, and therefore is suggested as an option.

4. Report on results.

Debrief the group on what they found out about the effects of falling objects on the sandy surface. Use some of these prompts for the discussion:

- What did you do to try to recreate the features in the Mars images? Did you change the height of the drop for the same object? Did you try a variety of objects? Did you add water to the sand?

- What happened? What kinds of features were you able to recreate?

7. What Else Do We Want To Find Out About Mars?

Participants discuss the models they created in the last three activities as models of forces that shape the surface of planets, and talk about the similarities and differences between models and real events. Then they brainstorm a list of questions and suggest ways they might find answers.

TIME:
- 45 minutes

Now that participants have created models to help explain features on Mars, they explore the limits of those models.

- Scientists rely on laboratory experiments and modeling to better understand and test their ideas.
- A model is different from the real thing but can be used to learn something about the real thing.
- Science is about raising questions and searching for answers.
- An important part of the scientific process involves comparing ideas that you develop through experiments and observations with the thinking of other scientists.
- Scientists often go to the research done by others to see if someone else has already answered any of their questions.

Materials

For the group:
- 1 set of Mars Images
- chart paper and markers

Preparation

1. Divide one sheet of chart paper into two columns. Label the first column "The Same" and the second column "Different". Hang up the chart.

2. Label another sheet of chart paper "Our Questions About Mars" and hang it up.

7. What Else Do We Want To Find Out About Mars?

Activity

1. Compare the sand tray models to images of Mars.

Hold up several of the Mars Images, one at a time, and ask:
• What do you think caused these features on Mars? Why do you think so?
• Why do scientists create models? How did your models help you understand the forces that might have caused the features?

Mention that participants used models of three different forces to try to recreate features on the surface of Mars. Ask them to think back:
• What represented the three forces? (wind, flowing water, falling objects)
• What represented the surface of Mars?

2. Discuss the similarities and differences between the models and the actual forces that shaped the surface of Mars.

Focus attention on the chart labeled "The Same" and "Different." Ask:
• In what ways were those three models similar to the things they represented? In what ways were they different? In other words, what was the same or different about the way these events happened in the experiments and the way they might happen in reality?

As participants respond, write their ideas on the chart in the appropriate column. Record all ideas before offering any of your own. Here are some key differences to mention if they don't come up in the discussion:
• Our test surface was always sand. It may not be exactly like the soil on Mars.
• Our experiments were small scale. Particularly with impacts, events at higher speed and larger scale could produce different results. For example, using our models, the crater shape depended somewhat on the shape of the object and the angle of the impact. But at greater speeds and in outer space, the shock wave of an impact almost always produces a round crater, regardless of the shape of the object or the angle of impact.
• Our experiments took place over a short period of time. It is possible that some of these features took many years to develop. This is especially true of features created by flowing water, such as canyons.

7. What Else Do We Want To Find Out About Mars? - Activity

3. Introduce the science journals.

Invite the group to share their unanswered questions about Mars. Now that we have thought about ways the classroom experiments compare to the real events on Mars, we need to think about what else we could find out that would help us understand our experiments or the images even better. What else do we want to know?

Record all ideas on the chart you have labeled "Our Questions About Mars". Participants may wonder, for example, if there is life on Mars, if there is water, or what kind of weather the planet might experience.

When the question list is complete, have participants vote on the three questions they are most interested in finding answers for. On the chart, circle the three questions for easy reference.

4. Discuss how scientists search for answers.

Group participants into teams of three of four and have them discuss how they think scientists would go about finding answers to the three questions circled on the chart.

After the small group discussion, bring everyone back together to share ideas. Refer back to the three questions on the chart and ask:

- How do you think scientists would try to answer these questions?
- How many different ways might they use?

Participants will probably mention that scientists might do more experiments; use books, magazines, TV, and the Internet; visit science museums; or consult with other scientists.

Explain that scientists don't always have to do a new experiment when they develop a question that is new to them. One of the first things that a scientist usually does is to find out what other scientists have already discovered about their question. In the next session, participants will be doing the same: researching what scientists have already found out about their questions.

8. How Can We Find Out More About Mars?

Overview

Participants use a variety of resources to try to find answers to their questions. Then they hold a science conference to share their findings.

