Explore: Life on Mars?

Hands-on Science Activities

Implementation Guide

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About *Explore*

The *Life on Mars?* module is a product of the Lunar and Planetary Institute's *Explore* program, a national program designed to engage children in Earth and space science in libraries and other out-of-classroom environments. Library staffs across the country are using the activities to bring new audiences into the library. Since its inception over a decade ago, the *Explore* program has grown to support a community of more than nearly 800 individuals in 34 states — all trained to bring Earth and space science to their children's and youth programs. The program began through a generous grant from the National Science Foundation, and NASA continues to nurture the breadth and depth of *Explore* materials, resources, and trainings.

This material was supported by a generous supplemental education and public outreach grant from the National Aeronautics and Space Administration's (NASA's) Science Mission Directorate to Drs. Walter Kiefer and Allan Trieman. The Lunar and Planetary Institute is operated by the Universities Space Research Association (USRA) under Cooperative Agreement Number NCC5-679 issued through the Solar System Exploration Division of the NASA. LPI Contribution Number 1716.

Credits and Acknowledgments

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Explore: Life on Mars? Hands-On Science Activities were developed in accord with guidelines set forth by the National Science Education Standards and American Association for the Advancement of Science (AAAS) benchmarks with special consideration toward effectively engaging girls in science.

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Appreciation is extended to the librarians who field tested the materials in their children's, youth, and teen programs.

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LPI Contribution Number 1716
The Lunar and Planetary Institute is operated by the Universities Space Research Association under Cooperative Agreement Number NCC5-679 issued through the Solar System Exploration Division of the National Aeronautics and Space Administration.

Life on Mars' Key Features

Welcome to Life on Mars?

Is there life on Mars? Within our solar system, Mars has always been in the forefront of our search for life beyond Earth. From little green men to alien-made canals, our imaginations have sometimes gotten the better of us, but as missions shed new light on the Red Planet, our hopes for uncovering the building blocks of life on another world are renewed. *Explore: Life on Mars?* will introduce children to and engage them in the science of life in the universe (i.e., astrobiology) and Mars.

Through hands-on investigations and discussions, children will build an understanding of five key messages relating to the search for life on Mars:
Living things have certain recognizable properties.
Life as we know it requires liquid water, energy, nutrients, and shelter to survive.
Life exists in all sorts of environments on Earth, including extreme ones.
Earth is the only planet known to offer liquid water, moderate temperatures, and protection from radiation due to its atmosphere and distance from the Sun.
Mars is a good candidate for helping us to understand the likelihood of life beyond Earth by comparing its past and present environment with Earth's.

The *Life on Mars?* activities were developed in accord with guidelines set forth by the National Science Education Standards and American Association for the Advancement of Science (AAAS) benchmarks, and they are designed for 8–13-year-olds with special consideration toward effectively engaging girls in science. Specific tips for effectively engaging girls in STEM are provided within each activity.

You may design your own program with one or more of these flexible activities, or you may choose to build the story of Mars and the search for life beyond Earth through the completion of the entire series in your programs. *Explore* activities have been used as part of science clubs in the library, in family science exploration nights or Science Saturdays, with story time, during night-sky viewings, and in many other out-of-classroom programs. Background information, an implementation guide, and facilitator resources are provided to help you prepare to lead the activities. Encourage further exploration with the books, websites, and videos listed in the resource section.

Use this implementation guide to plan your approach to any and all of the *Life on Mars?* activities, which are described in separate documents. All *Explore* materials are available free for educational use at www.lpi.usra.edu/education/explore/.

Inexpensive and Flexible

The activities are designed to be easy to implement — use them in family events, after-school programs, summer programs, festivals, engineering days . . . They require readily available — and generally inexpensive — materials. The activities are designed to be expandable and adaptable to a variety of lengths of time and available materials. Select one activity or conduct the entire module! Additional science activities are listed as possible extensions, and many of the books listed in the resources section offer even more!

Opportunities for Partnership

While the activities can be implemented by an individual, there are many opportunities to bring in members of the community as co-facilitators!

Partner with educators from a local community institution (e.g., National Girls Collaborative Project member, museum staff, 4-H club leader, etc.)

Collaborate with a school. An elementary-, middle-, or high-school teacher could co-facilitate the activities with you, or offer extra credit for students who participate — or for teens helping to co-facilitate! Provide the teachers with a copy of the correlations to National Science Education Standards listed in this guide.

Invite Science, Technology, Engineering, and Mathematics (STEM) professionals to share personal stories about themselves and their careers, co-facilitate activities with you, and be on hand to answer questions. Or, use a platform such as Skype to host a real-time Q&A between the STEM professional and the audience.

Recruit community college, undergraduate, or graduate astrobiology and space science students to serve as facilitators.

Adapting Activities for Your Needs

This module is intended to be flexible! Make it your own!

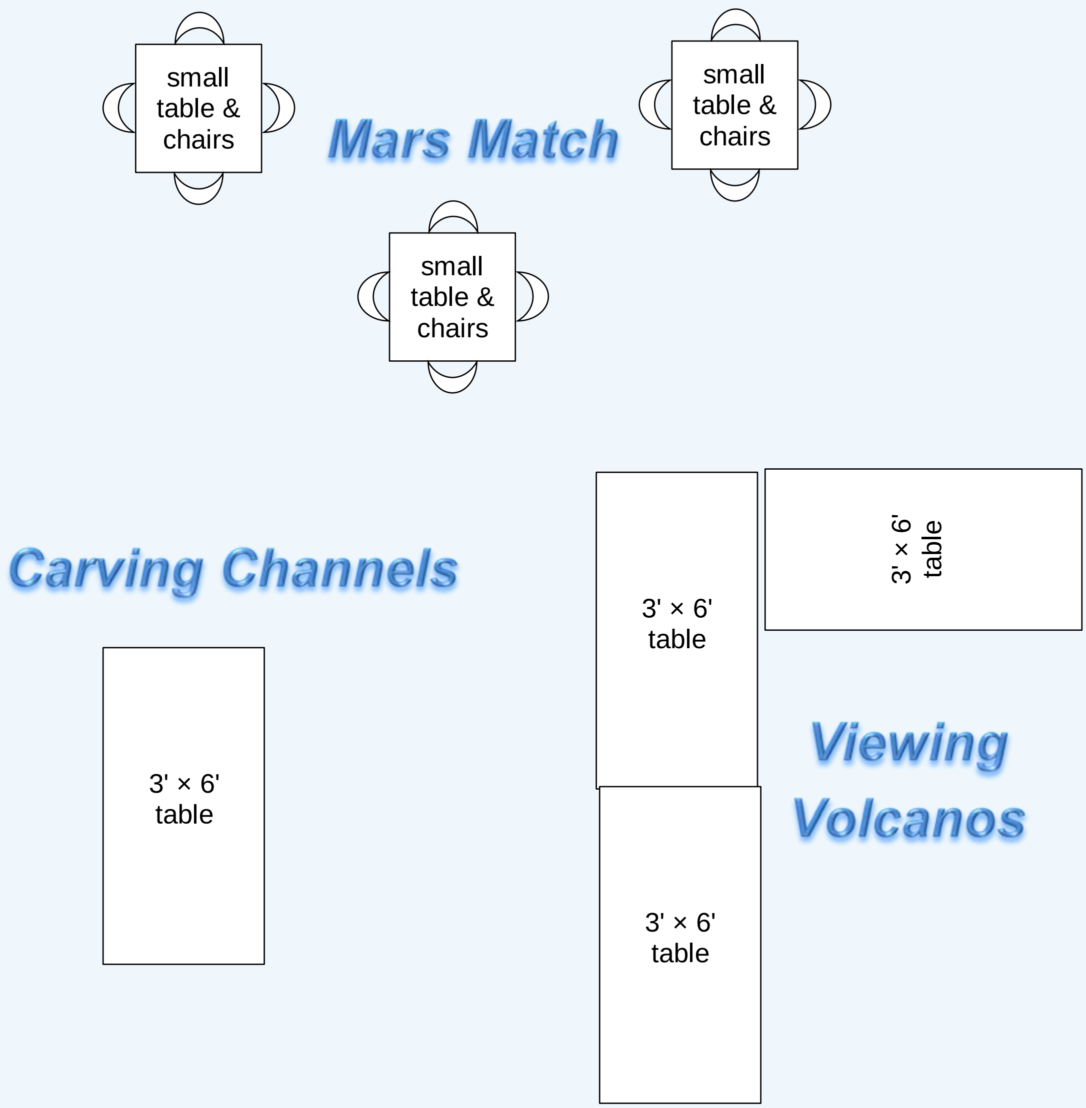
The activities can be facilitator-led and undertaken during separate events. Focusing on a single activity during an event allows participants to spend as much time as they wish completing their science exploration.

Alternatively, several activities may be offered simultaneously as a series of stations during one or more longer events. Offering several activities alongside each other allows participants to build a story for what it is like on Mars and the possibility of life there in a single event. Extra time, space, support staff or volunteers to host stations, and materials — perhaps as duplicate stations — may be necessary, depending on the expected number of participants.

Tips for Offering Multiple Activities as Stations

Each activity has step-by-step instructions for the station hosts.
Create and post a sign for each area.
Plan to allow adequate time for each station. Use a bell, chimes, or cell phone alarm to let the groups know when it is time to rotate.

Sample Room Setup: Mars from Above



Annotated Facilitation Outline

The following outline can be used to organize your thoughts as you introduce the science of astrobiology — the search for life in the universe — and key messages about the search for life on Mars before launching into one or more activities. These points are summarized in the brief facilitation outline that accompanies each activity document.

Introduction

Introduce yourself and the library/facility.

Facilitator's Note: If the participants have never been to your library/facility before, use this time to let them know where restrooms and the drinking fountain are and emphasize any safety considerations.

Frame the activity(ies) in a way that provides personal relevance (to life, helping others, and having fun) by introducing the main message: Scientists work to understand the world around us and beyond!

Use open-ended questions (such as those suggested below) to start a conversation about things we (living things) need to live and how we could use this to look for life elsewhere in the solar system.

What do you need to survive? If you were camping out, what would you need?

What are some characteristics of living things?

What signs of life (living things) can we find here on Earth? Do you think that you could use any of those characteristics to look for life beyond Earth? If yes, which ones?

Facilitator's Note: Open-ended questions are a great way to start an activity! They have no right or wrong answer, so they invite your audience into the conversation — even if they are not very familiar with the topic.

Be sure to allow enough time for participants to respond (try counting silently to yourself for up to a full 15 seconds).

Covering this information as a conversation, rather than as a traditional classroom- or lecture-style presentation:

Invites participants to be fully engaged in the activity — and motivates them to do so!

Gives credit to the participants' own ways of thinking.

Helps participants recall their own knowledge and experiences, and puts the facilitator in the role of "guide on the side" rather than "sage on the stage."

Science is a social endeavor.

Scientists often work in teams, with different people contributing in different ways, to take on a challenge.

Scientists build on the ideas of others.
Encourage persistence by noting that successful science exploration involves a process of thinking, testing . . . and doing it again! It is not a set of facts to be memorized but a process for understanding the world and universe around us.

