

## Activity 8: Live Tonight – The Planets!

### Overview

This activity encourages children, ages 7 and up, and their families go outside on a clear evening to view the planets and other celestial bodies for themselves. Using sky charts and other resources, and possibly in partnership with a local astronomical society or club, children and their families view Mars with binoculars and/or telescopes. Depending on what works best for your library, this outdoor night viewing can be combined with highlights of past activities from the module, having the audience undertake some of the activities, and hosting a presentation by an astrobiologist or Mars scientist. The children who have participated in the other *Explore: Life on Mars?* activities may serve as docents at this public, community event, sharing what they have done and learned about what life is, the requirements for life, and the possibility for life on Mars now – or in the past!

It is recommended that the viewing event be paired with the hands-on experiment within the *Searching for Life* activity if space and time allow. “Soil” samples and materials should be supplied, one for each child. Please follow the procedures/instructions located within the *Searching for Life* activity for testing the three soil samples. This activity may be set up as a station within the library.

### What's the Point?

- We can see Mars in the night sky with our eyes, and in even more detail with binoculars and telescopes; Mars has been the object of investigation in this module of activities.
- Children can share their projects and what they've learned over the course of the program with their families and the community.
- Planets and even some of their moons can be seen through binoculars or a telescope.
- Telescopes are scientific tools, which astronomers in the past used to observe features on Mars and other planetary bodies in the solar system.
- Our understanding of planets and moons improves as more is learned with telescopes, spacecraft, landers, and rovers.

### Materials

For each group of approximately 20 visitors:

- 1 Telescope monitored by an amateur astronomer
  - 1 or more small Step–stools for children to stand on to reach high telescope eyepieces
- Optional: 1 pair of Binoculars
  - Optional: 1 Camera tripod and binocular adapter (adapters are available through discount retailers)

- Tables set up indoors or outside, in a well-lit area and out of the path of traffic
- Art supplies such as colored pencils, crayons, and markers
- Books and other resources about Mars, space exploration, life in the solar system, extremophiles (possible selections are listed in the module resources)

For each child:

- 1 Pencil/pen
- 1 sheet of Paper
- Optional: Sky map of the current night (monthly sky charts showing the current positions of the planets relative to constellations) are available free from a variety of websites such as:
  - StarDate: <http://stardate.org/>
  - Tonight's Sky: [http://hubblesite.org/explore\\_astronomy/tonights\\_sky/](http://hubblesite.org/explore_astronomy/tonights_sky/)
  - Planet Finder applet: <http://planetfinderapp.info/>
- Optional: 1 Mars Lithograph (NASA educational product number LG-2009-09-569-HQ  
([http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Mars\\_Lithograph.html](http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Mars_Lithograph.html)))
- Optional: Materials to complete the *Searching for Life* soil experiment.

For the facilitator(s):

- Background information
- Shopping list
- Appendix A: Throw a Star Party
- Flashlights for staff, preferably with red plastic wrap or red paper taped over the light
- Optional: Access to electricity for telescopes and a well-marked extension cord, secured so that it won't be a hazard in the dark
- Glow sticks to mark cords
- Access to drinking water
- Access to bathrooms
- Optional: *Explore: Life on Mars?* activity projects (stories, rovers, garden, etc.) to share with the community.

## Preparation

- Get in touch with your local astronomical society. Local clubs can be found listed through Sky & Telescope: <http://www.skyandtelescope.com/community/organizations>, as well as other sites on the Internet.
- If possible, invite a local astronomer, astrobiologist, planetary scientist, or NASA Solar System Ambassador to give a presentation or lead an activity.
- Suggested online resources for connecting with scientists and female role models in your area:
- NASA Solar System Ambassadors:  
<http://www2.jpl.nasa.gov/ambassador/directory.htm>

- Sky & Telescope: <http://www.skyandtelescope.com/community/organizations>
- FabFems: <http://www.fabfems.org/>
- National Girls Collaborative Project: <http://www.ngcproject.org/programs>
- Plan your event using the **Appendix A: Throw a Star Party!** Tips. The best time to view Mars is when the planet is at least 30 degrees above the horizon and in opposition with the Earth. Your local astronomical society can help determine the best time for your location, if needed.
- Set out the step–stool(s) where needed
- If you are also featuring some or all of the previous module projects – or activities for the visitors to undertake – provide additional space for these activities and signs directing visitors to their locations.

**Facilitator's Note:** Because of Mars' small size and great distance, many of its features are not recognizable from average telescopes on Earth. Visitors may be able to see ice caps on the north or south pole, but they will not see the detail that is available in the close–up photos from the recent NASA missions.

## Activity

### 1. Invite the children and their families to line up in front of the different telescopes.

- Ask each child to put his hands behind his back when it's his turn to look through the telescope (this will reduce the chances of moving the telescope).
- As the families line up, point out where the planets are in the sky, and which one they will see through the telescope. Ask the children to share what they know about the object before they view it.

### 2. Ask the children to describe what they see:

- What color was the planet? *Mars is red.*
- Invite the children to discuss what they saw; did any of them see any markings or features on the planet?
- How did the planet compare with stars through the telescope? *The planet should be brighter than the stars in the same field of view, and look like a disk.*

### 3. Discuss how telescopic views can be misleading:

- Share that people have been trying to see features on the planets, using telescopes, for hundreds of years—ever since Galileo first observed the night sky with a telescope. Ask how some of these scientists might have made mistakes. *Sometimes it's easy to see things that aren't really there (optical illusions), or that might be scratches on the lens or mirror. Sometimes the objects cannot be seen very clearly, so scientists interpret what they see based on what they know.*
- Share that one astronomer, named Giovanni Schiaparelli, thought he saw lines on Mars. He drew detailed maps with these lines, which he called “canali” which

is Italian for “channels.” But some Americans thought that he meant something else.

- What did they think he was calling those lines on Mars? *Canals*.
  - Are canals natural, or man-made? *Man-made*.
- So these people spent many years looking for and making maps of what they thought were canals on Mars. If Mars really did have canals, it must have had aliens making them. There were stories about Martians for many years, up until we started sending missions to take better pictures of Mars.
- How can scientists learn more about the planets? *By viewing them with larger telescopes and those above our atmosphere (like the Hubble Space Telescope), by sending spacecraft to fly by or orbit them, and by sending missions like rovers to land on them.*

*Note: If your event is featuring the children's Mars Engineering projects, direct the viewers to visit the children's work.*

**Facilitator's Note:** Provide some information about NASA's current robotic explorations: Mars is orbited by Mars Odyssey (<http://mars.jpl.nasa.gov/odyssey/>) and Mars Reconnaissance Orbiter (<http://mars.jpl.nasa.gov/mro/>), and is being studied by the Mars Exploration Rover, Opportunity (<http://www.jpl.nasa.gov/missions/mer/index.cfm>), as well as the newest rover, Curiosity (with the Mars Science Laboratory aboard), that landed successfully and began exploring Mars in August 2012 (<http://mars.jpl.nasa.gov/msl/>).

- 4. Share that we have learned a lot about Mars by using telescopes and exploring it with missions. We now know that Mars has one of the most important ingredients for life—water!!**
- a. Ask the children whether they saw any evidence for frozen water on Mars. If they saw an ice cap, they saw a combination of frozen water and dry ice.
  - b. If you are featuring the Mars from Above – Carving Channels activity, direct visitors to that area to learn more about past water on Mars.

## **In Conclusion**

**Thank the visitors for coming and invite them to explore any other activities that are being conducted or featured.** Encourage them to check out the library resources to explore life on Mars further!