TIME:
- 1 hour or more for research
- 1 hour for the science conference

Big Ideas

- Scientists do research and tap into sources of established knowledge.
- They compare their thinking to established knowledge.
- Scientists communicate what they have learned and which questions still remain open.

Connections

Participants explore resources to find out what is known about Mars and hold a science conference to share their new information.

Materials

For the group:
- Chart labeled "Our Questions About Mars" (generated in Activity 7)
- A variety of books, videos, and CD-ROMs about Mars (See Resources on page 35 for a detailed list of suggestions)
- Access to computers, if possible
- Chart paper and markers

For each participant:
- 1 science journal

Preparation

1. Read over the five options for research presented in the activity and decide which ones to use with your group.
2. Gather together a variety of resources about Mars suitable to your group's age and ability level.
3. If possible, arrange a time for participants to have access to the internet.
4. Hang up the chart called "Our Questions About Mars".

8. How Can We Find Out More About Mars?

Activity

1. Review the questions for research.

Focus participants' attention on the questions they generated in the previous activity. In their journals, have older participants record the three questions the group selected for research.

Explain that participants will be conducting research to try to find answers to those questions. As they go through the resources, they should write down new things that they learn about Mars in their journals, especially if they might provide answers to questions on the list. For younger participants, you will act as group recorder.

2. Conduct research.

There are five options suggested for research. Please select those that are most appropriate for your group and for the resources you have available.

FIVE OPTIONS FOR RESEARCH

OPTION 1: USING BOOKS (for all ages)

- Present participants with a collection of books about space science and let them suggest one to use to begin the research.
- Have participants select one of the questions from the list and help you look at the table of contents or index (if present) of your chosen book. If there is no table of contents or index, simply leaf through the book to see if it deals with your topic.

Mention that science books are not like story books. You don't have to start at the beginning and read through to the end. You can often find pages about your question and read those first.
- When you find a page related to your questions, read it aloud to the group.

FOR K-2 LEARNERS: Ask if anything you read seems to answer one of the questions. If so, record the information on chart paper. If not, pick another book or another page and continue reading together.

FOR 3-5 LEARNERS: Ask if anything you read seems to answer one of the questions. If so, have them record the information in their journals. Once participants understand how to use science books, break them into small groups, assign each group a question, and have them explore the books on their own.

8. How Can We Find Out More About Mars? - Activity

OPTION 2: WATCHING A VIDEO TOGETHER (for all ages)

- Tell participants that they will watch the video called *Mars: Past, Present, and Future*. (See the Resources on page 35.) If the video presents information that answers one of their questions, participants should signal you to stop the video.
- Play the video. As participants signal, stop the tape to discuss what was just shown or said. Replay the tape if necessary.

FOR K-2 LEARNERS: Record the information on chart paper.

FOR 3-5 LEARNERS: Have them write down the information in their journals.

OPTION 3: USING PRESELECTED SITES ON THE INTERNET (for 3rd grade and above)

- Bookmark a list of websites about Mars. (See the Resources on page 35)
- Have participants explore the selected sites with partners and record information related to their questions in their notebooks.

OPTION 4: DOING YOUR OWN INTERNET SEARCH (for 4th grade and above)

- With the group, brainstorm a list of "key words" they could use to conduct a search on the Internet.
- Either bookmark some websites for participants or show them how to get to a search engine page.
- Discuss the importance of knowing the source of the information, and talk about the kinds of sites that are likely to have reliable information about Mars, such as NASA or university websites.
- Allow participants to search on their own and record new information in their journals.

Caution: As they work, circulate to make sure that each learner is on a safe and reasonable website.

OPTION 5: TAKING A FIELD TRIP

- Take a field trip to your local library to do research. Be sure to call ahead to schedule the visit, and to let the librarians know what topics participants are researching.
- Visit your local science museum. Check that they have exhibits related to your topic. Try to arrange a guided tour with a docent.

4. Hold a science conference.

Explain to participants that they will continue to work the way scientists do by communicating what they learned from their research about Mars. In addition to sharing their findings, scientists also present questions they still have and that others might want to think about researching in the future.

Now participants will hold a science conference to share their new information as well as their unanswered questions. Give them a few minutes to review questions and answers they recorded. Then ask:
- What did you find out about Mars by doing research? What do you know now that you didn't know before?
- Which questions did you answer?

8. How Can We Find Out More About Mars? - Activity

- Which questions remain unanswered? How might you look for more answers?
- What did you learn about the ways that scientists think and work?