Activity(ies)

Follow the steps within the activity write-ups.
Utilize the “Tips for Engaging Girls in STEM” found at the beginning of the activity.
Listen and encourage creative exploration!

Conclusion

Summarize the groups’ explorations of the science, especially as it relates to the possibility of life on Mars (now or in the past).
Congratulate the groups on their efforts and accomplishments during the activity(ies).
Advertise any future science and/or mission events: Invite the groups to return to explore the possibility of life beyond Earth!

Be a Science Guide!

Modified from "Tips to Guide Your Child's Enjoyment of Learning: Be a guide on the side!," *Family Guide to Mars* — Field Test Version, © 2004 Space Science Institute.

This guide is intended to assist you in sharing the joy of exploration and discovery with your young patrons.

1. Children are naturally curious and enthusiastic to learn about the world around them. Listen to their ideas and opinions — they will fascinate you! Encourage your young patron's inclination to observe, wonder, and investigate.

2. You can be a good teacher, even if learning about space science is new to you. Your enthusiasm for the topic will go a long way!

3. Good teachers introduce ways to find the answers, rather than presenting themselves as a source of all information. Get in the habit of replying to children's questions with new questions that will help guide them to the answer. Remember that is the quest for discovery, rather than a mere listing of facts, that generally motivates individuals to become life-long learners.

4. Even if you don't know the answer, you can explore with the child to find answers together. The resources section of this *Explore: Life on Mars?* module can assist your patrons in finding answers — as well as new questions!

5. If you do know the answer, it is often valuable to ask leading questions that guide a child to discover something new for him- or herself.

6. The activities provided in this *Explore: Life on Mars?* module can assist you in making enjoyable connections between space science and your patrons' everyday experiences.

7. Encourage young patrons to use different dimensions of their intelligence to record their impressions and observations. Telling stories, drawing pictures, creating poems or songs, making a photo album or collage, recording a video, and writing in a journal are all ways to remember and share information.

Engaging Girls and Underserved Audiences in STEM

Sources: *Why So Few: Women in Science, Technology, Engineering, and Mathematics.* Catherine Hill, Chrstianne Corbett, and Andresse St. Rose, AAUW, 2010 (www.aauw.org/learn/research/upload/whysofew.pdf) and *Encouraging Girls in Math and Science (NCER 2007–2003).* Washington, DC: National Center for Education Research, Institute of Education Sciences, U.S. Department of Education (ies.ed.gov/ncee/wwc/pdf/practice_guides/20072003.pdf/).

The Explore: Life on Mars? educational resources and materials have been developed with careful consideration for use in serving girls, a traditionally underserved audience in science, technology, engineering, and math (STEM). Although the overall trend of girls in math and science at the high school level is good, far fewer girls than boys are entering college with the intent of pursuing a science, technology, engineering, or math (STEM) career or major. Both social and environmental factors contribute to the underrepresentation of girls in STEM. Research suggests that girls tend to believe that these abilities are innate, while in reality, they are skills that can be acquired and improved with experience and training. By understanding these factors, educators can help to overcome these challenges.

Research has shown that girls benefit from learning the design process and taking part in STEM activities that are project-based. These activities should focus on collaboration and teamwork, not competition. Educators/activity facilitators should give the mission or project a clear purpose and encourage the girls to work together. The following are some **"Advice from the Literature on Engaging Girls Tips"** from the Institute of Education Sciences (IES) Engaging Girls in Math and Science Practice Guide:
Understand and communicate that academic abilities are expandable and improvable
Expose girls to female role models who have achieved in math in science in order to promote positive beliefs regarding women's abilities
Foster girls' long-term interest in math and science by choosing activities connecting math and science to careers (don't reinforce existing gender stereotypes; choose activities that spark initial curiosity about content)
Spark initial interest
Embed activities in interesting and relevant contexts (for example, for middle-school age, use real-world problems such as building a skateboard ramp on a budget/hovercraft that flies so many students)
Provide engaging informational and narrative texts
Use project-based learning, group work, innovative tasks, and technology (i.e., the Internet)
Provide ongoing access to resources for students who continue to express interest in a topic after the class has moved on
Provide opportunities for students to engage in spatial skills training
Encourage girls to play with toys involving spatial skills, such as building toys
Require answers that use both words and a spatial display

Facilitator Background Information

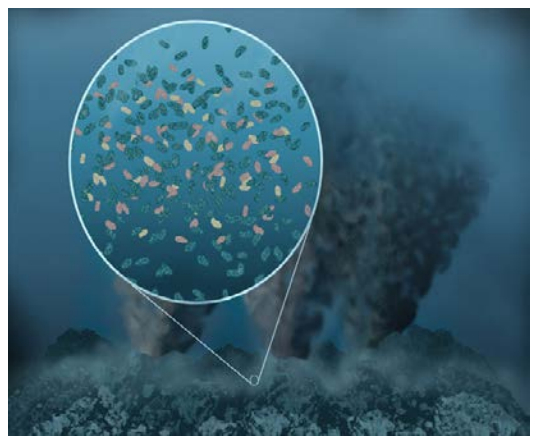
Life on Mars: Are We Alone?

This profound question has captured our imaginations for many years. Only now are we gaining the knowledge and technology to attempt a scientific answer. We know more today than at any other time in the past about the qualities that a planet must possess in order to potentially support life. Within our solar system, Mars has always been in the forefront of this search. From little green men to alien-made canals, our imaginations have sometimes gotten the better of us, but as missions shed new light on the Red Planet, our hopes for uncovering the building blocks of life have been renewed. As a result of this interest in the search for life beyond our home planet over the past century, a new and exciting field of science has emerged to help examine these questions and more.

What is Astrobiology?

Astrobiology is the study of life in the universe. It investigates the origins, evolution, distribution, and future of life on Earth and beyond. This branch of biology requires an understanding of biological, planetary, and cosmic phenomena. By viewing biology as a planetary phenomenon, astrobiologists strive to address three questions:

How does life begin and evolve?
Is there life elsewhere in the universe?
What is the future of life on Earth and beyond?



Origin of Life? Scientists believe that life on Earth may have begun as microscopic organisms in extreme underwater hydrothermal environments such as depicted here.
Credit: ***Lunar and Planetary Institute*.**

Through our efforts to understand how life began and evolved on Earth, we hope to determine where and how to best look for it elsewhere. The scientific field of astrobiology embraces the search for life both close to home (Earth) and far beyond. From laboratory and field investigations on Earth — to the exploration of Mars and the outer planets — to the search for potentially inhabited planets beyond our solar system, scientists are studying the potential for life to adapt and thrive beyond our home planet. This research, like other space-related science programs, involves a broad range of research interests, and requires partnerships among many fields of science, including (but not limited to) molecular biology, ecology, planetary science, astronomy, information science, and space technologies.

How is NASA Searching for Life?

In 1998, in a concerted effort to address the challenges in finding life beyond Earth, the National Aeronautics and Space Administration (NASA) established the NASA Astrobiology Institute (NAI). As an innovative way to develop the field of astrobiology and provide a scientific framework for flight missions, the NAI is composed of competitively selected teams across the country that incorporate astrobiology research and training programs in concert with the national and international science communities.

Community and collaboration are essential to achieving the NAI's mission and to effectively answering the fundamental questions of astrobiology. During its first decade, NAI had many significant research accomplishments, as well as contributions to NASA missions. It was influential in defining the landing sites for the Mars Exploration Rovers (Spirit and Opportunity), which ultimately provided evidence of past liquid water on the martian surface. NAI scientists may have also detected methane gas in the martian atmosphere, which would suggest that the planet is at least geologically alive, if not biologically as well.

Here on Earth, NAI scientists have discovered microorganisms living completely independently of the Sun, almost 2 miles (3 kilometers) beneath Earth's surface. They have also expanded their search to planets around other stars, detecting both water vapor and carbon dioxide in the atmospheres of some of these newly discoveRed Planets. As NAI continues in its mission, scientists will continue to explore the limits of life on Earth, developing new ways to search for life elsewhere in the universe, and advancing our understanding of how life originated on our own planet.

For more information about the NAI and its teams, please visit astrobiology.nasa.gov/nai/.

What is Life?

Identifying the characteristics of life is necessary to astrobiologists because they need a working definition of life — a set of criteria for something to be considered alive — to use in their work. Would you be able to identify life if you saw it? You probably have a set of criteria, whether you think about them specifically or not. Given the broad range of life, some of the characteristics of living things may be more obvious than others.

Defining life is not easy. Part of the complexity of is caused by the fact that there are nonliving examples that display one or more of these same characteristics. How, then, do we design instruments, sensors, probes, and missions to seek out life, if we cannot even define it in a way that satisfies everyone in the scientific community? Despite these differences in opinion, scientists have worked together to developed a set of general characteristics of life.

Based upon the examples on Earth, there are several characteristics that can be agreed upon:

1) Life stores and uses energy

2) Life engenders more life (reproduces and/or grows)
3) Life responds to its environment (external stimuli)
4) Life changes (evolves and adapts) over time

All Earth life, life as we know it, is organized in essentially the same way: It is all based on the chemistry of the element carbon, it requires liquid water, it engenders further life via DNA and/or RNA, it uses phosphate molecules to store energy, and it uses protein molecules to respond to and affect (influence) its environment. Despite differences in preferred environment or complexity of body structure, all life on this planet adheres to these basic principles, and as far as we can tell, this has been the case for billions of years.

What Does Life Need?

There are four main requirements that have been the focus of our search for life in the universe. Life as we know it needs an energy source, nutrients (something to eat or consume), protection from the elements, and liquid water. Scientists are looking for places in our solar system — and beyond — that have all the things that we know life needs.

Of the four identified necessities for life, the presence of **liquid water** is considered to be one of the most important and perhaps useful to scientists. Liquid water has been a focus in the search for life beyond Earth because, to date, we have only found living organisms where liquid water exists. Pure water is a liquid over a fairly wide range of temperatures — between 0°C (32°F) and 100°C (212°F). Under special circumstances, however, water can remain a liquid beyond this range. For example, at high pressures (like at the bottom of the ocean or deep in the Earth's crust), water can remain a liquid at higher temperatures. Similarly, saline water (water containing salt, like our ocean water) has a lower freezing temperature, allowing it to remain a liquid at temperatures that are colder than the normal freezing point. However, temperatures much above or below this normal range for liquid water negatively affect the cellular structures of living organisms — potentially destroying them. The presence of water on a planetary body is one requirement for life to exist there (past or present), thus scientists are interested in identifying locations in the universe that possess water — especially liquid water — to better narrow their search for life beyond Earth!

The unique properties of water are also important as a component of life as we understand it. Water participates in many chemical reactions that are essential to life, both as a nutrient and as an energy source. Water also is an excellent solvent; it can dissolve many important chemicals and molecules, and so help transport nutrients, waste products, and chemicals, whether within cells or across oceans. Water has another unusual trait: It expands when it freezes. This means that solid water (ice) is less dense than liquid water, and thus it floats. As a result, water freezes at the top first, keeping bodies of water from freezing solid during times of global cooling. Water is a common component of planets as they form and is released readily by volcanic activity. This means that although liquid water may not be present at a planet's surface, it may still exist below the surface. Because water has so many essential functions in life (as we know it), identifying its presence will continue to be a focus for astrobiologists; however, the other requirements of life must be met as well.