## **Correlations to National Science Education Standards**

### **Grades 5–8**

#### **Science as Inquiry – Content Standard A**

##### **Understandings About Scientific 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.

#### **Physical Science – Content Standard B**

##### **Earth in the Solar System**

- The 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 asteroids and comets. The sun, an average star, is the central and largest body in the solar system.

# Appendix A: Throw a Star Party!

## Tips for Offering a Nighttime Viewing Session with Telescopes

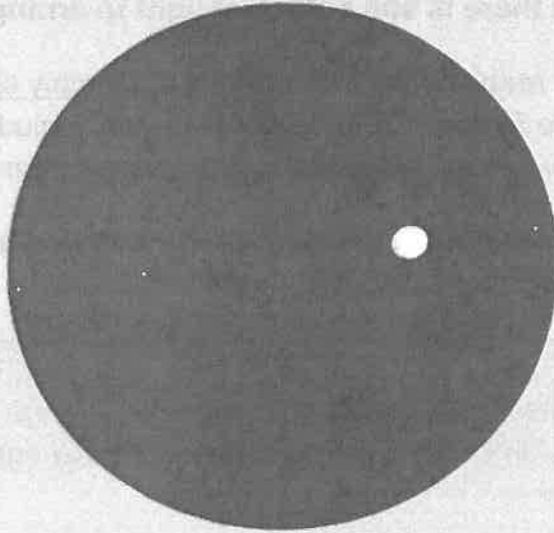
- 1. Optional: Contact your local astronomy club or other amateur astronomers.** They can help you determine the best time for viewing Mars in the night sky, offer viewing tips, and provide telescopes – and lots of knowledge! – for your event. To contact your local astronomy club, type in your zip code at [Astronomical League](#) or search at [Sky and Telescope](#). Let them know which planets or other objects you would most like for the children to see.
- 2. Pick a date at which one or more bright objects will be high in the evening sky.** Select a time when planets (especially Mars) will be visible in the early evening sky using sources such as [StarDate](#), the [Planet Finder](#) applet (<http://planetfinderapp.info/>), or other planetarium program. Try to avoid dates when the Moon is full or nearly full (see below), as its light will wash out other nighttime objects. The Moon itself is best viewed when it is a crescent or in first quarter. A brief tour of the month's constellations, deep-sky objects, planets, and events is available through [Tonight's Sky](#) ([http://hubblesite.org/explore\\_astronomy/tonights\\_sky/](http://hubblesite.org/explore_astronomy/tonights_sky/)).  
  
*Note: Venus and Jupiter are almost always bright when visible, Mars is often bright, and Saturn and Mercury are always a bit faint. Uranus and Neptune are too faint to see without telescopes or binoculars.*
- 3. Identify a start and end time for your program on your intended date.** Best viewing times will begin about an hour after sunset. Find sunset times and Moon phases for your area through [Sunrise Sunset](#) or similar sources.
- 4. Provide a viewing area, preferably away from bright lights and traffic.** Try to avoid nearby obstructions, such as trees or buildings, which will block certain sections of the sky. Will the objects you intend to view be visible from that location in early evening?
- 5. Plan for access to restrooms, and if possible, to drinks.** Have water available for amateur astronomers and visitors.
- 6. Have a back-up plan in place before the announcement for inclement weather:** Will the event be cancelled, postponed, or moved inside with different activities? If the event is cancelled or postponed, at what time or point will the decision be made to do so, and how will the audience hear about it?

7. If appropriate, plan to have the viewing area sprayed for mosquitoes or treated for fire ants in advance of the observing session.
8. If possible, ask for nearby bright overhead lights and sprinkler systems to be turned off during the period of the observing session.
9. On the night of the observing session, arrange for telescopes to be set up before sunset, so that there is still sufficient light to arrange things.
10. **Optional: Provide sky maps of the current night.** Monthly sky charts or simple sky wheels are available free from a variety of websites, including the links offered here; note that the sky wheels require assembly but work year-round.
11. **Review the information below in preparation for discussing the night sky with visitors.**

**Facilitator's Note:**

- Ancient civilizations studied the skies and noted the strange motions of “wanderers” (“planets” in Greek), which seemed to move against the background of familiar constellations.
- Planets don’t make their own light. They appear bright because they are reflecting sunlight.
- Mercury, Venus, Mars, Jupiter, and Saturn often can be seen with the naked eye on clear, dark nights.
- Uranus is barely visible in very dark locations to observers who know where to look!
- The existence of Neptune was deduced mathematically and then confirmed by telescopic observations. It can be viewed through binoculars from a very dark location.
- Through a telescope:
  - Venus often looks like the Moon — a crescent, quarter, or gibbous phase. Since Venus lies between us and the Sun, we are able to view both its day (sunlit) and night (dark) sides. Our perspective of Venus changes as the Earth carries us in its orbit around the Sun, revealing different angles of Venus. At different angles, Venus appears in different phases.

- Jupiter has faint bands of different colors, and sometimes a centuries-old storm, called the Great Red Spot, or some of its moons can be seen. Jupiter's four largest moons, Io, Europa, Ganymede, and Callisto, appear as bright dots on the sides of Jupiter, and disappear from view occasionally as they pass in front of or behind the planet.



*A view through a telescope reveals Jupiter's banded atmosphere. You might also spot several or all of Jupiter's four largest moons. Callisto, Ganymede, and Europa appear here as small "dots" from far left to far right. Io is often also visible as a fourth "dot."*

*Credit: Modified from NASA/JPL/Malin Space Science Systems*



*Mars is a small red circle through most telescopes; the reddish appearance is due to its rusty soil. Credit: NASA Science News*





*Saturn is an incredible sight through a telescope.*  
*Credit: Modified from Adam Block/NOAO/AURA/NSF*

- Galileo first used his telescope to study the Moon, Venus, Jupiter, and Saturn 400 years ago; his observations of depressions and mountains on the Moon, moons orbiting Jupiter, and the phases of Venus revolutionized our understanding of the solar system and Earth's place in it. Telescope optics have improved over time, allowing scientists to make more detailed observations of objects in the night sky.
- Telescopes allowed astronomers to view the *surfaces* of planets; spacecraft instruments now allow us to infer information about the *interiors* of planets.
- Pluto is a tiny, distant dwarf planet and can be viewed through a small telescope from a very dark location.

## Activity 5: Protecting Life

Adapted from *Imaginary Martians*, **DESTINATION: MARS**, NASA Johnson Space Center, 2002 (<http://ares.isc.nasa.gov/ares/education/program/destinationmars.cfm>), and the *Space Radiation* unit of **EXPLORE: HEALTH IN SPACE**, Lunar and Planetary Institute, 2006 ([http://www.lpi.usra.edu/education/explore/space\\_health/space\\_radiation/activity\\_1.shtml](http://www.lpi.usra.edu/education/explore/space_health/space_radiation/activity_1.shtml)).

### Overview

During this 60 minute activity, children ages 8 to 13, create their own 'Martian' using craft materials and UV beads. They will explore how UV radiation from the Sun can affect living things, comparing conditions on Earth and Mars, and then discussing ways that organisms may protect themselves from UV radiation. They will then take part in a Mars Creature Challenge, where they will change their creature to help it survive harsh UV conditions – like on Mars. They will then test their Mars Creatures by subjecting them to different environmental conditions to see how well they “survive” in a Martian environment. This investigation will explore shelter and protection as one of life’s requirements and how Earth’s atmosphere protects life from harmful UV radiation.

This activity may be split into a two-part series of activities, 30 minutes each, if needed.