EXTENSION ACTIVITY

An excellent website produced by NASA gives viewers the opportunity to explore features such as volcanoes, canyons, and craters on Mars.

Go to: http://www.marsquestonline.org and click on "Explore Mars".

After you select a feature, there are several options. The two we suggest are:

- "How Big is It?"
  Allows the viewer to drop different sized objects (such as a school bus or the whole U.S.) on top of a feature to gauge how large the feature is.

- "Fly in 3 D"
  Lets you explore the feature in three dimensions.

9. Which Planet Shall We Visit?

Overview

Participants compare images of planets and select one planet on which to base the story of their imaginary voyage. They create comic strips to tell the tale.

TIME:
- 1 hour

Big Ideas

- Scientists use skills they have learned and apply them to new situations.
- They communicate creatively about what they have learned and talk about what still remains unanswered.

Connections

Participants apply what they have learned about how to interpret images of Earth and Mars to interpret images of other planets.

Materials

For each group of 3 to 4:
- 1 set of Solar System Lithographs (can be downloaded from http://teachspacescience.org)
- drawing materials such as large sheets of paper, colored pencils or pens, markers, rulers
- sample comic strips (optional)

Preparation

Bring in several pages of comics (optional) to serve as samples.

Activity

1. Compare images.

Distribute a set of Solar System Lithographs to each group of three or four participants. Ask participants to compare and contrast the images. Have them point out those that appear to be most like Earth, least like Earth, and any other categories they choose.

Ask each group to present their categories, and give reasons why they assigned each planet to a particular category.

2. Design a comic strip to tell the story of a mission to another planet.

Have each group select one planet, and make up a story about their mission to that planet. Then have them design a comic strip to tell their story. You may want to show the group some samples of comic strips to inspire them, and to make sure everyone understands how comics are set up.

Suggest the following strategies for creating a comic strip story:

- One good approach is to work as a group to make up the story first. The story might include how you travel to the planet and what you find when you get there.

- Next, figure out the number of panels (picture boxes that show the action) you will need to tell the story, and what part of the story goes in each panel.

- Divide up the work so that everyone in the group gets to work on a panel or two.

3. Display the comic strips and tell the stories.

When groups have finished their comic strips, hang them up for all to see. Invite each group to tell its story.

Resources For The Mars Curriculum

Books

For ages 5-8

- Seymour, Simon. *Destination: Mars*. New York, NY: Harper-Collins, 2000.
- Vogt, Gregory. *Solar System*. New York, NY: Scholastic Science Readers, 2001.

For ages 9-12

- Campbell, Ann-Jeanette. *The New York Public Library Amazing Space: An Answer Book for Kids*. Hoboken, NJ: Wiley, 1997.

- Dickinson, Terence. *Other Worlds: A Beginner's Guide to Other Planets and Moons*. Richmond Hill, Ontario: Firefly Books Ltd., 1995.

- Henbest, Nigel and Heather Couper. *DK Space Encyclopedia*. New York, NY: DK Children, 1999.

- Kerrod, Robin. *Mars*. Minneapolis, MN: Lerner Publications, 2000.

- Murray, Steward and Edward Bernard. *Mars (Eyewitness Books)*. New York, NY: DK Publishing, Inc, 2004.

Websites to Explore

- NASA's Mars Exploration Program (main site)
  http://mars.jpl.nasa.gov/index.html

- Mars Quest Online
  http://www.marsquestonline.org/

- The International society for Microbial Ecology
  http://www.microbes.org

Materials Available from NASA

The following materials may be ordered through NASA CORE (Central Operation of Resources for Educators) at
http://education.nasa.gov/edprograms/core/home/index.html

- *Mars VE: The Virtual Explorers* CD ROM
- *Pathfinder and the Best of Mars* CD ROM
- *Mars: Past, Present, Future* DVD/VHS
- *Destination Mars* VHS

Relevant National Science Education Standards

The National Science Education Standards (National Research Council, The Academic Press, Washington, D.C., 1999) relevant to the activities in this educator resource guide are listed below.