Early microscopic life, such as cyanobacteria, may have thrived in shallow water environments similar to this artist's depiction.
Credit: ***Lunar and Planetary Institute.***

All organisms require some form of **energy** to run their life processes (like growing, moving, and reproducing). The organisms that we are familiar with primarily use either light energy or chemical energy. Plants get their energy from light. Microbes at deep-sea vents do not have access to light and instead get their energy by breaking down chemical compounds dissolved in water circulating from Earth's interior. Light energy available to a planet diminishes with distance from the Sun, and it also diminishes with distance from a planet's surface. On Earth, an example of this could be the ocean bottom or deep within caves. If light energy is absent, then there must be an alternate energy source that can be utilized by organisms.

All organisms also require **nutrients**, the minerals and other chemicals used to maintain and grow their bodies and structures. Plants get nutrients from soils and the atmosphere. Animals get their nutrients as food by eating plants or other animals. Life must have a continuing source of nutrients, not only for an individual plant or animal, but over long periods of time so that the plant-animal communities can continue.

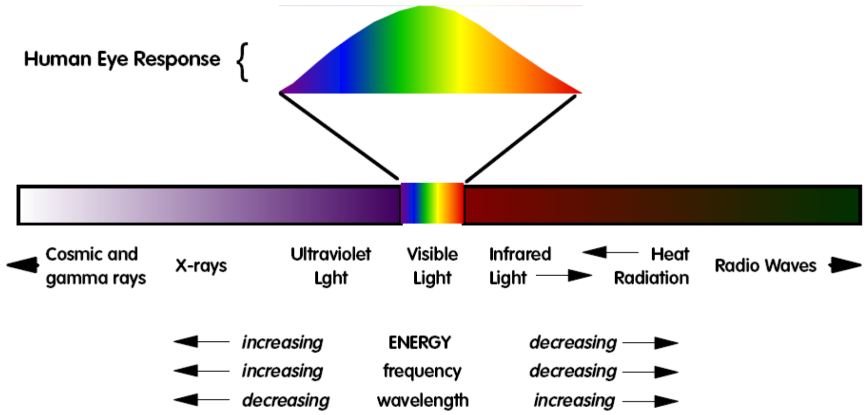
Finally, all organisms require **protection** from the extremes of the space environment in which the planets reside. This protection may provide the environmental stability necessary for the development and continuation of life. Otherwise, life would fall victim to high-energy processes in solar systems, like asteroid/comet impacts and ultraviolet radiation from the Sun. Rock layers and deep water can provide this protection, and many organisms on Earth live underground or deep in the ocean. A planet's atmosphere can provide some protection from hazards (like ultraviolet radiation, extreme temperature variations, and small- to medium-sized meteorite impacts) and allows access to sunlight as a major source of energy. Atmospheres also help to moderate day to night temperature changes, helping to maintain a habitable temperature range. However, to serve as an effective shield or insulator, an atmosphere has to be fairly substantial, such as that found on Earth, Venus, or Saturn's moon Titan. A planet or moon depends upon its own interior processes, such as volcanic activity, to create an atmosphere and its gravity (of adequate strength) to hold onto the atmosphere (keep it there). A small-sized body such as Pluto or Earth's Moon has a gravitational field that is too weak to hold onto a significant atmosphere, making life on or near the surface difficult.

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 are all 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.



Electromagnetic spectrum.

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), but some still gets through (UVA and a bit of UVB). We can protect ourselves completely by covering ourselves with clothing and using sunblock. Our atmosphere protects us from most of the X-, gamma, and cosmic rays 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.

How Did Life Begin on Earth?

According to our current understanding, the origin of life on Earth was dependent upon the geological processes that are driven by the heat from Earth's interior. These interior processes have played an important role in shaping the surface. The surface of Earth is a dynamic place, changing over time due to the influences of plate tectonics and volcanism (interior processes), external events such as impacts, an active water cycle, and weathering of various forms (wind, water, etc.). These early geologic processes helped in the formation of Earth's atmosphere and liquid water at the surface.

Over the past few decades, our view of the origin of life on Earth has advanced substantially. Life on Earth has been shown to be much more robust and adaptive than previously imagined, and has been found in places where no one had previously thought to look for it. Our current understanding of Earth life suggests that it may have originated very quickly in geologic terms, developing from inorganic matter in much less than one billion years. Scientists are working hard to understand the specific set of processes that led to the origin of life and the amount of time required; this search is especially difficult as we know of only life on Earth, and have not figured out how to create life in the laboratory. Despite this, we do have some basic understanding of the processes involved.

The raw materials from which life arose are now known to be relatively common throughout the universe. The most important of the major biogenic elements are carbon (C), hydrogen (H), oxygen (O), and nitrogen (N). Comets and some asteroids are rich in these elements (and their compounds, like water), and an early influx of comets and asteroids may have provided additional amounts of these elements to Earth. It is significant that these compounds have been shown to come from a far larger and more ancient process, one that operates in vast clouds from which the stars themselves are formed. Life, then, appears to be a natural outgrowth of the universe's basic structure and organization.

What Can Life Tolerate?

Based on what we know, life on Earth exists in nearly every environment that includes liquid water, even those that only experience water occasionally. Most of the life on Earth lives in the range of temperatures between 30°C (86°F) and 45°C (113°F), averaging around 37°C (98.6°F). However, particular varieties of life — extremophiles — can thrive in conditions far below freezing (down to –15°C, 5°F) and far above the boiling point of pure water at surface pressure (up to +121°C, 250°F). Temperatures above this range break down cellular materials and lower temperatures cause chemical reactions to be too slow to maintain life functions.

Extremophiles

Much of the research taking place in astrobiology emphasizes the environment and habits of extremophiles — organisms that thrive in conditions that we would consider "extreme" and life-threatening (e.g., very high or low temperatures, very salty or acidic water). Extremophiles can live where most organisms cannot because they have adapted special mechanisms for survival. Any life that may exist beyond Earth in our solar system would likely be found to exist in these types of harsh conditions. By studying analog sites on Earth — places that have similar environmental conditions to those currently found or that may have existed in the past beyond Earth (such as Mars) — scientists are working to understand the processes that allow these resilient organisms to live and thrive despite the unfriendly environment.

One such analog environment that may be of use in the search for signs of life on Mars is hydrothermal vents. A *hydrothermal vent* is a hot spring on the seafloor. It continuously spews super-hot, mineral-rich water that helps support a diverse community of organisms. Although most of the deep sea is sparsely populated, vent sites abound with a fascinating array of life. The first hydrothermal vent was discovered in 1977. These vents occur along mid-ocean ridges (spreading seafloor) in all the Earth's oceans, at an average depth of about 7000 feet (2100 meters). The creatures that live in darkness, from bacteria to tubeworms, may light the way to the development of new drugs to improve human health and industrial processes, and may help us in identifying life beyond Earth.

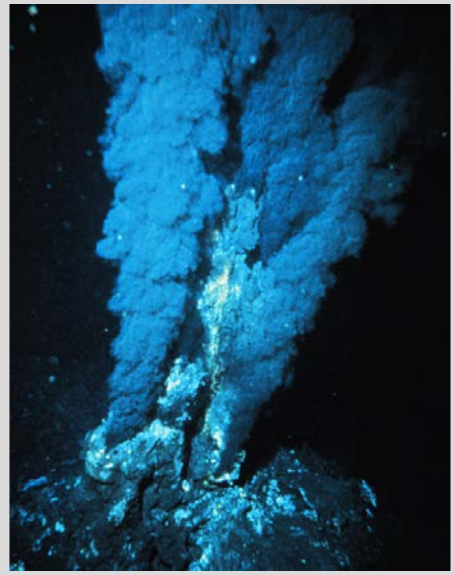
Deep Sea Hydrothermal Vent: Black Smoker

Black smokers are an interesting type of hydrothermal vent found deep within the ocean at about 7000 feet below the surface.

The plumes of superheated water from within Earth's crust are laden with minerals, which are responsible for the black appearance of these features.

Despite the seemingly inhospitable location, scientists have discovered thriving communities of organisms living within the hydrothermal vents.

Credit: NOAA (National Oceanic and Atmospheric Administration).



Extreme environments may also include extreme depths, pressures, alkaline or saline waters, or severe radiation conditions. The majority of these extremophiles are microbes, and they belong to an ancient group of life called archaea (the other two groups are bacteria and eukaryotes). Astrobiologists are interested in these microbes because they closely resemble fossilized remains of earliest discovered fossils on Earth and thrive in environments very similar to the conditions that scientists think fostered the origin of life as we know it.

Earth contains an interesting menagerie of extremophiles, such as *Pyrolobus fumarii*, the hydrothermal vent dweller that lives at temperatures of 113°C (235°F), or the *Cryptoendoliths,* which live at temperatures of –15°C (5°F) inside sandstone rocks in the Antarctic. Anaerobic extremophiles can exist in an environment without oxygen, such as the early Earth, which lacked oxygen in the atmosphere. Many of these microbes have remained nearly unchanged for the past 3 billion years. The microscopic *Menthanococcus jannaschii* lives in hydrothermal vents on the floor of the Pacific Ocean. Thriving under pressures that would crush a conventional submarine, this heat-loving microbe lives without sunlight or oxygen and gives us hints about conditions and life on early Earth.

Might There be Life on Mars?

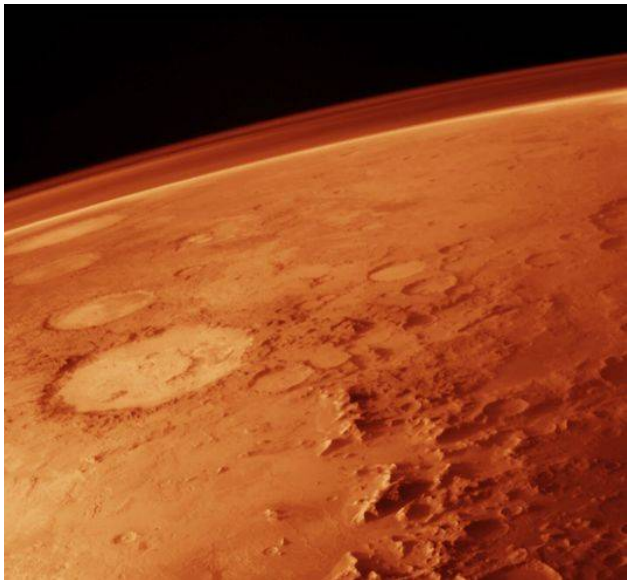
All life as we know it requires liquid water, hence the strong interest in finding evidence of past liquid water on Mars and understanding the history of this water. There is good evidence that liquid water once flowed and ponded on the surface of Mars, so it is possible that life could have become established there. The first evidence for life on Earth, in the form of *fossil bacteria,* is in rocks that formed about 3.5 billion years ago — at approximately the time that the martian environment was changing from warmer and wetter to colder and drier. Microbial life on Earth probably existed before this time period, possibly becoming established after the period of intense asteroid bombardment was over, but there is no record of it. In short, life may have taken up to a billion years to become established on Earth, although it may have happened more quickly, and so scientists consider this to be a reasonable timeline for Mars as well.