### What's the Point?

- Ultraviolet radiation comes from the Sun.
- Ultraviolet radiation from the Sun travels through space.
- The blanket of Earth's atmosphere protects us from much of the Sun's ultraviolet radiation.
- The atmosphere of Mars does not protect its surface from ultraviolet radiation. Earth is protected but Mars is not.
- Mars is harsh: dry, very cold, a thin atmosphere, and lots of UV radiation.
- While some ultraviolet radiation is necessary, too much can harm humans (and other living organisms).
- Life needs protection from ultraviolet radiation.
- Life on Mars would have to be able to withstand harsh conditions, including exposure to ultraviolet radiation.
- There are ways we can protect ourselves from harmful UV radiation.
- Be creative, design, and protect a 'Martian.'

#### Tips for Engaging Girls in STEM:

- **Spark initial interest in the topic.** In this case, by engaging the children's natural curiosity, imagination, and interest in alien life and giving them the opportunity to design their own version of a Martian.

- **Embed activities in interesting contexts.** For 8–13 year old children, use real-world problems like how to change their creature so that it may survive (part II of this activity). Girls are motivated by projects they find personally relevant and meaningful.
- **Allow children to approach the activities in their own way.** Girls are motivated when they can approach projects in their own way, applying their creativity, unique talents, and preferred learning styles. This activity allows the children freedom in the design and creation to their 'Martian.'
- **Use project-based learning, group work, innovative tasks, and technology (i.e., web) to help engage children.** Girls enjoy hands-on, open-ended projects and investigations. This activity (particularly part 2) requires the children to collaborate to complete the survival challenge.
- **Provide opportunities for participants to engage in activities to develop their spatial skills, such as constructing and engineering projects.** This activity provides an opportunity for children to design, build, and draw.

## Materials

For the large group:

- A selection of **non-fiction** books about extremophiles and life in the universe

### 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 IN SPACE**

*Helen Orme, Ransom Publishing, 2009, ISBN 184167690X*

Could there be life on other planets? If so, where will we find it? Mars? What do you need for life? How did life start? For children ages 10 and up.

#### **LIFE ON THE EDGE**

*Cherie Winner, Lerner Publications, 2005, ISBN 0822524996*

This book explores extreme locations and uncovers some of the most fascinating creatures in the world. For children ages 9 and up.

#### **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**

*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.

#### **MICROSCOPIC LIFE (KINGFISHER KNOWLEDGE)**

*Walker Richard, Doherty Peter, Kingfisher, 2004, ISBN: 0753457784*

The author opens the doors to the microscopic world. Discover the life that is all around us – and we aren't even aware of it! This book is appropriate for children ages 9-12.

## **THE SEARCH FOR EXTRATERRESTRIAL LIFE**

*Don Nardo, Lucent Books, 2006, ISBN 1590188322*

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.*

For each child:

- 1 Pen/pencil
- 1 pair of Scissors
- Tape and / or glue

### Activity Part 1:

- 3 UV beads (can be found in craft stores; other sources listed below)
- 2 Non-UV beads
- 2 Pipe cleaners
- Various craft items for constructing a creature, such as Styrofoam balls, felt, foil, additional pipe cleaners, small milk cartons, empty small water bottles, colored card stock, old CDs, pompoms, and colored yarn

### Activity Part 2:

- 1 Mars creature (should have been made during Part 1 of the activity)
- Various materials that will "protect" the Mars creature from ultraviolet radiation, for example: Construction paper of different colors (green or blue offers the best protection), foil, plastic wrap (of various colors), paper sunglasses (may be obtained from an optometrist), sunscreen (try different SPFs), masking tape, paper, cloth, etc. You may even wish to include containers of water for the children to experiment with (outside perhaps?).
- Optional (recommended): NAI Extremophile Trading Cards
- Optional: 1 copy of *Extreme—O—File: Protecting Life* activity pages
- Optional: 1 copy of *Life on Mars?* (extremophile) trading cards and/or Scientist spotlight pages
- Optional: 1 Hair dryer

### **Sources for UV Beads:**

*Educational Innovations*

<http://www.teachersource.com/direct/33370>

Phone: 1-888-912-7474 / Fax: 203-229-0740

*Steve Spangler Science*

<http://www.stevespanglerscience.com/product/1350>

Phone: 1-800-223-9080

For the facilitator:

- Background information
- Shopping list

- An outdoor area where the children can spread out a little, preferably with both shady and sunny areas
- An area indoors where the children can move around and interact with each other

## Preparation

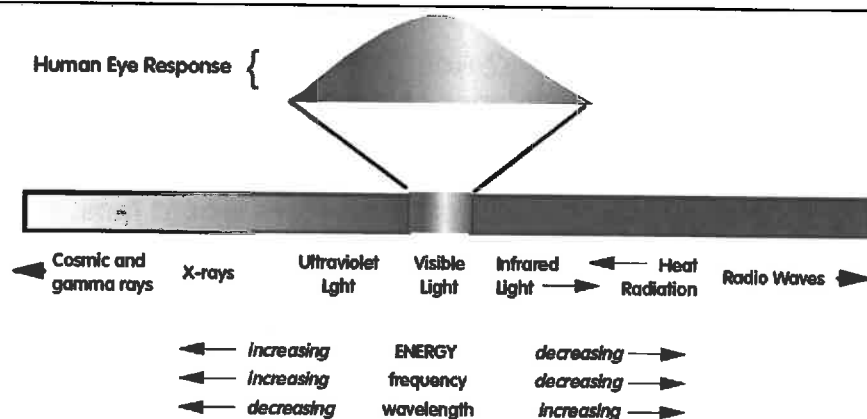
- Review the activity procedures, activity pages, and science background information
- Locate an outdoor area close by that has both shady and sunny spots, if possible
- Prepare an area indoors with the craft materials, where the children will create their Mars characters
- Optional: Print copies of the *Extreme-O-File: Protecting Life* activity pages and/or *Life on Mars?* trading cards (extremophiles) and scientist pages

### Facilitator's Note: Radiation and the Electromagnetic Spectrum

Light ~~and heat~~ are part of the spectrum of energy – or radiation – our Sun provides. We can “see” light ~~and we can feel heat~~. But there are other types of energy that our Sun produces. Much of this energy makes up the electromagnetic spectrum. Light is part of the visible section of the spectrum ~~and heat is part of the infrared section of the spectrum~~. Radio waves, microwaves, ultraviolet rays, X-rays, and gamma-rays all are parts of the spectrum of electromagnetic energy – or radiation – from the Sun.

Radiation is energy that travels in waves or as particles. Radio waves, microwaves, visible light, and infrared radiation have relatively long wavelengths and low energy. But ultraviolet rays, X-rays, and gamma-rays have shorter wavelengths and higher energy. This shorter wavelength is so small that these wavelengths interact with human skin, and cells, and even parts of cells – for good or for bad!

Our Sun also produces cosmic radiation. Cosmic rays are very high energy, fast moving particles (protons, electrons, and neutrinos) that can damage DNA, increasing the risk of cancer and causing other health issues. Cosmic rays have such high energy that it is difficult to design shielding that blocks them; Cosmic rays do not only come from our Sun, but from other places in our galaxy and universe.



The subject of this activity is ultraviolet – UV – radiation. Humans need UV radiation because our skin uses it to manufacture vitamin D, which is vital to maintaining healthy bones. About 10 minutes of Sun each day allows our skin to make the recommended amount of vitamin D. However, too much exposure to UV causes the skin to burn and leads to wrinkled and patchy skin, skin cancer, and cataracts.

On Earth, we are protected by our atmosphere from most UV radiation coming from the Sun. The Ozone layer absorbs much of the UV portion of the spectrum (UVB and UVC). Some still gets through (UVA and a bit of UVB). We can protect ourselves completely by covering ourselves with clothing and using sun block. Our atmosphere protects us from most of the X-, gamma-, and cosmic radiation as well.