As a result of activities in grades K-4, all students should develop understanding of:

Standard A: Science as Inquiry

- Abilities necessary to do science inquiry:
  - o Ask questions about objects, organisms, events in the environment
  - o Conduct a simple investigation
  - o Employ simple equipment and tools to gather data and extend the senses
  - o Use data to construct a reasonable explanation
  - o Communicate investigations and explanations

- Understandings about science inquiry:
  - o Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.
  - o 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).
  - o Simple instruments, such as magnifiers, thermometers, and rulers, provide more information than scientists obtain using only their senses
  - o Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations.
  - o Scientists make the results of their investigations public; they describe the investigations in ways that enable others to repeat the investigations.
  - o Scientists review and ask questions about the results of other scientists' work.

Standard D: Earth and Space Science

- Properties of Earth Materials: Earth materials are solid rocks and soils, water, and the gases of the atmosphere. The varied materials have different physical and chemical properties, which make them useful in different ways, for example, as building materials, as sources of fuel, or for growing the plants we use as food. Earth materials provide many of the resources that humans use.

- 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.

Mars Image Set

Image Credit: NASA/JPL/Malin Space Science Systems

IMAGE 1

Mars and Earth: Science Learning Activities for Afterschool

Mars Image Set

Image Credit: NASA/JPL/Malin Space Science Systems

IMAGE 2

Mars Image Set

Image Credit: NASA/JPL/Malin Space Science Systems

IMAGE 3

Mars Image Set

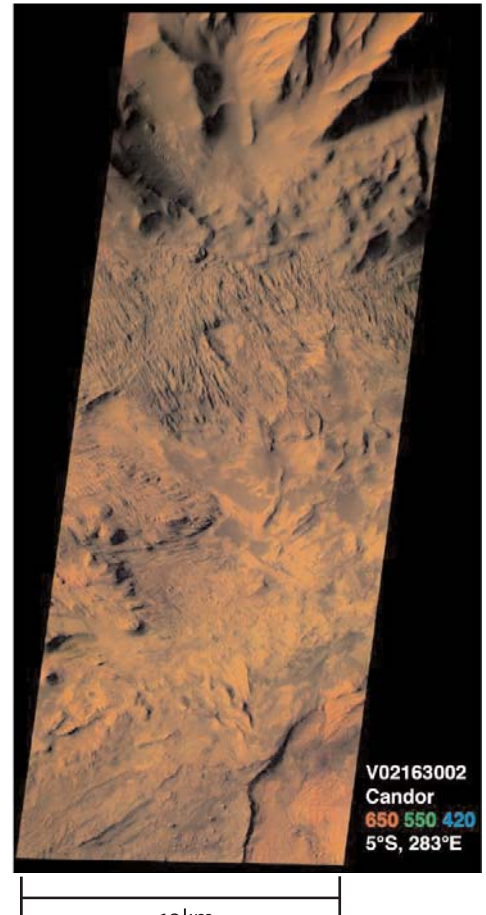


Image Credit: NASA/JPL/Arizona State University/Cornell University

IMAGE 4

Mars Image Set

Image Credit: NASA/JPL/Malin Space Science Systems

IMAGE 5

Mars and Earth: Science Learning Activities for Afterschool

Mars Image Set

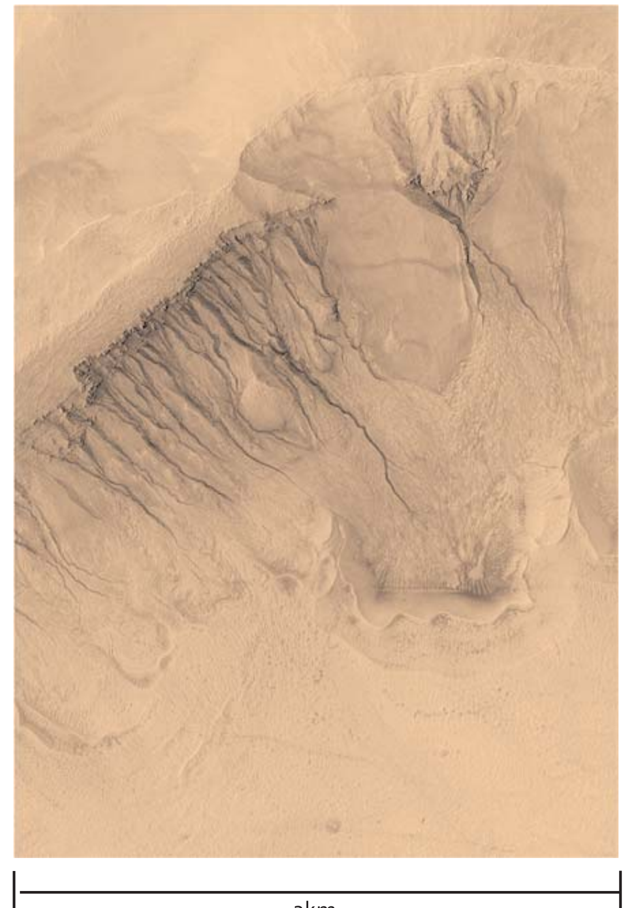
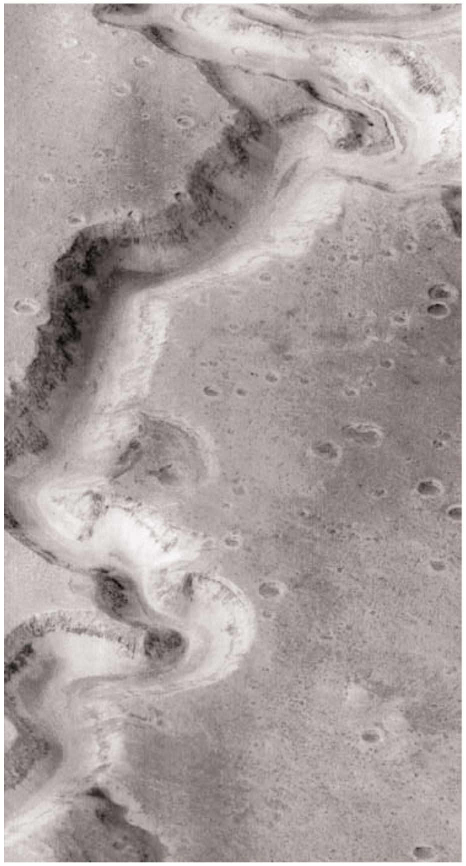