Given this start, and using Earth as a model, conditions on much of Mars would have been suitable for life for about a half billion years, before the climate deteriorated. However, the features recording flooding events suggest that there were occasional warmer and wetter periods, and there may have been refuges for life, such as moist areas near warm volcanic regions. Given the harsh conditions, and lack of evidence, it is improbable that life evolved into complex multicellular forms, like it did on Earth between 1 and 500 million years ago. Life on Mars — if it exists or existed in the past — would most likely have been in the form of microbes.

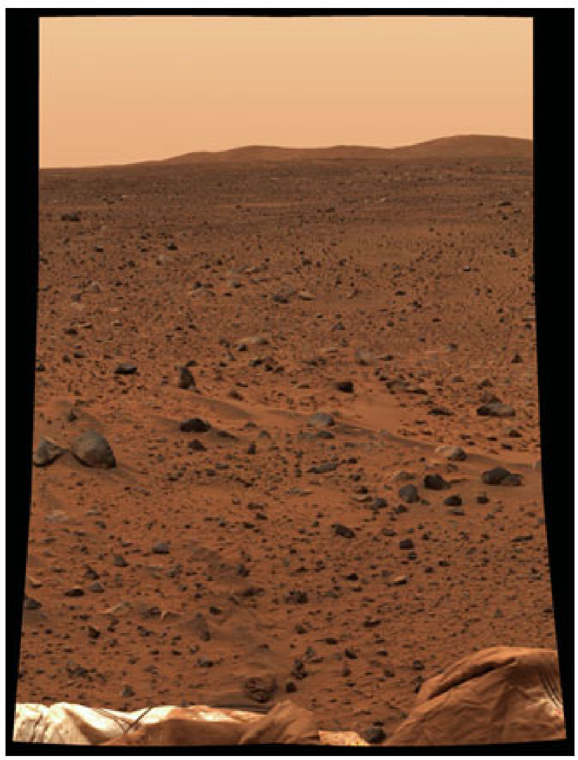
In the 1990s NASA scientists announced the presence of organic molecules, mineral features that could have been formed by biological activity, and possible microscopic fossils of primitive, bacteria-like organisms in a martian meteorite recovered in Antarctica. They interpreted the features to have formed on Mars more than 3.6 billion years ago, and to be evidence that life existed on Mars. The results have been hotly debated in the scientific community. Many scientists believe the structures could have been formed by chemical processes, rather than biologic; such chemically formed features are known to exist. Others suggest that the organic signature is contamination from Earth. At present, few scientists are convinced that the features are evidence of life. Debate is a healthy part of the scientific process, and it has served an additional purpose — it has helped scientists better identify the “signals of life” and develop more tools in the identification process being used by astrobiologists today.

Losing the Atmosphere

Early Mars probably had a thicker atmosphere with more carbon dioxide and water vapor, provided by vigorous volcanic activity. As mentioned previously, volcanic activity (i.e., a geologically active environment) is believed to be important for the development of life. The young Mars’ magnetic field shielded the surface from the charged particles of the solar wind and dangerous cosmic radiation. This Mars was warmer and wetter, and the higher atmospheric pressure permitted flowing water at the surface. However, by about 4 billion years ago, Mars’ environment became cold and dry, as it is now. As Mars’ interior cooled, the gases and water vapor from the volcanism gradually dwindled and the magnetic field disappeared. Left unprotected, the atmosphere was worn away by the solar wind, and the martian surface was bathed in radiation.



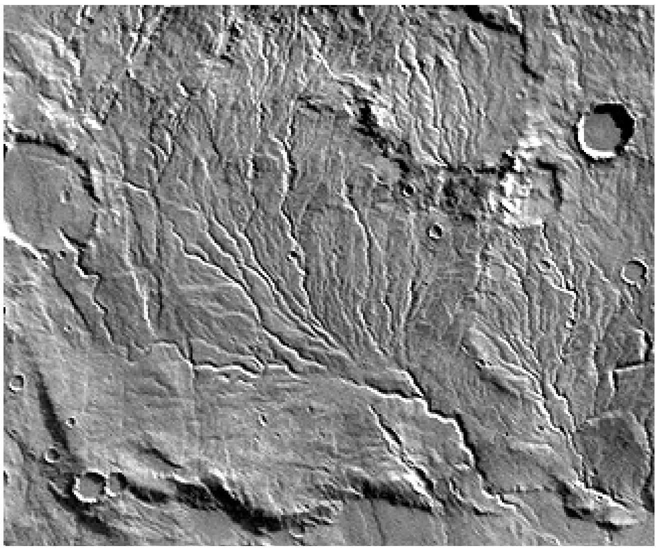
This image looks obliquely at part of the southern hemisphere of Mars. The numerous circular structures are impact craters, indicating that this is an old part of the martian surface. The thin martian atmosphere can be seen as a layer between the rock surface of the planet and the black of space. Credit: NASA.



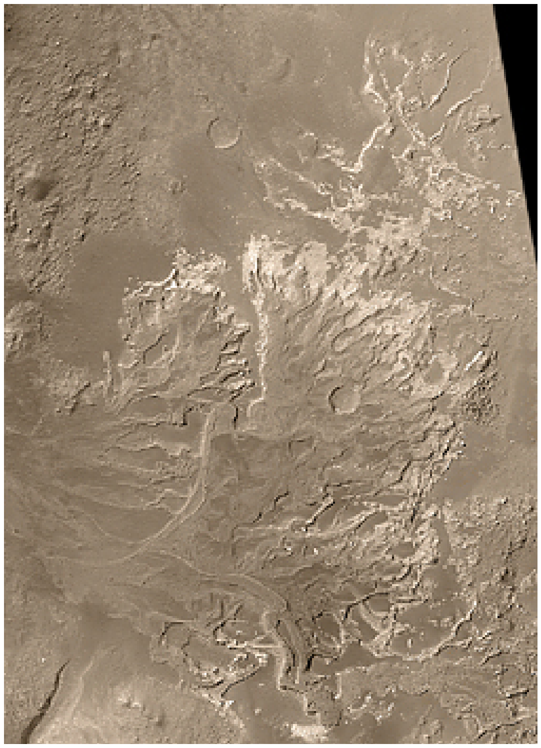
An image of the cold, dry Mars of today, taken by the Mars Exploration Rover, Spirit. Credit: NASA/JPL/Cornell.

Disappearing Water

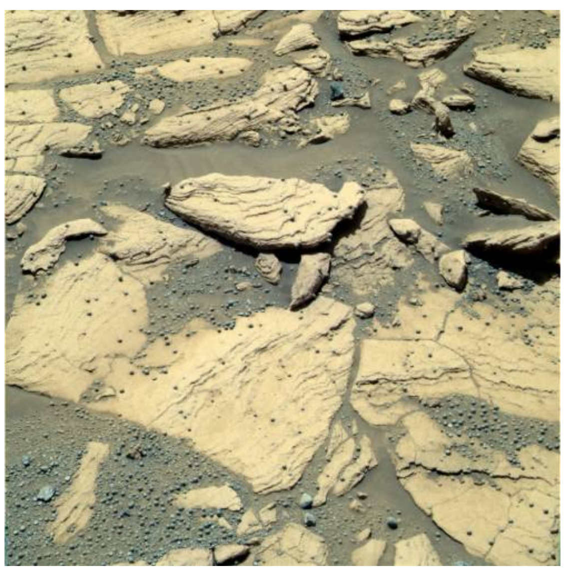
Early Mars was wetter and warmer. Several lines of scientific evidence support this claim. Images obtained by Mars orbiters have revealed that the ancient southern highlands are covered by dendritic drainage patterns — networks of stream channels, or "valley networks," that erode into the highland craters.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



Stream drainage across the southern highlands of Mars.
The streams erode the edges of some of the older, larger craters. This pattern is similar to stream drainage patterns — dendritic drainage — seen on Earth that is caused by flowing water. The image is 200 kilometers across (125 miles); Viking Orbiter image 606A56. Credit: NASA.



Features that look like the Mississippi River Delta (minus the water) are found on Mars' surface, suggesting that water flowed across the surface for a long period of time, gradually creating a delta in a body of water. The feature is 11 kilometers wide (7 miles) and 13 kilometers from top to bottom (8 miles) in the image.
Credit: NASA/JPL/Malin Space Science Systems.
www.msss.com/mars_images/moc/2003/11/13/



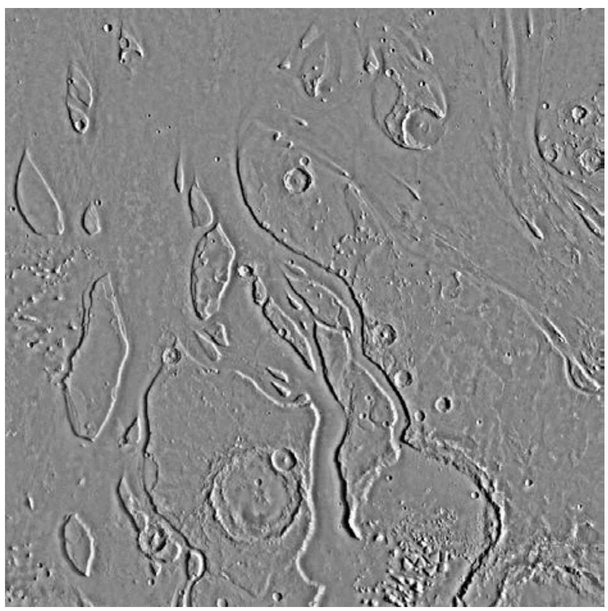
Rover images of layers in the rocks at the martian surface. The thin layers are interpreted to be sediment deposited by flowing water. The "blueberries" are small, BB-sized deposits of hematite. Hematite is a mineral that typically, although not always, forms in water.
Credit: NASA.

Some scientists have calculated that Mars may have had a global layer of water that was about 394 feet (120 meters) thick. Imagine Mars with an ocean at its northern hemisphere, and streams flowing across the landscape, draining into it.