On Mars there is very little atmosphere to protect living things from UV radiation – or from X-rays and gamma-rays or even more dangerous cosmic rays. Organisms would have to provide their own protection in the form of body changes (adaptations) or sheltered environments (such as underground). These measures would work fairly well for protecting against UV radiation.

The UV-sensitive beads used in this experiment serve as UV radiation detectors. They contain a pigment that changes color when exposed to ultraviolet radiation from the Sun or from UV lights. The intensity of the color corresponds to the intensity of the UV radiation. When shielded from UV sources, or when exposed to light that does not contain UV radiation – such as indoor light bulbs – the beads remain white. The beads are designed for multiple uses and, according to the manufacturers, will change color up to 50,000 times.

## Activity – Part 1

1. Have the children describe some characteristics of Mars that might be helpful to life. If you have conducted previous activities, such as *Mars by the Book* or the *Mars from Above* activities, remind the children of their discoveries during those activities.

- Is there an atmosphere? *Yes!*
- What is it as thick as the Earth's? *No!*
- What is the surface like? What types of features are there? *Volcanos, craters, and stream channels.*

**2. Discuss the challenges that living things on Mars would face.** Recall the group definition for life and its needs (the four requirements) from previous activities.

- How is Mars different than Earth? *Smaller, much colder, drier, thin atmosphere, windy, no liquid water at the surface, etc.*

**3. Introduce the topic of *solar radiation*.** The children may be unfamiliar with UV radiation and its effect on skin; you may need to lead them through the discussion.

- What does our Sun give us? *Light and heat.*
- What happens when you stay outside in the Sun for too long? *You get sunburned!*
- What is the part of the Sun's energy that causes our skin to burn? *Ultraviolet energy or radiation. This energy is invisible to our eyes and we cannot feel it, but it still affects our bodies.*
- What protects us from much of the UV radiation on the Earth's surface? *Our atmosphere blocks much of the Sun's UV light. The ozone layer in our upper atmosphere forms a protective sphere, absorbing much of the UV energy.*
- How do you protect yourself from getting burned by the Sun? *You wear clothing, use sun block, and/or stay under a shelter like the shade of a tree, sun umbrella, or covered patio.*

**4. Introduce some types of life on Earth that survive in extreme (especially cold, dry) environments.** Look over the [NAI Extremophile Trading Cards](#). Optional: Have the children read and look over the extremophile features in the *Life on Mars?* trading card set or the activity pages. *Note: It may also be helpful to have books about extremophiles from your library collection available for the children to browse through.*

- Does life exist in cold, dry places on Earth? If so, what kind? *Yes! Microbes like bacteria and molds and fungi have been found living in ice sheets on Earth, as well as in the extremely dry and harsh conditions of a desert, such as the Atacama Desert in Chile (located in South America).*
- Does life exist in the cold, dry environment on Mars? If so, what kind? *We don't know! Scientists are sending missions to search for signs of life in these places.*
- Optional: Have the children "create their own" trading card from the module trading card set template.

**5. Invite participants to construct their own 'Martian' – a Mars creature.** Explain that their critters will include radiation detectors (UV beads) that are made from a



special pigment that is very sensitive and turns colors when exposed to the ultraviolet rays. Optional: Handout the *Explore: Life on Mars?* trading cards for inspiration. Optional: Refer the children to the module scientist pages/features.

- 6. Construct a Martian.** Have the children design their own creature with a set number of materials that you provide. Encourage them to share their ideas as they build. Optional: Have the children draw a picture of their creature in their *Extreme-O-File* activity pages, or have them “create their own” trading card from the module trading card template.

- 7. When the children finish, ask them what they observe.**

- What color are your Martian’s UV radiation detectors – the UV beads? *White or creamy*
- Are your creature’s radiation detectors picking up any signs of radiation in this building? *No*
- Do you think your Martian’s radiation detectors will turn colors if it goes out into the Sun? Why or why not? *Answers will vary*
- Will its radiation detectors turn colors if it goes outside into the shade? Why or why not? *Answers will vary.*

- 8. Ask the children to cover their Martian’s radiation detectors with their hands, and then take it outside.** Have them stand in the shade and uncover their creature.

- What do you observe happening to the Mars Creature’s radiation detectors? *The beads become lightly colored, indicating that, even in the shade outside, there is some UV radiation reaching the detectors and our skin.*

- 9. Ask the children to cover their Martian with their hands again so that no light reaches it.** Keep the creature covered for about 2 minutes while the beads change back to white. Use this opportunity to discuss their observations.

- What do you think will happen when we take our creatures out into the full sunlight? *It will change color. Many possible answers here.*

- 10. Let the children now take their Martian into the full Sun.**

- What happens to the beads? *The beads become deeply colored, reacting to the intensity of the UV radiation to which they are being exposed.*

- 11. Return indoors and continue the discussion.**

- What happened to your Martian’s radiation detectors? *They changed colors.*
- Did they change in the shade? Yes – a little.

- In the Sun? *Yes – a lot!*
- Where did they change the most? *In the direct Sun light*
- Was your prediction correct? *Answers will vary*
- What caused your creature's radiation detectors to change colors? *The ultraviolet radiation from the Sun*
- What happened to the radiation detectors after coming back inside, and what caused it? *They changed back to white because they were no longer detecting any radiation. UV radiation does not get through the building.*

**Facilitator's Note:** Some children may say light caused them to change, and others may say heat. Remind them of their observations about the beads inside; the beads were white, even though they were in the light of the room. Ask them what happened to their beads when they brought them back inside; the beads changed from a colored state in the Sun back to white in the room light. If it is heat that causes the change, invite the children to hold beads in their fists; the beads do not change color when heated. They can also heat the beads with a hair dryer (carefully!). The cause of the change comes from the Sun; it is from the part of the Sun's spectrum we do not see or feel directly.

- What did this experiment tell you about UV radiation and YOU? Just like my Martian, I am exposed to UV radiation when I am outside, and if I am exposed to too much, I can change color (i.e., get a sunburn) too!
- How do we protect ourselves from UV radiation? Answers may include wearing clothing, using sun block, using umbrellas, staying inside.

**12. Share with the children that with their Martian's help they have demonstrated the effects of the Sun's ultraviolet rays on objects (and people!) on Earth.** Just like it is important for us to protect ourselves from the harmful UV radiation of the Sun, life on Mars also needs protection! Remember, this is one of the requirements for life!

- Does Mars have more or less protection from the Sun's UV radiation than Earth? Does it have more or less of an atmosphere? *Mars has less atmosphere – less protection!*
- With less protection, what would this mean for life on the surface of Mars? *That it would need a way to protect itself!*

## **Activity – Part 2: Mars Creature Challenge**

**1. Recall the concept that the Earth's atmosphere protects us from ultraviolet radiation.**

- Where does UV radiation come from? The Sun and it travels through space.
- How does it reach Earth? It travels from the Sun to Earth.
- How do you protect yourself from too much UV radiation? Clothing, sun block, staying inside.

- What else naturally protects us from most of the incoming UV radiation? The atmosphere. Just like clouds can block some of the visible light on a rainy day, the outer layer of our atmosphere acts as a filter and filters out much – not all – of the UV radiation.
- Why might UV radiation be a concern on Mars? Because the atmosphere on Mars is much thinner and doesn't contain an ozone layer to help absorb the UV radiation like the Earth does.
- Can we change our creature to protect it from the UV radiation on Martian surface? Yes, let's try!

**Explain that Earth's atmosphere protects us from many of the dangerous types of radiation from our Sun – ultraviolet, X-rays, gamma-rays, and very high energy cosmic rays.** We know that some ultraviolet radiation still gets through (you observed that during Part 1 of this activity), but we can protect ourselves by covering up, limiting our time in the Sun, and using sunscreen. We are going to take what we've learned about Mars to help protect our Martians!