Image Credit: NASA/JPL/Malin Space Science Systems

IMAGE 6

Mars Image Set



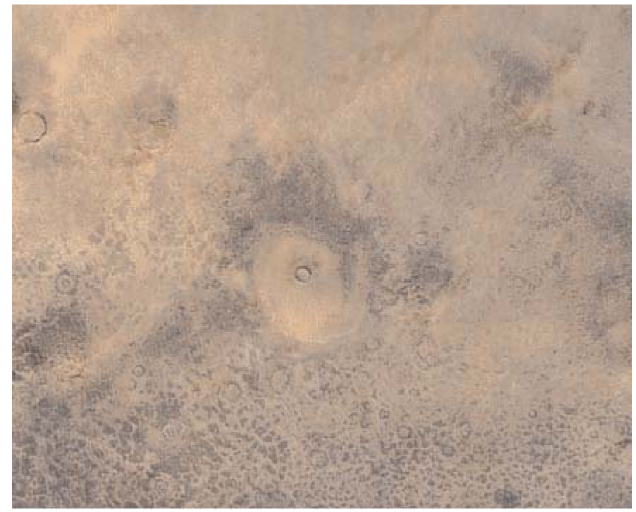
10km

Image Credit: NASA/JPL/Malin Space Science Systems

IMAGE 7

Mars and Earth: Science Learning Activities for Afterschool

Mars Image Set



168km

Image Credit: NASA/JPL/Malin Space Science Systems

IMAGE 8

Mars Image Set

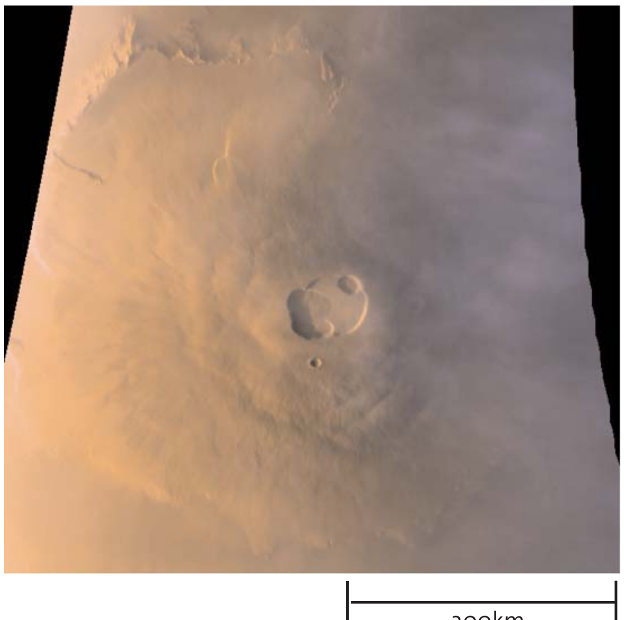


Image Credit: NASA/JPL/Malin Space Science Systems

IMAGE 9

Mars Image Set

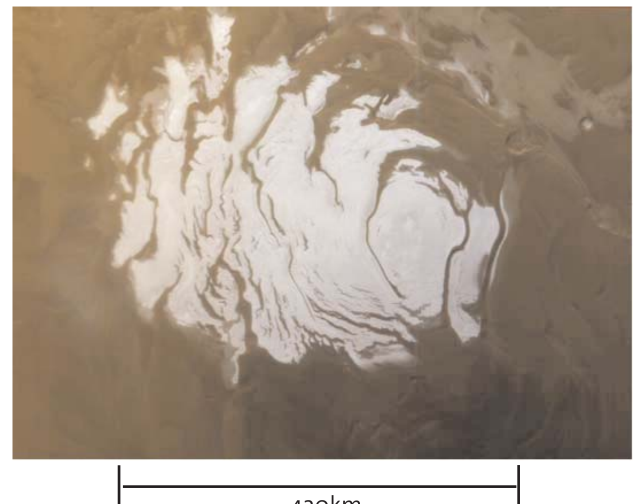


Image Credit: NASA/JPL/Malin Space Science Systems

IMAGE 10

Mars Image Set

INSTRUCTOR KEY

- **Image 1: Nirgal Vallis and its Windblown Dunes:** Nirgal Vallis is system of narrow valleys. The floor of the valleys are covered largely with light sand dunes. Just left of center in the image, the dunes have craters created by impacts. These indicate that the sand dunes are older than they might seem at first.
- **Image 2: Apollinaris Patera.** This ancient Martian volcano is located near the equator and is thought (based on observations made by the Viking spacecraft in the 1970s) to be as much as 5 km (3 miles) high
- **Image 3: Crater.** This crater was formed by the impact of the meteor on the surface of Mars.
- **Image 4: Cador Chasma.** This image shows the effects of erosion by a variety of processes, including wind and gravity, on colored layers of rocks.
- **Image 5: Happy Face Crater.** This crater was created by a meteor impact with the surface of Mars.
- **Image 6: Gullies in a crater wall.** This image shows gullies most likely created by flowing water, on the walls of an ancient crater.
- **Image 7: Nanedi Vallis.** The origin of this canyon is still debated. Some features, such as terraces in the canyon, suggest that fluid (most likely water) flowed continuously cutting through layer upon layer of the canyon. Other features, like the absence of tributary channels, suggest that it was formed by the collapse of the surface. Scientists now think it must be a combination of the two.
- **Image 8: Northern Plains.** While there are fewer impact craters in the Northern hemisphere than the southern on Mars, you can see some craters in this image.
- **Image 9: Olympus Mons is the largest volcano in the solar system.** It is more than three times the height of Mount Everest and is as wide as the entire Hawaiian Island chain.
- **Image 10: South Polar Cap.** The frozen polar frost at Mars' south pole is frozen carbon dixoide, thought scientists believe that their may be frozen water ice somewhere beneath the surface.