An artistic rendering of what an ancient ocean might have looked like on Mars.
Credit: Copyright Michael Carroll, all rights reserved.
www.lpi.usra.edu/publications/slidesets/redplanet2/slide_28.html

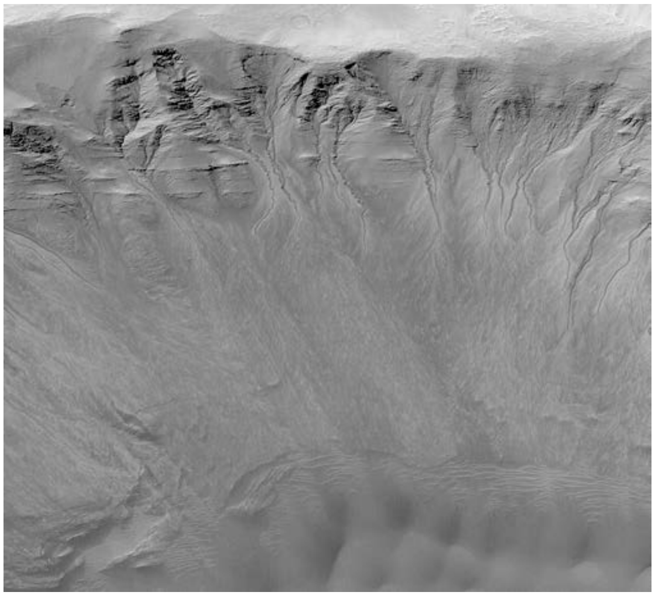
About 4 billion years ago, things changed. Mars became cooler and drier, because of changes in its atmosphere. The thin atmosphere and low air pressure no longer permitted liquid water to exist at the surface. Under these conditions, water turns directly from ice into gas — it sublimes — when it is exposed and warmed at the surface. As Mars cooled and the conditions became unstable for liquid water to exist at the surface, the water may have been sequestered underground, either as a liquid or as ice. Occasional warm periods in Mars' history resulted in melting of the subsurface ice and gigantic floods. The floods are recorded by outflow channels that feed into the northern lowlands. These features are much more chaotic than the orderly drainage patterns of the southern highlands. Outflow channels, similar in features to braided streams on Earth, form from catastrophic floods of water. Multiple wide channels "braid" together, transporting gigantic blocks of the underlying rocks.

Outflow channels cut by flood waters in Ares Vallis. The blocky "chunks" in the broad channel at the bottom of the image are displaced blocks of material pulled from the walls of the channel as the water rushed along. Credit: ESA/DLR/FU Berlin (G. Neukum).



Teardrop-shaped islands formed as flood waters rushed through this area. The circular depressions are impact craters. The region shown is 475 kilometers (295 miles across). Mosaic of images from NASA's Viking mission. Credit: NASA.

Recent images of gullies on the slopes of martian craters, compared to older images of the same crater, show a new flow of material down the crater slopes. Some scientists interpret these flows to suggest that water occasionally flows on the surface of Mars today. Ice below the surface may melt and carry material down slope, before the water evaporates or refreezes. The cause of these features continues to be debated by scientists. However, some scientists suggest that these gullies are created by the flow of dry sand, with no water present at all. Another martian mystery!



Martian Gullies
This image shows several gullies on the wall of Newton crater on Mars. Some scientists believe that the gullies are evidence of the recent flow of liquid water at the surface of Mars. The image is 3 kilometers (2 miles) across. NASA Mars Global Surveyor image. Credit: NASA.

In 2011, on the heels of the launch of the next rover to Mars, Curiosity, NASA scientists announced the discovery of bright veins of a mineral deposited by water, apparently gypsum, by the Mars Exploration Rover, Opportunity. The discovery helped to support the idea that liquid water flowed through underground fractures in the rock.

The vein examined most closely by Opportunity is about the width of a human thumb (0.4–0.8 inches, or 1.02–2.03 centimeters), 16–20 inches long (41–51 centimeters), and protrudes slightly higher than the bedrock on either side of it within the Endeavour Crater. The vein, which is informally named “Homestake,” contains plentiful calcium and sulfur, in a ratio pointing to relatively pure calcium sulfate. Calcium sulfate can exist in many forms, varying by how much water is bound into the minerals’ crystalline structure. Image data from Opportunity’s camera suggest that the vein is of the mineral gypsum, a hydrated calcium sulfate (gypsum is common on Earth and is used to make drywall and plaster of Paris).

Observations from orbit have detected gypsum on Mars previously. A dune field of windblown gypsum on far northern Mars resembles the glistening gypsum dunes in White Sands National Monument in New Mexico. The “Homestake” deposit, whether gypsum or another form of calcium sulfate, likely formed from water dissolving calcium out of volcanic rocks. The minerals combined with sulfur either leached from the rocks or introduced as volcanic gas, and were deposited as calcium sulfate into an underground fracture that later became exposed at the surface.

Throughout Opportunity’s long journey across Mars’ Meridiani Planum, the rover has discovered bedrock composed of magnesium, iron, and calcium sulfate minerals that also indicate a wet environment billions of years ago. This suggests that veins such as “Homestake” could have formed in a different type of water environment — one more hospitable for a larger variety of living organisms.

Where is the water now?
Much of Mars' water is underground, either as a liquid or as ice. Subsurface water is common on Earth, too! Much of our drinking water comes from "groundwater." NASA's Mars Reconnaissance Orbiter and the European Space Agency's Mars Express have instruments onboard designed to detect evidence of subsurface water on Mars.

And do not forget the polar *ice* caps! Mars' northern and southern ice caps contain water ice, as well as carbon dioxide ice — like the dry ice you can get in supermarkets. Mars' northern ice cap is mostly water ice.

Water and carbon dioxide ice ("dry ice") occur in the southern polar ice cap of Mars. Credit: NASA.

Residual water ice in Vastitas Borealis Crater. Credit: ESA/DLR/FU Berlin (G. Neukum).

There is no evidence that life exists on Mars right now, but finding life — or evidence of past life — is challenging when you are examining an entire planet! You need to be in the right place. Scientists will continue to work to identify where the conditions might be right for life, as we understand it, on Mars.

In 2011, a new NASA study suggested that if life ever existed on Mars, the longest lasting habitats for life were most likely below the surface. A new interpretation of years of mineral-mapping data suggests martian environments with abundant liquid water on the surface existed only during short episodes. These episodes occurred toward the end of hundreds of millions of years during which warm water interacted with subsurface rocks. This has implications about whether life existed on Mars and how its atmosphere has changed.

While the types of clay minerals that formed just below the surface are all over Mars, the types that formed on the surface are present only in very limited locations and are quite rare. The discovery of clay minerals on Mars in 2005 indicated the planet once hosted warm, wet conditions. If those conditions existed on the surface for a long period of time, the planet would have needed a much thicker atmosphere than it has now to keep the water from evaporating or freezing. Researchers have sought evidence of processes that could cause a thick atmosphere to be lost over time.

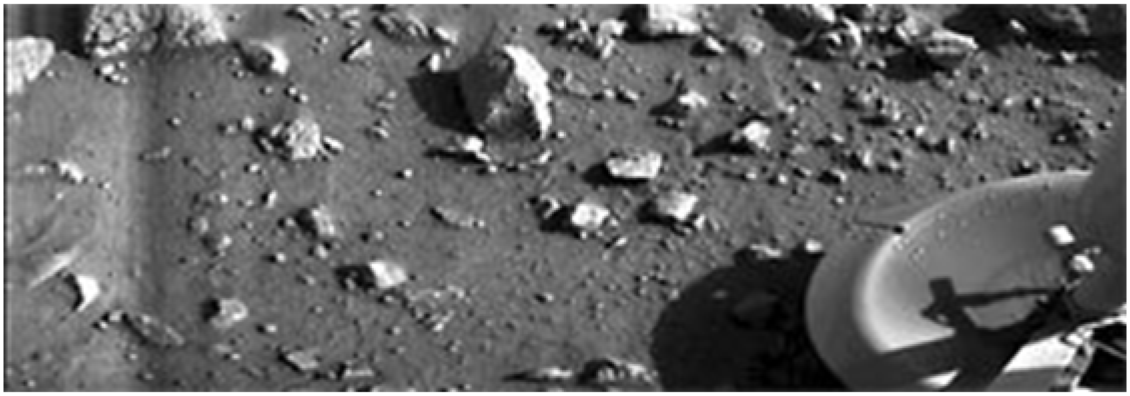
These new findings support an alternative hypothesis that persistent warm water was confined to the subsurface and many erosional features were carved during brief periods when liquid water was stable at the surface.

“If surface habitats were short-term, that doesn’t mean we should be glum about prospects for life on Mars, but it says something about what type of environment we might want to look in,” said Bethany Ehlmann, assistant professor (and lead author of the 2011 report) at the California Institute of Technology and scientist at NASA’s Jet Propulsion Laboratory in Pasadena.

One of the exceptions may be Gale Crater, the site targeted by NASA’s Mars Science Laboratory mission. Launched on November 26, 2011, the Curiosity rover landed safely and began investigating rock layers that contain clay and sulfate minerals starting in August 2012!

Missions to Mars: The Search for Signs of Life — Past and Present

While missions to Mars have faced significant adversity and setbacks at times, NASA has successfully conducted both orbital and lander missions to the Red Planet. The first successful missions, Mariner 4, 6, 7, and 9, launched over the course of the 1960s and early 1970s, were the first spacecraft to acquire and return close range images of Mars. These missions were also the first to take measurements of the martian magnetic field, cosmic dust and cosmic rays, and the solar wind. Building upon the Mariner program, NASA has continued to explore Mars through several successful missions.



This image, taken by the Viking 1 lander shortly after it touched down on Mars on July 20, 1976, is the first photograph ever taken from the surface of Mars. Credit: NASA.

In the 1960s, while the Mariner missions were under way, a group of NASA scientists, engineers, and technicians came together to design and create an ambitious robotic mission to Mars. They named this mission Viking in honor of the fearless Nordic explorers of Earth. The Viking mission was composed of four spacecraft (two orbiters and two landers) whose primary objectives were the following:
Obtain high-resolution images of the martian surface
Characterize the structure and composition of the atmosphere and surface
Search for evidence of life on Mars

Of these objectives, the principal reason for the mission was to look for evidence of life. The landers dug soil samples from the frozen surface and looked for signs of respiration — an indication of biological activity. Although the initial results were thought promising, Viking found no conclusive signs of life. However, it is important to note that these experiments were not very sensitive by modern standards. In fact, more recent discoveries by the Mars Phoenix Lander in 2008 have called into question the original conclusions that the Viking landers did not discover any organic compounds. Results of experiments from Phoenix suggest that soil examined by the Viking landers in 1976 may have contained carbon-based chemical building blocks of life. For more information about Mars Phoenix Lander, visit
www.nasa.gov/mission_pages/phoenix/main/index.html.

Following the successes — and disappointments (no confirmed life) — of the Viking mission, NASA's Mars Exploration program sent a series of missions to explore the surface features and history of Mars as well as its geology and water, but these missions did not search for signs of life. These missions did serve an important role in helping scientists to characterize the environment on Mars and to identify promising locations for future scientific studies.

Mars Exploration Rovers: Spirit and Opportunity
Launched in mid-2003, the Mars Exploration Rovers, named Spirit and Opportunity, landed on the Red Planet in January 2004 as a part of three-month missions to look for signs of past water activity on Mars. However, both rovers far exceeded their mission

goals and expectations, making important discoveries about wet environments on Mars in the past and possibly at the present. NASA ground controllers lost communication with Spirit in March 2010; after repeated unsuccessful attempts to awaken the rover, NASA sadly declared that Spirit was dead in May 2011. Opportunity, on the other hand, is still going strong (as of 2012) and has logged more than 20 miles (32 kilometers) on the Red Planet!