2. **The Creature Challenge: Invite the children work together in small groups (of 4–6) to protect their creatures from the harsh UV conditions on Mars.** The children may modify their creature itself (changing it to the environment) or create a shelter for protection. Ask them to choose one of these options for the challenge. They should make sure that they are able to peak in or hold up and see their UV beads on their creature for the outdoor testing. Encourage the children to share ideas and plan their modifications among their group. Optional: They may use the *Extreme-O-File: Protecting Life* activity page to help as they design and plan. Optional: Have the children draw a picture of their design in their *Extreme-O-File* activity pages.
- **What other features does their Martian need to protect itself from UV radiation?** Have them consider how animals and people on Earth protect themselves from the Sun (clothing, living underground, sunscreen, exoskeletons, etc.).
  - **Each group of children should do the following:**
    - Test at least two ways to protect their creature in two separate experiments. Each group can divide this between themselves so that half are testing the first experiment and others the second experiment. This will allow both experiments to take place at the same time, saving time required to complete the activity.
    - For each experiment, have them take their Mars creature outside again and test it. Remind the children to cover the Mars creature's radiation detectors with their hands, and then take it outside for testing.
  - What do you observe happening to the Mars creature's radiation detectors?  
*Many possible answers here!*

**3. As a large group, have the children share their creatures and observations.**

- What materials offered the best protection for their creature? The worst? None at all?
- The Sun's rays turned the Mars creature colors. Do the Sun's rays ever turn *you* colors? *Yes!*
- What practical things can, and should, you do to protect *yourself* from UV rays? *Wear protective clothing, use sunscreen, don't stay out in the Sun for extended periods, and definitely don't expect the shade to protect you! Overexposure to UV rays causes the skin to burn, sometimes badly (ouch!!). And extreme or excessive burning of the skin can lead to skin cancer.*

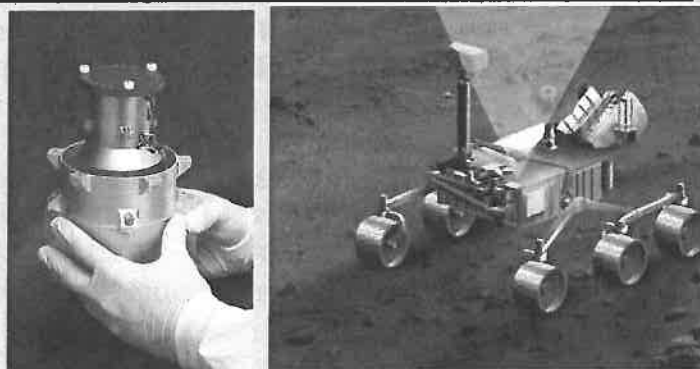
**4. Optional: Invite the children to consider any other features their Mars creatures might need to protect themselves from on Mars, like the dry and very cold Martian environment.** They can perform fun test at home such as having their creature spend the night in a baggie in the freezer, etc.

## **In Conclusion**

Summarize the results of the challenge and what they have learned about ultraviolet radiation on Earth and in space. What helps protect Earth from most of its harmful effects? The Atmosphere! How is ultraviolet radiation a challenge to life on Mars and other planets? Recall the requirements for life – particularly protection. What do you think are some ways for living things to protect themselves from UV radiation? What happens to organisms – and children – who receive too much UV radiation?

### **Facilitator's Note: NASA Mission Connection Radiation Assessment Detector (RAD) for Mars Science Laboratory**

This instrument, shown prior to its September 2010 installation onto NASA's Mars rover Curiosity, will aid future human missions to Mars by providing information about the radiation environment on Mars and on the way to Mars. The results may also help scientists to understand the implications for life there. In November 2012, early results showed a connection between impinging cosmic radiation with weather phenomenon on Mars. For more details, please visit: <http://www.spaceflight101.com/msl-rad-science-reports.html>.



*Images Courtesy: NASA JPL*

## National Science Education Standards

### Grades K–4

Science as Inquiry – Content Standard A

*Abilities Necessary to do Scientific Inquiry*

- Plan and conduct a simple investigation
- Employ simple equipment and tools to gather data and extend the senses
- Use data to construct a reasonable explanation
- Communicate investigations and explanations

*Understanding about Scientific Inquiry*

- Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations.

### Grades 5–8

Science as Inquiry – Content Standard A

*Abilities Necessary to do Scientific Inquiry*

- Identify questions that can be answered through scientific investigations
- Use appropriate tools and techniques to gather data, analyze, and interpret data
- Think critically and logically to make the relationships between evidence and explanation

*Understanding about Scientific Inquiry*

- Scientific explanations emphasize evidence and use scientific models.

Physical Science – Content Standard B

*Transfer of Energy*

- The Sun is a major source of energy for changes on the Earth's surface. The Sun's energy arrives as light with a range of wavelengths, consisting of visible light, infrared, and ultraviolet radiation

# Activity 6: Mars Engineering

Adapted from "Build An LRO" Activity, Explore! To the Moon and Beyond activities, Lunar and Planetary Institute, 2010 ([http://www.lpi.usra.edu/education/explore/LRO/activities/build\\_lro/](http://www.lpi.usra.edu/education/explore/LRO/activities/build_lro/)).

## Overview

Children ages 8 to 13 create their own models of a Mars rover out of readily available materials and craft supplies in this 45–60 minute activity. They determine what tools would be necessary to help them better understand Mars (and something about life on Mars/its habitability). Then they work in teams of 4–6 to complete a design challenge where they incorporate these elements into their models, which must successfully complete a task. Teams may also work together to create a large-scale, lobby-sized version that may be put on display in the library to engage their community.

## What's the Point?

- Scientists and engineers work together to design and build spacecraft such as NASA's Mars Science Laboratory (aboard the Curiosity rover).
- Scientists use tools to make measurements, observe, and experiment — to explore.
- Many of those tools measure things that humans cannot see, smell, taste, feel, or hear. The Mars spacecraft, such as the Curiosity rover, have instruments onboard to collect information.
- Science helps technology improve. Each new spacecraft carries many new instruments and some that are improvements on previous designs.
- There is always a balance between what scientists would like to test and what is possible. Many instruments were proposed by different teams of scientists and engineers, but not all could be selected because the spacecraft has a limited amount of space for the instruments to be mounted; it can carry only a certain weight, and there is a limited budget for developing the instruments.
- Technology is created to serve a purpose. Each mission has its own goals and objectives.
- Science is driven by technology and vice versa. They rely heavily on each other, with advancements in one leading to advancements in the other.
- To design and create your own rover!

### Tips for Engaging Girls in STEM:

- **Encourage a Growth Mindset.** Teach that intellectual skills can be acquired and developed over time. This activity provides an opportunity for the children to acquire new skills in engineering and problem solving.
- **Praise children for their effort (not intelligence).** Help them to view efforts as a path to mastery. Example: *"Well done, you worked really hard on that and got it to work!"* Girls' confidence and performance improves in response to specific, positive

feedback on things they can control – such as effort, strategies,, and behaviors. This activity provides an opportunity for the facilitator to provide feedback based on things the children can control.

- **Encourage children to persist despite obstacles.** Highlight the struggle and the attitude of “never give up” that is necessary in STEM. Note that in science and engineering, we embrace the challenge and the hard work. Working hard to gain new knowledge leads to improved performance.
- **Expose children to successful role models in math and science.** This can help children to realize their career-relevant skills (Professional societies, such as the Society of Women Engineers, are often willing to take part in programs and may be a source for positive role models). This activity provides an opportunity to involve a positive role model and provides suggestions for where to find one.
- **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 design, draw, and build.