Earth Image Set

Image Credit: Landsat 7 team

IMAGE 1

Earth Image Set

Image Credit: Jacques Descloitres, MODIS Rapid Response Team, NASA/GSFC

IMAGE 2

Earth Image Set

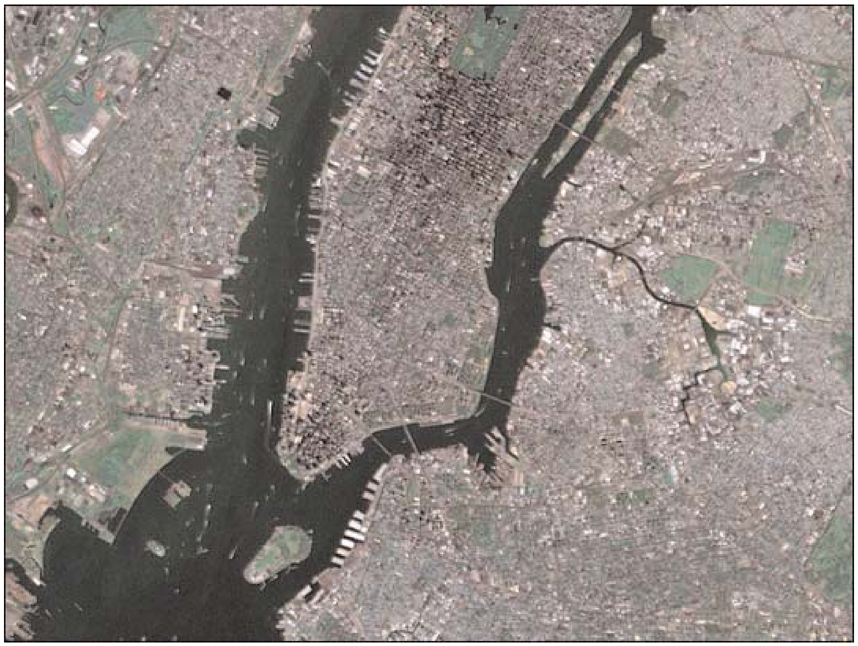


Image Credit: U.S. Geological Survey, EROS Data Center, Sioux Falls, SD

IMAGE 3

Earth Image Set

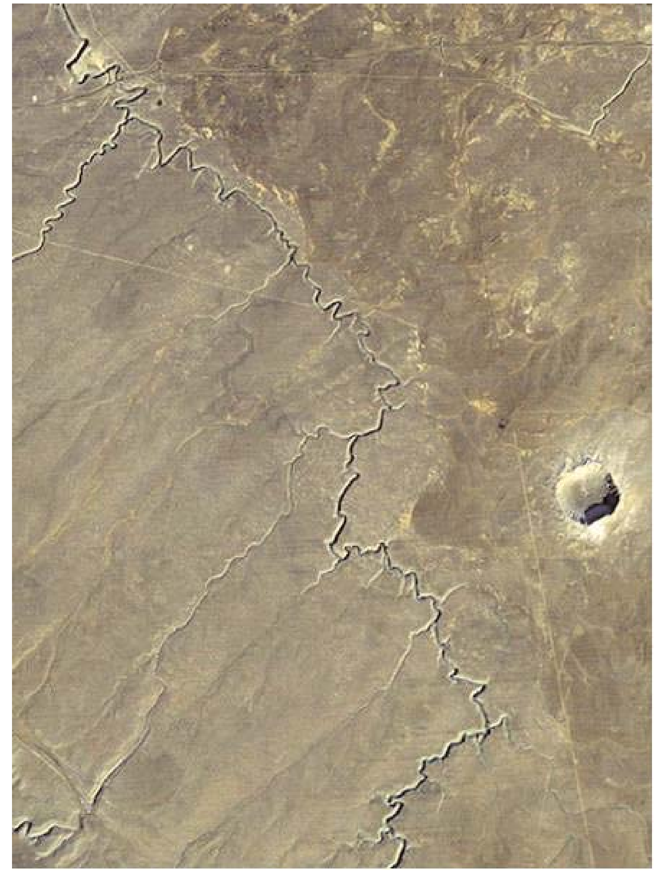


Image Credit: Jacques Descloitres, MODIS Rapid Response Team, NASA/GSFC

IMAGE 4

Earth Image Set

Image Credit: Jacques Descloitres, MODIS Rapid Response Team, NASA/GSFC

IMAGE 5

Earth Image Set

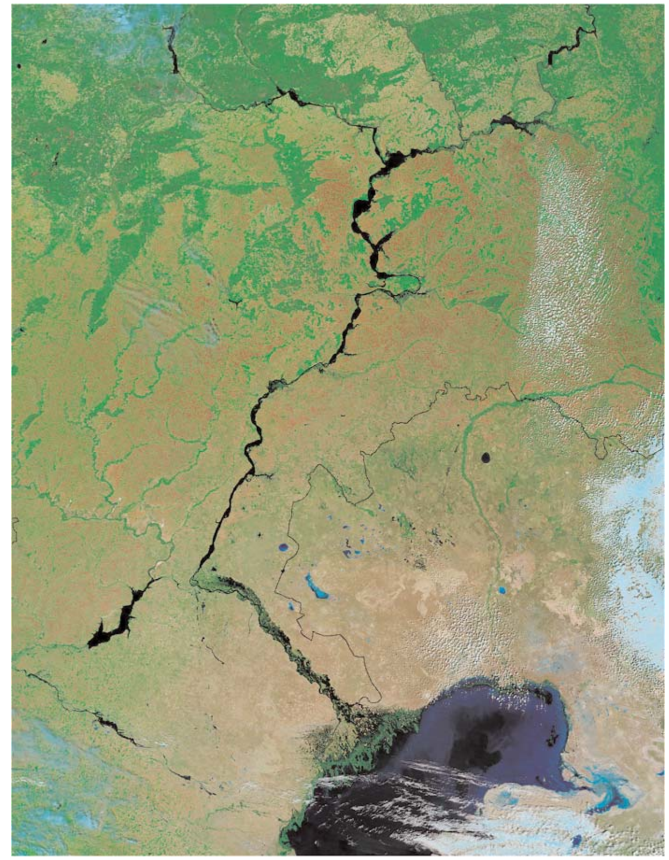


Image Credit: Jacques Descloitres, MODIS Rapid Response Team, NASA/GSFC

IMAGE 6

Earth Image Set

Image Credit: Jacques Descloitres, MODIS Rapid Response Team, NASA/GSFC