An artist's representation of the MER rovers, Spirit and Opportunity. Credit: NASA/JPL-Caltech.

For more information about the Mars Exploration Rovers, visit www.nasa.gov/rovers and marsrovers.jpl.nasa.gov.

The latest mission to Mars, Mars Science Laboratory (MSL), is looking for the precursors (building blocks) of life and evidence of past habitable environments, but not for life itself. MSL's Curiosity rover will study rocks, soils, and the local geologic setting in order to detect chemical building blocks of life (e.g., forms of carbon) on Mars and will assess what the martian environment was like in the past. For more information about MSL, visit marsprogram.jpl.nasa.gov/msl/.

Lessons learned from Viking technology have blazed the trail for Mars research. *Scientists stand in the midst of three generations of NASA's Mars rovers (Pathfinder's Sojourner, MER's Opportunity/Spirit, and MSL's Curiosity). Curiosity is the largest and most technologically advanced rover to date. Credit: NASA.*

The Next Generation: Mars Science Laboratory

The Mars Science Laboratory rover, Curiosity, is continuing the exploration of Mars and is specifically searching for signs that habitable environments existed on Mars in the past. Within its first 40 days on the Red Planet, Curiosity had already uncovered evidence of a stream that once ran vigorously across the area on Mars where the rover was driving. Previous missions provided earlier evidence for the presence of water on Mars, but this evidence — images of rocks containing ancient streambed gravels — was the first of its kind.

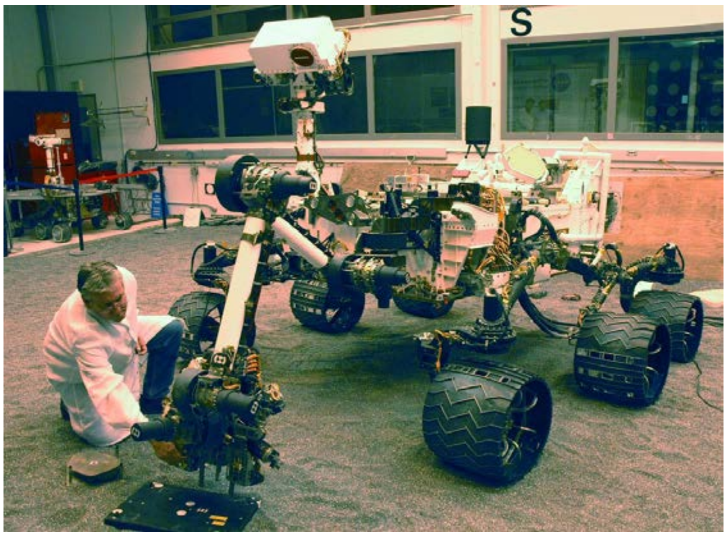
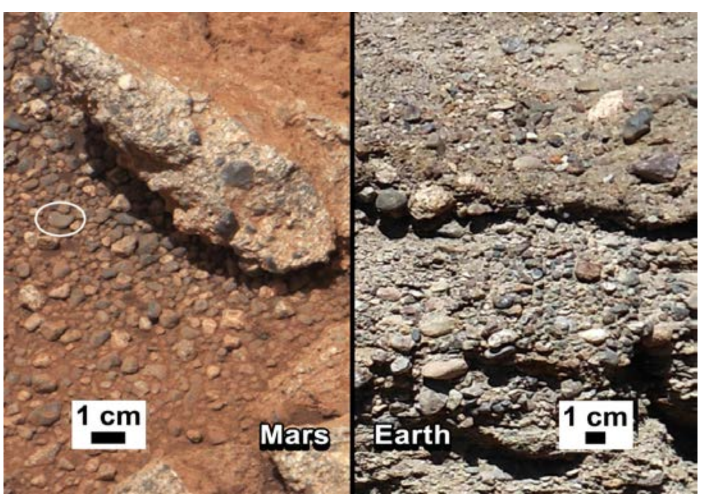


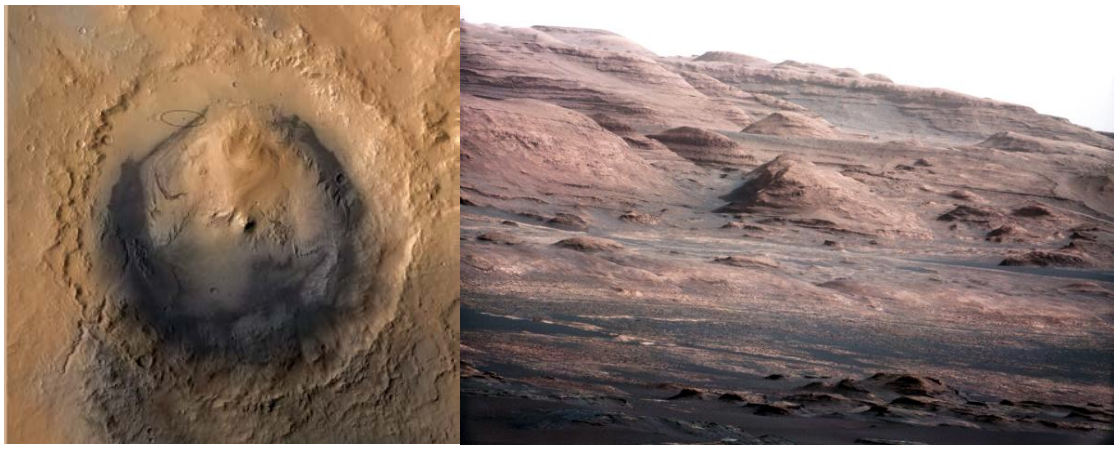
Image of the MSL "Curiosity" rover. Credit: NASA/JPL-Caltech.

Scientists are studying the images from the Curiosity rover of stones cemented into a layer of conglomerate rock. The sizes and shapes of stones offer clues to the speed and distance of a long-ago stream's flow. This was the first time scientists were actually seeing water-transported gravel on Mars, and was a transition from speculation about the size of streambed material to direct observation of it.



This set of images compares the "Link" outcrop of rocks on Mars (left) with similar rocks seen on Earth (right). The image of "Link," obtained by NASA's Curiosity rover, shows rounded gravel fragments up to a couple inches (few centimeters), within the rock outcrop. Credit: NASA/JPL-Caltech.

The “Link” finding site lies between the north rim of Gale Crater and the base of Mount Sharp, a mountain inside the crater. Earlier imaging of the region from Mars orbit allows for additional interpretation of the gravel-bearing conglomerate. The imagery shows an alluvial fan of material washed down from the rim, streaked by many apparent channels, sitting uphill of the new finds.



This view of Gale Crater (on the left) is derived from a combination of data from three Mars orbiters. The view is looking straight down on the crater from orbit. Gale Crater is 96 miles (154 kilometers) in diameter. Mount Sharp (closeup image on the right) rises about 3.4 miles (5.5 kilometers) above the floor of Gale Crater. Credit: NASA/JPL-Caltech.

For more information about the history of NASA Mars Exploration, please refer to the following: WhyMars.pdf

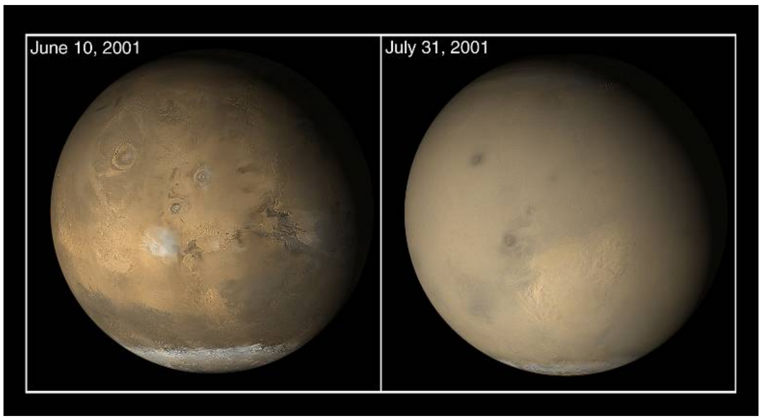
A Little More About Mars

The martian day, the time it takes Mars to spin once on its axis, is 24 hours and 40 minutes long, very similar in length to Earth’s day. Its year is almost twice as long as Earth’s, however. It takes Mars 687 Earth days to orbit the Sun. That path around the Sun is slightly more elliptical than Earth’s, and the Sun is not exactly in the center of its orbital path.

Like Earth, Mars is tilted on its axis. This tilt, combined with the elliptical orbit, contributes to seasons on Mars. Because Mars is closer to the Sun during its southern hemisphere summer, the summer in that hemisphere is warmer than the summer in the northern hemisphere.

Mar’s surface is cold — a warm summer day might reach 27°C (80.6°F), and winter at the poles can be as cold as –125°C (–193°F) — and its atmosphere is very thin. The atmospheric pressure at the surface of the planet is about 1/100th of that of Earth’s. Mars’ atmosphere is mostly carbon dioxide (95%), with significant nitrogen (3%) and argon (2%) and trace amounts of other gases, such as oxygen (<0.15%). In contrast, Earth’s atmosphere is much thicker and is mostly nitrogen (77%) and oxygen (21%). The thin martian atmosphere offers little protection from dangerous ultraviolet light and radiation (subatomic particles) from the Sun; unlike Earth, Mars does not have an ozone layer to protect the surface from solar ultraviolet radiation.

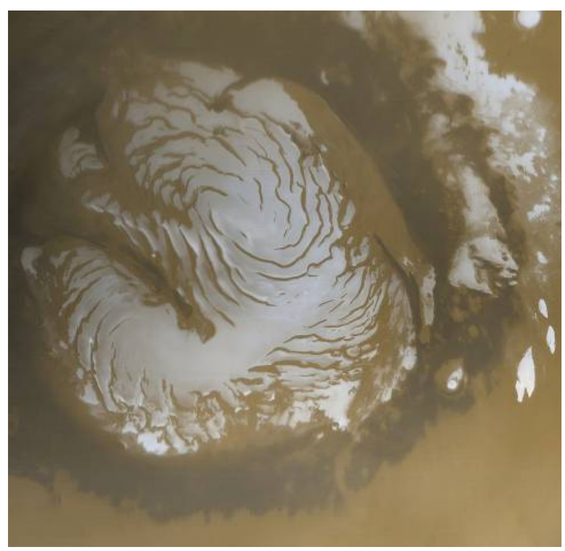
Mars has massive dust storms that can cover the entire planet! Wind speeds can reach 100 kilometers per hour (62 miles per hour), stirring up the fine red dust. The martian atmosphere always contains some of this reddish dust, so that the martian sky is not blue like Earth's but reddish-pink instead.



A dust storm obscures the surface features on Mars.
Credit: NASA/JPL/Malin Space Science Systems.
www.msss.com/mars_images/moc/E01_E06_sampler2002/dust/2001duststorms50.jpg

The martian atmosphere contains much less water vapor than Earth, making clouds a rarity — but not unheard of (especially near the poles) — on Mars. There is no liquid water present at the surface. There may be frozen water in the ground, and Mars has ice caps in its polar regions that are mixtures of carbon dioxide ice (dry ice) and water ice.