## Materials

For the team of 4–6 children:

- 2 copies of the Engineering design process (The Works or Design Squad are good options)
- 3 rolls of Duct tape (variety of colors and metallic)
- 1 roll of Masking tape
- 1 roll of Scotch® tape
- 2–3 pairs of Scissors
- 4–6 Markers (permanent, in a variety of colors)
- 1 bottle of Glue
- 1 roll of Aluminum foil
- 3, 2–3 inch diameter Rocks (any type that is easily available)
- Materials for building a model rover: A variety of building materials:
  - Miscellaneous Craft and Everyday Items: Straws, pencil top erasers, beads of various sizes, foil cupcake holders, screens, wooden miniatures, aluminum foil, plastic wrap (of all colors), old CDs, pipe cleaners, toothpicks, wire, wire cutters, Legos, construction paper (variety of colors, black), tinsel, ribbon, fabric, gauze, wood dowels/skewers, rubber bands, shiny streamers, etc.
  - For Rover Wheels: Wooden spools, large buttons, bottle caps, plastic cups (sturdy), empty (clean) Play-Doh® containers, old CDs, etc.
  - For Rover Body: Pint-sized milk containers, coffee cans, soup cans (tape any sharp edges), paper or Styrofoam cups, or other objects for the

spacecraft body, empty DVD cases, black plastic or biodegradable seedling (plant) trays, empty egg cartons, cereal boxes, 2L soda bottles, different-sized Styrofoam blocks, other empty plastic or cardboard containers/boxes, etc.

- Other: Use your imagination and best judgment for providing safe, fun, and readily available materials!

For each child:

- Pencil
- 1 Copy of the Curiosity Tools Schematic, preferably in color
- Optional: *Extreme–O–File: Mars Engineering* activity pages for this activity (includes the Team Design Worksheet)

For the facilitator:

- Background information
- Shopping list
- An area indoors where the children can move around and interact with each other
- Butcher paper/disposable table cloth to cover tables
- Optional: Hot Glue Guns with glue sticks \*Use caution and have an adult in charge of the hot glue at a station for all teams to access as needed.

## Preparation

- Review activity procedures and background Information
- Cover work tables with butcher paper
- Print copies of the Curiosity Tools Schematic (rover)
- Prepare an area for rover building:
  - A set of rocks (2–3 inches in diameter), 3 rocks per team
  - A variety of craft and other materials for building
- Optional: Print copies of *Extreme–O–File* activity pages

## Activity

1. **Divide the children into teams of 4–6 children.**
2. **Share that NASA wants to learn more about Mars and its ability to support life in order to prepare for future explorations.** Because it's expensive to send humans, it's important to learn more about Mars with robotic explorers and probes. These robots aren't like those we see in movies, with eyes, hands, and legs, but rather spacecraft and rovers that have many instruments to test for water ice and elements in rocks, map where the surface is safe for landing and building, and find where scientific questions, such as signs of life, can best be studied. All these



activities will prepare future astronauts — the children in your program — to explore even more of the Solar System!

**3. Share with the children that they will be working in teams to make their own Mars rovers, but first they need to learn more about the rover and the engineering process.** Handout and discuss the engineering design process and *Extreme-O-File* activity pages (optional). Optional: Have the children record their ideas on their activity pages.

- What is engineering? The engineering process? Handout pencils, copies of the activity pages for this activity (that will contain the Team Design Worksheet), and one copy of an engineering design process to each team.
- What tools do you use to explore? *Eyes, ears, noses, senses of touch and taste, cameras, thermometers, flashlights, magnifying glasses, etc. Encourage imaginative answers!*
- What kinds of tools can you design for your rover to explore with? *Cameras, thermometers, telescopes, etc. Encourage imaginative answers!*
- In what ways are robots, like the rover, different from human explorers?
  - They don't need to eat, but they need power from solar panels or batteries.
  - They are stronger — better able to withstand the radiation, cold and heat, and vacuum of space.
  - They can't think for themselves, and they are not creative, so we have to tell them what to do with antennas and program their computers.

**Facilitator's Note:** Rovers operate on the surface of Mars, so they are able to mimic human senses like sight and smell, but their "sight" and range of view are limited (more so than an orbiter).

**4. Share with the children the schematic of the Curiosity rover that is currently exploring Mars.** Discuss its mission and timeline (details can be found at: <http://mars.jpl.nasa.gov/msl/mission/overview/>).

**Facilitator's Note: NASA Mission Connection**

The Curiosity rover's (Mars Science Laboratory) primary mission objective is to investigate whether conditions have been favorable for microbial life on Mars in the past, to study the geological past and conditions on Mars, and to preserve clues in the rocks about possible past life. Curiosity carries the most advanced payload of scientific gear ever sent and used on the Martian surface and is about ten times more massive than earlier Mars rovers. It is helping scientists advance technologies for precision landing of heavy payloads to the surface, which will be necessary if people are ever to go to the red planet. That capability will also be important for future missions to Mars in order for them to pick up and return rocks to Earth, as well as to conduct further surface exploration for Martian life. Mars Science Laboratory (aboard

the Curiosity rover) launched from Cape Canaveral, FL in November 2011 and arrived safely on Mars in August 2012. Curiosity is currently conducting its primary mission which will continue for at least 2 years.

- **What different parts do you see?** Look at descriptions/schematics of the Rover.
  - A **body** that holds the instruments (engineers call this a platform). Solar panels for collecting **energy** from the Sun (the energy is stored in a battery). **Communications** equipment to send information back to eager scientists on Earth. A **propulsion system** to help the spacecraft move a bit in its journey. **Shiny film** to shield the spacecraft. **Cameras** pointing down/out at the planet.
  - Are the instruments spread out or crowded into a few places? *Pretty crowded!*
  - Due to the diverse tasks and science objectives, Curiosity is crowded with several very important instruments. Scientists had to design these instruments to be as compact and lightweight as possible. Curiosity is testing out a new landing system designed to allow the successful delivery of heavy payloads to the Martian surface.
  - Optional: Show the children this online, interactive Curiosity rover website and allow them time to explore it:  
<http://mars.jpl.nasa.gov/msl/multimedia/interactives/learncuriosity/index-2.html>
- What kinds of information will the rover collect for scientists?
  - Pictures
  - Chemical information
  - Geologic information
  - Testing and implementation of new technology and techniques

**5. Design Challenge! Each team's mission is to design and build a rover out of the materials available that can pick up, move, and set a rock down into a (fake) scientific instrument on the rover body, like the Sample Analysis at Mars (SAM) instrument aboard the Curiosity rover. This test will mimic a function that may be used by a real rover, such as Curiosity, as it explores and tests rock samples.** Provide the materials and prompt them to keep in mind important elements to include in their designs. Engineers have multiple challenges – creating a functional rover and also the scientific instruments to go aboard it! Optional: Have the children complete the *Extreme-O-File* activity pages, recording their design and testing.

Have them identify what component each material represents on their model. Remind the children about the design process used in engineering and encourage them to follow the steps to complete the challenge. Each team should work through the design process (*Extreme-O-File* activity pages optional) together, making sure to answer and address the following:

- What will you use to power your rover? *Solar, Batteries, etc.*
- How will your rover move around? *Wheels, rocket, etc.*
- *Note: The children will need to manually push their rovers for the rock challenge, but they can use their imagination for what would really power their rover on Mars.*
- What tools will your rover use to explore Mars? *Cameras, lasers, etc.*
- Where will you place your instrument for analyzing rocks on your rover? This is the location where the rock will be placed for the design challenge.
- How will it report back to scientists on Earth? *Communications*
- Which materials will you use to represent each component of your rover and why?