IMAGE 7

Earth Image Set

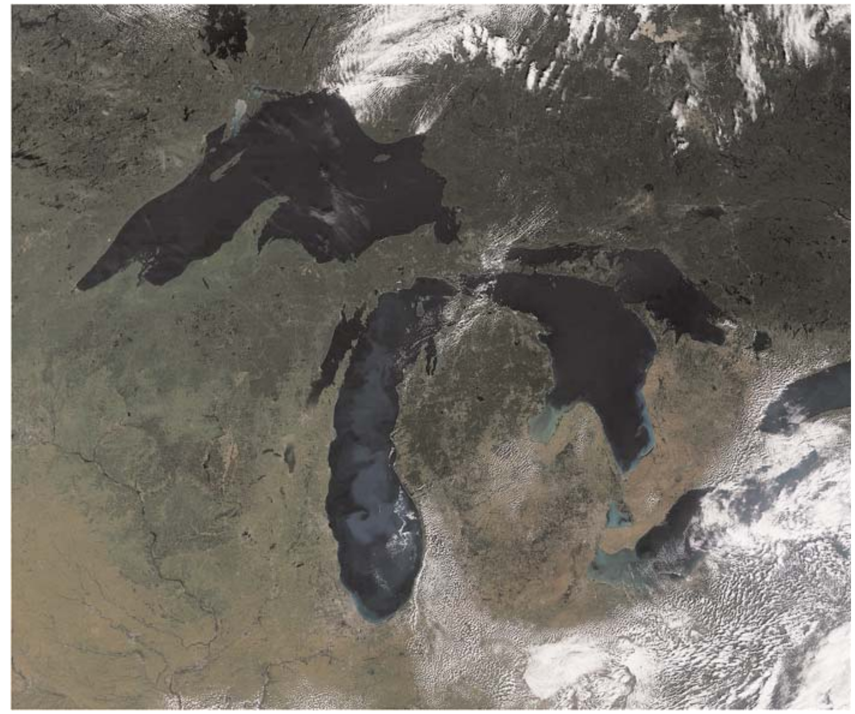


Image Credit: Jacques Descloitres, MODIS Rapid Response Team, NASA/GSFC

IMAGE 8

Earth Image Set

INSTRUCTOR KEY

- **Image 1:** Lake Manicouagan in Canada is the remnant of one of the largest impact craters on Earth.
- **Image 2:** Grand Canyon
- **Image 3:** New York City area – including lower Manhattan, Ellis Island, and parts of Brooklyn, Queens, and New Jersey
- **Image 4:** Meteor Crater in Arizona. This imapact crater is 174 m (570 ft) deep and 1,300 m (0.8 miles) in diameter.
- **Image 5:** Pacfic Coast of Canada
- **Image 6:** Volga River in Russia
- **Image 7:** The Nile River in Egypt
- **Image 8:** Great Lakes in North America