Northern ice cap of Mars. The polar cap is about 1100 kilometers (700 miles) across.
Credit: NASA.
ai.jpl.nasa.gov/public/home/chien/spring–agu–images/MLS/Mars_Ice_Cap.jpg



Mars is about half the size of Earth. Because it has less mass, it has a smaller gravitational attraction. Surface gravity on Mars is less than 40% of Earth's. If you weighed 100 pounds (45 kilograms) on Earth, you would weigh 38 pounds (17 kilograms) on Mars.

Shopping List

The following is an abbreviated list of the materials required for the *Life on Mars?* module of activities. Refer to the materials section of each activity for details, such as possible substitutions, suggestions for books and websites, printing recommendations, and other notes. Many of the materials are repurposed items, such as empty, cleaned 2-liter bottles; consider gathering donations from your community.

Ice Breaker Activity: Is it Alive?

For each child:
1 printer label with “living” or “nonliving” listed on it (standard mailing labels)
1 pencil/pen
optional: 2–3 markers

For the facilitator:
Brief Facilitation Outline page
background information
1–2 permanent markers
an area where the children can move around
Post-it® pads (3" × 3" or 4" × 4") or index cards
optional: 1 cardboard box (approximately 12"W × 18"L × 12"H)
optional: a variety of props and pictures representing characteristics of living things
Fake food, mom and baby stuffed animals/dolls, etc.
There are many possibilities here, so use your imagination! Use items to represent the children’s ideas.

Activity 1: Searching for Life

For each pair of children:
3 clean plastic cups (5–8 oz.), clear if available
enough sand to fill all the cups ¼ full
3 teaspoons sugar, evenly divided between the cups
1 teaspoon instant active dry yeast
1 tablet of crushed (as finely as possible) Alka-Seltzer® or comparable fizzing tablets
hot water (105°–115°) F to cover the sand in each cup (not hot enough to kill the yeast)
1 pitcher/carafe/other appropriate container for hot water
optional: library books related to the topic
optional: variety of colorful Post-It® notes

For each child:
1 pencil/pen
1 copy of the *Extreme-O-File: Searching for Life* activity pages

For the facilitator:
Brief Facilitation Outline page
background information
flip chart, white board, or blackboard and appropriate writing utensils
permanent marker for writing on the cups
thermometer
container (large mug, cup, or pitcher) of water to fill all the cups to cover the sand
optional: article on defining life: www.astrobio.net/exclusive/226/defining-life

Activity 2: Mars by the Book

For the group:
markers or colored pencils
1 large piece of poster paper or butcher paper
1 red balloon
1 blue balloon
1 piece of blue string or yarn 25 inches long
1 piece of red string 13 inches long
3-4 packages of sticky dots (small round labels)
selection of nonfiction books about Mars
1 copy of the *Earth Fact sheet* (per child)
optional: whiteboard or poster paper and markers or chalkboard and chalk to record the children's ideas

For each child:
1 pencil/pen
1–2 pieces of paper

For the facilitator:
Brief Facilitation Outline page
background information
1 copy of the *Earth-Mars Comparison Fact Sheet*
1 black permanent marker (fine tip)

Activity 3: Nurturing Life

For each group of 3–4 children:
selection of books about gardening, life in the universe (astrobiology), and extremophiles

For each large group (maximum of 15 per facilitator):
2–3 pitchers or watering cans (watering hose if outside, to be controlled by an adult)
1 set of the NAI Extremophile Trading Cards

<u>Garden Option #1: Outdoors Garden (select one or more of each plant)</u>
select a garden plan appropriate for your geographic region
purchase plants/seeds appropriate for your geographic region
3–5 hand trowels/shovels

<u>Garden Option #2: Indoor Container Garden</u>
select plants/seeds appropriate for your geographic region
purchase plants/seeds appropriate for your needs (light conditions, watering, etc.)
2–4, 1 cup-sized measuring cups or 8-oz. plastic cups for scooping dirt/sand/rock
1 (0.5 cubic foot or larger) bag of gravel or pea rock for the bottoms of containers
containers (pots or long window containers)
soil, enough to fill your containers to approximately ½ inch below the rim
for Xeriscaping (optional): use a sandy mix, as described in the "Preparation" section or a "Succulent and Cactus" mix

For each child:
1 pencil/pen
1 pair of scissors

1 set of the Explore: Life on Mars? Trading Cards and Scientist Spotlight pages

<u>Garden Option #3: Take-Home Garden (per child)</u>
select and purchase seeds/plants
optional: rooting hormone powder or gel (available at most garden centers or department stores with garden centers)
**Note: This is needed only if you plan to use jade or other plant cuttings.*
½ cup to ¾ cup of gravel or pea rock for the bottoms of containers
1 clean, empty 1-liter or 20-oz. plastic bottles (no lids/caps)
2 cups of soil
½ cup of water
duct tape (in fun colors, if possible), approximately 4–6 inches per child
1 plant care label/card, including plant name, lighting, temperature, and watering/feeding requirements
optional: copy of the *Extreme-O-File: Nurturing Life* activity pages

For the facilitator:
Brief Facilitation Outline page
background information
1 large poster (22" × 28" or larger)
3 packs of washable markers (a variety of colors)

an outdoor garden area approximately 4' × 4' or larger
OR
an indoor area near a window (that is sunny for at least half of each day and at least 3' long or longer)

an area indoors where the children can move around and interact with each other
1 whiteboard or poster paper
3–5 Markers
3–5 Post-It® pads (or colored paper)
NASA online video clips
Optional (highly recommended): computer, projector, and access to the Internet
optional: extra copies of the *Extreme-O-File* activity pages, Trading Cards, and/or resource pages for this activity (for the extension poster)

Activity 4a: Mars from Above — Mars Match

For each Earth/Mars Team of 3–4 children:
1 set of Mars Cards (cut)
1 set of full page print outs of Earth Image Placemats, printed on cardstock if available
optional: sheet protectors for the images or lamination pages

For each child:
1 pencil or pen
optional: clipboard
optional: 1 set of *Extreme-O-Files: Mars from Above* activity pages

For the facilitator:
Brief Facilitation Outline page
background information
1 flashlight
1 empty soup bowl
1 copy of the *Mars Match Image Descriptions*

Activity 4b: Mars from Above — Caring Channels

For each station (serving ~10 children):
About 10 pounds of clean playground sand
4–5 rocks (2" diameter or less)
4–6 (2-liter) bottles, without lids, filled with water
access to water to refill the bottles as needed
2 plastic wallpaper trays or other long narrow plastic container such as plastic window planter boxes
4 standard bricks (foam floral/craft bricks if desired)
2 (5-gallon or larger) trash cans or buckets
2 large trash bags to line the buckets or trash cans
1 set of full-page Earth Image Placemats (stream channel images only)
1 set of Mars Cards (channel images only)
Optional (recommended): 5 pounds of pesticide- free diatomaceous earth
*Note: Aids in creating well-defined channels
optional: 1–2, 24-oz. bottles of craft stand, any color (readily available at hobby or department stores)

For each child:
1 pencil or pen
optional: 1 set of *Extreme-O-File: Mars from Above* activity pages
optional: clipboard
optional: 1 set of *Life on Mars? Trading Cards*

For the facilitator:
Brief Facilitation Outline page
background information
scissors or other tool to poke holes though thin plastic trays

Activity 4c: Mars from Above — Viewing Volcanos

For each station (serving 4–6 children):
2–3 rolls of Scotch® tape
1 small bottle of white vinegar
1, 1-cup measuring cup
1 tablespoon (for measuring vinegar)
1 small box of baking soda (16 oz.)
4 plastic spoons (for measuring/scooping baking soda)
1 roll of paper towels
1 plastic tablecloth (to cover and protect the table)
1 garbage can (lined)
1 set of full-page *Earth Image Placemats* (volcano images only) from Mars Match activity
1 set of *Mars Cards* (volcano images only) from the Mars Match activity
optional: laminating pages or page protectors for the volcano images

For each child:
1 pencil/pen

Materials for a volcano:
1 heavy-duty paper plate
1 piece of aluminum foil approximately 18" long
1 small paper cup (4 oz. or smaller)
optional: 1 cookie sheet or other shallow pan
optional: 1 set of *Extreme-O-File: Mars from Above* activity pages
optional: clipboard

For an audience of 15–20 to share:
1 (8½" × 11") *Be Creative…Be an Engineer!* poster
A selection of adhesives:
3 or more rolls of masking tape
3 packages of putty adhesive, such as Sticky Tack
1 (½" size, 200 count) roll of Glue Dots®

For the facilitator:
Brief Facilitation Outline page
background information
1 empty soup bowl
1 flashlight

Activity 5: Protecting Life — The Martian Challenge

For the group:
A selection of **nonfiction** books about extremophiles and life in the universe

For each child:
1 pen or pencil
scissors
tape and/or glue
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 *Scientist Spotlight* pages
optional: 1 hair dryer

Activity Part 1:
3 UV beads
2 non-UV beads
2 pipe cleaners
various craft items for constructing a creature, such as Styrofoam balls, felt, foil, 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 this 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

For the facilitator:
Brief Facilitation Outline page
background information
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

Activity 6: Mars Engineering

For each 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)

<u>Materials for building a model rover</u>: 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, empty DVD cases, black plastic or biodegradable seedling (plant) trays, empty egg cartons, cereal boxes, 2-liter 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:
1 pencil
1 copy of the *Curiosity Tools Schematic*, preferably in color
optional: *Extreme-O-File: Mars Engineering* activity pages

For the facilitator:
Brief Facilitation Outline page
background information
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

Activity 7: Mars Imaginings — The Story

For the group:
1 whiteboard, large sheet of butcher paper, or poster paper
Markers or chalkboard and chalk to record the children's ideas
computer/TV/projector to show brief sci-fi video clips
staplers (one per 4–6 children)
selection of **science fiction** books about Mars
optional: selection of **nonfiction** books about Mars
optional: video camera to record the group movie trailer

For each child:
1 pencil/pen
1 *Zine template* and folding instructions
art supplies, such as colored pencils, crayons, and markers
optional (Extension): 1 release form for the parent or guardian to sign (if the "movie trailer" is to be filmed)
optional: copies of the *Extreme-O-File: The Story* activity pages
optional: 1 set of the *Life on Mars? Trading Cards*

For the facilitator:
Brief Facilitation Outline page
background information
2–3 markers or chalkboard and chalk to record the children's ideas
1 computer/TV/projector to show brief sci-fi video clips
connection to the Internet

Activity 8: Live Tonight — The Planets!