Optional: You may have the group or an individual team work together to create a larger model that will be used as an exhibit to be placed on display at the Library for a certain amount of time. This display could tie in nicely with a family event such as the **Live Tonight: The Planets!** activity (included within this module).

**6. Build and test the Rovers.** Allow each team time to build, test, modify, and re-test their rovers. Make sure to let them know how much time they will have to complete the challenge (to be decided by the facilitator), giving them reminders every 10 minutes of time passed. It is important for the teams to stay on task in order to complete the challenge on time. Remind them of the challenge task below – it may be useful to post the challenge task for the group where all can see it. *Note: It is recommended that you give each team at least 30 minutes for this phase of the activity. You may allow more time if desired.*

- Each Team's rover should be tested 3 times and successfully complete the following task:
  - Pick up a rock
  - Move the rock to the rover body
  - Set down the rock in/on the rover's rock sample analysis instrument

**7. Invite the children to share their rover designs, and how they will help to meet the mission objective and successfully complete the challenge.** With these in mind, ask each group to share the following:

- How did your team go about selecting the tools/instruments for your rover to meet the mission objective (moving the rock)? What worked well? What didn't?
- How did you work together to solve problems?
- What other tools does your rover have and what will it tell scientists?
  - Optional: Recall your group definition for life and the four requirements of life discussed in previous activities. Did your group use these in your rover design? If so, how?
- How will the rover communicate with Earth?
- What powers your rover?

- What helps it move around?
- Any other features that you would like to share?

## In Conclusion

Explain that many NASA engineers and scientists worked **together** to plan, build, and launch spacecraft such as the Curiosity rover (much like the children just did). They, too, had to decide what tools to give the spacecraft, given specific mission goals/objectives. Many instruments were proposed by different teams of scientists and engineers, but not all could be selected because the rover has a limited amount of space for the instruments to be mounted; it can carry only a certain weight, and there is a limited budget for developing the instruments. ***There is always a balance between what scientists would like to test and what is possible.*** The specific instruments were selected to help scientists and engineers meet the objectives of the mission — to characterize the Martian surface, help us to determine important characteristics of the surface and environment, and to prepare for future human missions. ***These scientists used their understanding of life and what it needs in order to address these mission goals.*** Some of the instruments are new technologies and others build on successful technology used on other spacecraft. They provide scientists and engineers with information that is not available or with more detailed information than what has been collected in earlier missions.

Summarize the Mars Science Laboratory (Curiosity rover) mission objectives, and how the results of the mission science may help to identify locations on Mars where the building blocks for life were present in the past – as recorded in the rocks. Mars is a good candidate for finding past and/or present life beyond Earth.

Explain that you will put each team's rover on display in the library to share with their community, along with a brief poster about the activity. Ask them to quickly decide who on their team will pick up and keep the rover in 2 weeks' time (or set another date as appropriate). Congratulate them on a job well done and invite them to bring their family and friends to see their creations and check out related library resources.

Optional: If a large-scale exhibit rover was created for the library, then put it on display with information from your program.

## Extension

1. **Create a poster as a group about your Mars Engineering Rovers to put on display in the Library for your community.** Using what you have learned and the *Extreme-O-File* (optional) and Astrobiology resources, have the children work as a group to create a poster describing the project to put on display in the Library. You may cut out and use parts of the *Extreme-O-File* activity pages and other activity resources (make sure to have extra copies available for this purpose), as well as

creating text and artwork to include on the poster. They should be sure to include the following:

- The group definition of Life (if this was completed previously)
- The four requirements for life: *Water, Energy, Protection, Nutrients*
- What is it like on Mars? *Compare temperature, water, and nutrients on Mars versus Earth*
- Design/Engineering Process
- The Mission/Challenge: *To design and create a Mars Rover that can successfully pick a rock, move it to the rover body, and set it in/on the rover's rock analysis instrument. Relate their rover to the Curiosity rover and its SAM instrument.*

*Note: You may want to have the children work in groups of 4–6 for each question to be addressed in the poster, and then bring all groups together to assemble it.*

- 2. Create a Mars Landscape to go along with your rovers!** Provide a variety of craft materials that may be used to draw or make a model landscape of Mars (for example, clay or Play-Doh, sand, rocks, colored and/or plain paper, markers, crayons, glitter, pipe cleaners, foil, pom-poms, tape, glue, images of Mars for a background, etc.) inside of a box (with no top and one side mostly removed for viewing). When the children are finished with their rovers, invite them to work together to create a model of the Martian landscape in order to create a display to the library to set out and share with their community.

*Note: Research pictures of Mars by browsing through library books or NASA online mission images (such as those taken by the Curiosity rover: <http://mars.jpl.nasa.gov/msl/multimedia/images/>)*

## Correlations to National Science Standards

### Grades K–12

Unifying Concepts and Processes

*Evidence, Models, and Explanation*

- Models are tentative schemes or structures that correspond to real objects, events, or classes of events, and that have explanatory power. Models help scientists and engineers understand how things work. Models take many forms, including physical objects, plans, mental constructs, mathematical equations, and computer simulations.

### Grades K–4

Science as Inquiry — Content Standard A

*Understandings about Scientific Inquiry*

- Scientists use different kinds of investigations depending on the questions they are trying to answer. Types of investigations include describing objects.
- Simple instruments, such as magnifiers, thermometers, and rulers, provide more information than scientists obtain using only their senses.

## Earth and Space Science — Content Standard D

### *Objects in the Sky*

- The Moon has properties, movements, and a location that can be observed and described.

## 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**

### Science as Inquiry — Content Standard A

#### *Understandings about Scientific Inquiry*

- Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve seeking more information.

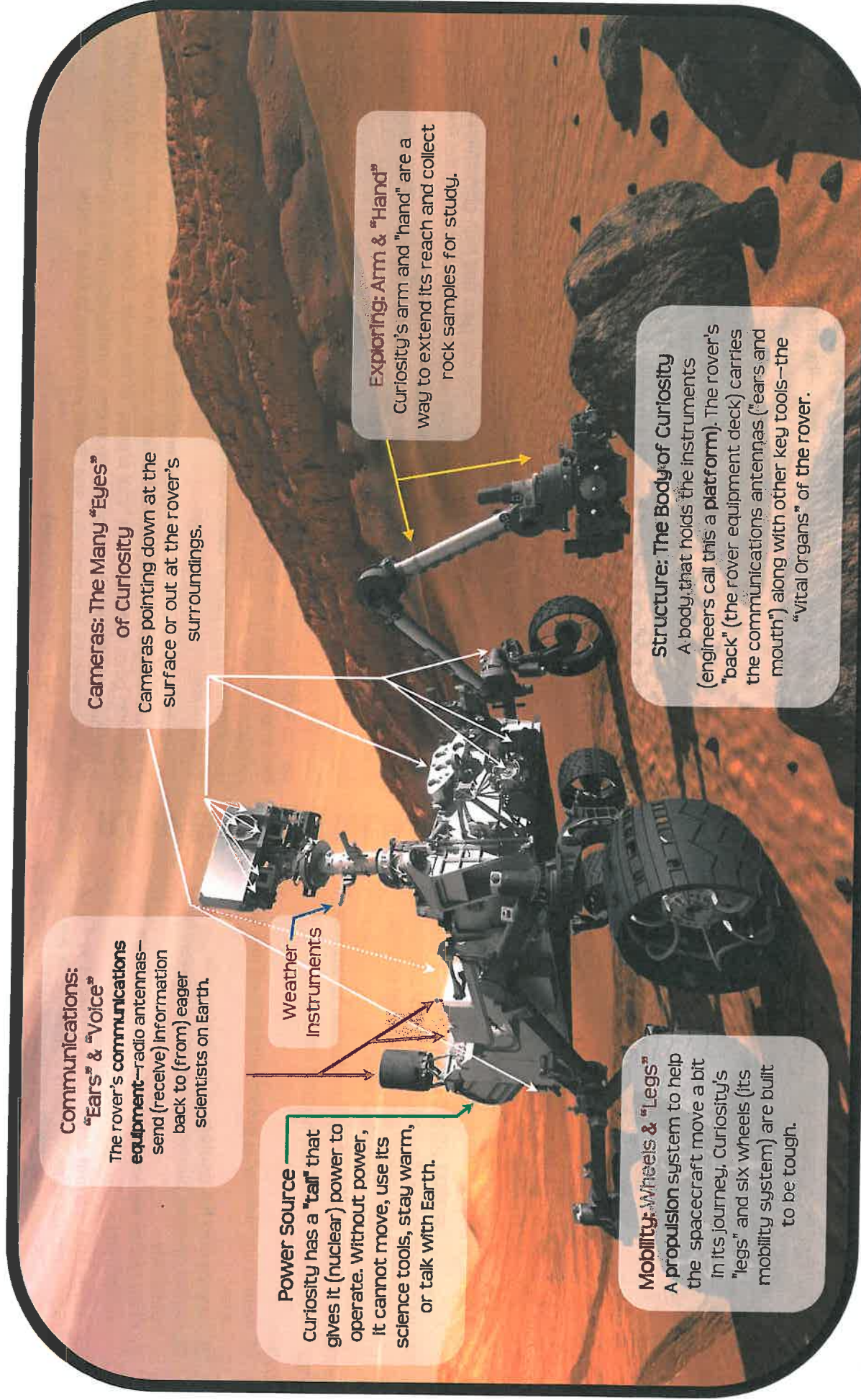
### Science and Technology — Content Standard E

#### *Understandings about Science and Technology*

- Science and technology are reciprocal. Science helps drive technology as it addresses questions that demand more sophisticated instruments and provides principles for better instrumentation and techniques perfectly designed solutions do not exist. All solutions have trade-offs such as safety, cost, efficiency, and appearance. Technological solutions have intended benefit.



# Mars Engineering: CURIOSITY



## Communications: "Ears" & "Voice"

The rover's **communications equipment**—radio antennas—send (receive) information back to (from) eager scientists on Earth.

## Power Source

Curiosity has a "tail" that gives it (nuclear) power to operate. Without power, it cannot move, use its science tools, stay warm, or talk with Earth.

## Cameras: The Many "Eyes" of Curiosity

Cameras pointing down at the surface or out at the rover's surroundings.

## Weather Instruments

## Exploring: Arm & "Hand"

Curiosity's arm and "hand" are a way to extend its reach and collect rock samples for study.

## Structure: The Body of Curiosity

A body that holds the instruments (engineers call this a **platform**). The rover's "back" (the rover equipment deck) carries the communications antennas ("ears" and the "mouth") along with other key tools—the "vital organs" of the rover.

## Mobility: Wheels & "Legs"

A propulsion system to help the spacecraft move a bit in its journey. Curiosity's "legs" and six wheels (its mobility system) are built to be tough.

For more details and to explore MSL aboard Curiosity (interactively) yourself, please visit: <http://mars.jpl.nasa.gov/msl/multimedia/interactives/learncuriosity/index-2.html>

## FULLY LOADED FOR SCIENCE

Mars Science Laboratory aboard the Curiosity Rover

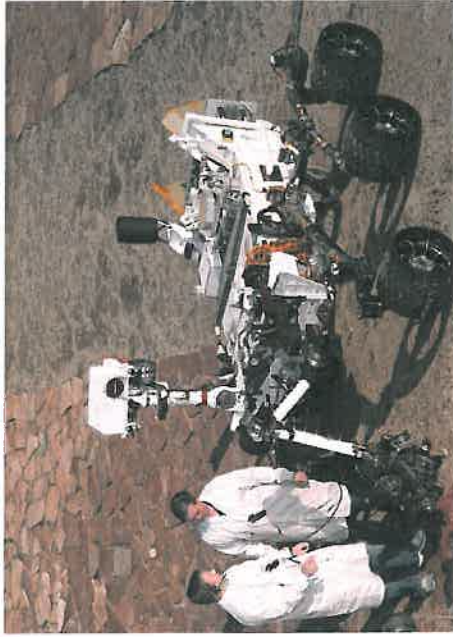


Image of the rover prior to launch (on Earth). Image Courtesy : NASA/JPL

### ROBOT AS BIG AS A CAR

Curiosity is a nuclear-powered, six-wheeled science lab the size of a Mini Cooper and weighs 1,982 pounds (899 kilograms).

**Mission:** To access whether the Martian environment has ever been a potential habitat for life.

**Goals:**

- 1) Assess the **biological potential** of at least one target area
- 2) Characterize the **geology** of the landing site
- 3) Investigate past **planetary processes** relevant to habitability
- 4) Characterize the **surface radiation** in the Mars environment

**Note:** While MSL cannot detect either present-day life or fossilized microorganisms, Curiosity's instruments are capable of verifying three conditions that would be necessary for life on Mars:

- 1) Liquid Water
- 2) Certain necessary chemical ingredients
- 3) An energy source

## Brains, Head, & Neck

Curiosity has computers onboard to serve as its "brain" and process information. It also has a "head" and "neck" - or as scientists call it—the **mast**, which gives the rover a human-scale view. Curiosity's mast carries seven of Curiosity's seventeen camera "eyes."

## Eyes

Cameras give the rover (and scientists) information about its environment and are an extremely powerful tool for the scientists back on Earth. Cameras on Curiosity's mast provide a view similar to what a nearly seven-foot-tall basketball player would see on Mars. Before deciding whether it is worth it to make the drive over to rocks and rock layers of interest, a laser on the rover's "forehead" can zap them from a distance analyze what the vapor is made of to see if they are interesting enough to study close up. Most interesting are materials that formed in water, key to life as we know it.

## Ears & Voice: Communications—Can you hear me now?!

Curiosity will use its radio antenna for sending large data sets of its discoveries back to Earth. Because the rover's and orbiters' antennas are close-range, they act a little like "walky talkies" compared to the long range of the low-gain and high-gain antennas.

Using orbiters to relay messages is beneficial because they are closer to the rover than the Deep Space Network (DSN) antennas on Earth and they have Earth in their field of view for much longer time periods than the rover does on the ground. That allows them to send more data back to Earth at faster rates.

## Hand, Arm, & Body

Curiosity has a "hand" at the end of its jointed robotic arm called a **turret**. The turret carries a drill, a brush to remove dust, a soil scoop, a camera for close-up views, and two science tools to understand if Mars ever had habitable conditions for microbial life. One science tool can detect rocks and minerals altered by water and another is designed to detect carbon-based compounds known as organics, the chemical building blocks of life.

The rover body holds the instruments (engineers call this a platform). The rover's "back" (the rover equipment deck) carries the communications antennas ("ears" and "mouth") along with other key tools—the "vital organs" of the rover. Some of these vital parts (and a few not so vital) include: the observation tray, sundial, scientific instrumentation (which will analyze rocks and minerals), and "Send your name to Mars" chips!

## Legs & Wheels (Going Mobile)

Curiosity's "legs" and six wheels (its mobility system) are built to be tough. The rover will land on its wheels and also cross potentially rugged terrain. The rocker-bogie design of the "legs" allows the rover to keep all of its wheels on the ground, even on uneven terrain.

# ROVER INSTRUMENTS & TOOLS