For each group of approximately 20 visitors to share:
1 telescope operated by an amateur astronomer
1 or more small stepstools for children to stand on to reach high telescope eyepieces
optional: 1 pair of binoculars
optional: 1 camera tripod and binocular adapter
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 about Mars, space exploration, life in the solar system, extremophiles

For each child:
1 pencil/pen
1 sheet of paper
optional: 1 Mars Lithograph (NASA educational product number LG-2009-09-569-HQ)
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)
optional: materials to complete the *Searching for Life* soil experiment

For the facilitator:
Brief Facilitation Outline page
background information
1 copy of *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

Extended Supporting Media Suggestions

Be sure to connect with scientists and engineers and space enthusiasts in your own region! Don't be shy — many of these individuals are more than happy to visit your program and share their knowledge!

Sky and Telescope
www.skyandtelescope.com/community/organizations
Find the contact information for **museums, science centers, planetariums, observatories, and astronomical societies** in your neighborhood using Sky & Telescope's search tool.

Solar System Ambassadors
www2.jpl.nasa.gov/ambassador/directory.htm
Locate a **Solar System Ambassador** in your area. The Solar System Ambassadors program, directed by the Jet Propulsion Laboratory, trains space enthusiasts to share the latest mission and space science information with their communities.

NASA's Space Grant Program
calspace.ucsd.edu/spacegrant/webmap/sg_homepages.html
Contact scientists and engineers involved in space sciences through **your state's NASA's Space Grant Program.** Share your needs with the Space Grant Outreach Coordinator or, if you can't find the right person to contact, communicate with the program director.

Great Online Listening and Viewing Resources

These 90-second broadcasts from Earth and Sky are great ways to start conversations with children and adults as you begin your program.

100 Days on Mars: Broadcast and seven-minute interview of scientists who simulated the experience of living in an isolated, martian-like environment, and did science in space suits.
www.earthsky.org/clear-voices/51837/kim-binstead

Did Early Life Originate on Mars?
www.earthsky.org/radioshows/49043/did-earthly-life-originate-on-mars

What Do the Two Martian Moons — Phobos and Deimos — Look Like from the Surface of Mars?
www.earthsky.org/radioshows/45283/phobos-and-deimos

Kids Earth and Sky: What would happen to an apple on the surface of Mars?

www.earthsky.org/radioshows/46183/mars-apple

These podcasts and short videos from NASA's Jet Propulsion Laboratory are great ways to start conversations with children and adults as you begin your program.

> **Mars in a Minute: How Do You Get to Mars?**
> mars.jpl.nasa.gov/msl/multimedia/videos/index.cfm?v=32
>
> **Mars in a Minute: Is Mars Really Red?**
> www.jpl.nasa.gov/video/index.cfm?id=1033

Curiosity Rover Trailer — An animation showing the major mission events of the Curiosity rover's landing on Mars.
mars.jpl.nasa.gov/msl/multimedia/videos/index.cfm?v=2

The Challenges of Getting to Mars: Launching a Mars Rover — A video of the Mars Science Laboratory spacecraft launch from Cape Canaveral, Florida, on November 26, 2011, onboard an Atlas V rocket.
mars.jpl.nasa.gov/msl/multimedia/videos/index.cfm?v=38

Mars Mission Begins Collecting Data While Still Near Earth — The Radiation Assessment Detector on NASA's Mars Science Laboratory has begun collecting data that will aid planning of future human missions to Mars.
mars.jpl.nasa.gov/msl/multimedia/videos/index.cfm?v=35

Related 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. This is appropriate for ages 8–11.

Archaea: Salt-Lovers, Methane-Makers, Thermophiles, and Other Archaeans
David M. Barker, Crabtree Publishing Company, 2010, ISBN 0778753875
Some Archaea thrive in extreme places around the planet such as in thermal pools, hot vents at the bottom of the sea, extremely salty water, and even in underground oil reserves. This book examines the three main divisions into which members of the diverse Archaea kingdom are grouped according to their unusual biology. It also explains why little in general is known about them, and why further classification of Archaea is so difficult. For ages 10 and up.

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. This book brings to life a subject that children are intrigued by.For ages 10 and up.

Are We Moving to Mars?
Anne E. Schraff, John Muir Publications, 1996, ISBN 1562613103
Different ideas about colonizing Mars are presented for ages 8–9.

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 ages 10 and up.

Astrobiology (Cool Science)
Fred Bortz, Lerner Publications, 2007, ISBN 0822567717
This book discusses the meaning of astrobiology and its beginnings. It's great for ages 12 and up.

Astronaut Travel Guides
Chris Oxlade, Heiiinemann-Raintree, 2012, ISBN 1410945790
This series takes readers on an imaginary trip through the universe. Nicely paced conversational texts deliver full descriptions about "What's Out There?" and instructions for how to prepare for the journey, including how to train and what to bring. The history of previous exploratory ventures is detailed, and information about what space scientists hope to discover in the future is covered. For ages 9–12.

Cars on Mars: Roving the Red Planet
Alexandra Siy, Charlesbridge Publishing, 2011, ISBN 1570914621
Readers can follow the course of NASAs Mars Exploration Rover (MER) mission as twin rovers, Spirit and Opportunity, explore the Red Planet. Learn how scientists determined that there was once water on Mars and how the Earthbound NASA team resolved problems with the rovers from afar in order to prolong the mission, which continues today. Back matter includes glossary, source notes, and resources. For ages 10 and up.

Complete Guide to Mars Science Laboratory
World Space Flight News and NASA, Progressive Management, 2011, ASIN: B0068XQPQQ
Comprehensive coverage of all aspects of NASA's Mars Science Laboratory (MSL) and its Curiosity rover, which launched on an Atlas rocket in late November 2011, is provided in this unique compilation of official NASA material. There is complete data on the MSL mission, science investigations, historical Mars missions, the Gale Crater

landing site, the radioisotope nuclear power source and nuclear safety issues surrounding its use — including radiological contingency planning and launch hazards — and much more. For ages 16 and up.

Destination: Mars
Seymour Simon. Harper Trophy; Reprint edition, 2004. ISBN-10: 0060546387
This book includes new pictures from the Mars Orbiter Camera, the Hubble Space Telescope, and the Pathfinder lander. It also reflects NASA missions that gathered information about Mars in the late 1990s. Appropriate for ages 4–8.

Evolving Planet: Four Billion Years of Life on Earth
Erica Kelly, Abrams Books for Young Readers, 2008, ISBN 0810994860
From single-celled organisms, to dinosaurs, to mammals, and finally to humans, *Evolving Planet* traces the path of life that has been constantly evolving. The book provides an overview of Earth's amazing diversity of life, both in the seas and oceans as well as on the land, and reveals its variety and uniqueness throughout the ages. Readers will be able to see the whole history in perspective in this fascinating volume. The book includes a glossary, a pronunciation key, a bibliography, and an index.For ages 8 and up.

Exploring Mars
David Ward, Lerner Publications. 2006, ISBN-10: 0822559366
Children ages 9–12 will learn all about Mars with this exciting book. The topics include an introduction to Mars and its moons, past missions to Mars, future missions to Mars, the possibility of water on Mars, and the possibility of people living on Mars! It also includes additional reading suggestions and websites.

Exploration of Mars (Fast Forward)
Mark Bergin, Franklin Watts. 2000, ISBN-10: 0531148076
What will humans need to survive on the Red Planet? Children ages 9–12 learn about past, present, and future missions and the possibility of future human colonies.

Exploring Planet Mars (Humans in Space)
David Jefferis, Crabtree Children's Books, 2007, ISBN-10: 0778731146
How will we get to Mars? This book, for children ages 9–12, examines flight to Mars and the features of the planet.

From Lava to Life: The Universe Tells Our Earth Story
Jennifer Morgan, Dawn Publications, 2003, ISBN 1584690429
This book begins with the first appearance of life on Earth. It's a thrilling story about how Earth triumphs over crisis to become bacteria, jellyfish, flowers . . . even dinosaurs! For ages 8 and up.

How to Live on Mars
Clive Gifford, Franklin Watts, 2000, ISBN-10: 053116201X
What would it be like to live on Mars? How long will it take to get there? What might we learn? Children ages 9–12 explore these questions as they learn *How to Live on Mars*.

Is There Life in Outer Space? (Isaac Asimov's 21st Century Library of the Universe)
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 ages 8 and up.

Is There Life on Mars?
Dennis Brindell Fradin and Margaret K. McElderry, 1999, ISBN-10: 0689820488
Children, ages 9–12, explore Mars and how humans of different cultures have regarded it through time.

Is There Life on Other Planets?
Asimov Isaac, Gareth Stevens Publishing, 1989, ISBN 1-55532-359-6
The author covers the basic concepts from life on Earth, life in our solar system, and life in extreme environments. Appropriate for ages 6–10.

Life in Outer Space
McDonald Kim, 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 kids ages 7–12.

Life in Space
Helen Orme, Ransom Publishing, 2009, ISBN 184167690X
Is our planet Earth the only place in the universe where there is life? Or 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? The story appears in two formats: one with simple texts for poor or reluctant readers; the other with an illustrated "speech bubble" version for those who are just starting to read. For ages 10 and up.

Life on Earth: The Story of Evolution
Steve Jenkins, Houghton Mifflin Books for Children, 2002, ISBN 0618164766
Author Steve Jenkins explores the fascinating history of life on Earth and the awe-inspiring story of evolution, Charles Darwin's great contribution to modern science. For ages 7 and up.

Life on Earth — and Beyond: An Astrobiologist's Quest
Pamela Turner, Charlesbridge Publishing, 2008, ISBN 1580891349
NASA astrobiologist Dr. Christopher McKay has searched Earth's most extreme environments in his quest to understand what factors are necessary to sustain life.

Behind-the-scenes photos capture McKay, his expeditions, and the amazing microbes that survive against all odds. For ages 10 and up.

Life on Mars

David Getz, Henry Holt and Co. (BYR); Revised edition 2004. ISBN-10: 0805077294
This book for 9–12-year-olds begins with an imaginary space flight from Earth to Mars. Getz shows how our knowledge of Mars has changed over time, relates the findings of the Viking landers, considers what scientists think is necessary for life, and discusses how Mars might be terraformed into a planet hospitable for human life.

Life on the Edge

Cherie Winner, Lerner Publications, 2005, ISBN 0822524996
All extreme organisms, or extremophiles, have one common trait: They can survive in conditions that would kill almost every other creature on the planet. From thermal pools in Yellowstone National Park to an icy ledge in Antarctica, this book explores extreme locations and uncovers some of the most fascinating creatures in the world. For 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 ages 9–14.

Mars (Isaac Asimov's 21st Century Library of the Universe: Solar System)

Isaac Asimov, Prometheus Books, 2003, ISBN-10: 1591021243
A "Mars standard," this book for children ages 9–12 provides a good overview of the Red Planet.

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 ages 10–13.

Mars

Larry Dane Brimner, Children's Press (CT), 1999, ISBN-10: 0516264354
This book, great for ages 4–8, very simply describes how Mars was named. It discusses past, present, and future missions to Mars as well as why humans want to go to Mars.

Mars (DK Eyewitness Books)

DK Publishing, 2004, ISBN-10: 0756607655
Children ages 9–12 learn about the Red Planet, from its importance in early cultures, to past, present, and future exploration.

Mars (Galaxy)
Steven L. Kipp, Capstone Press, 2006, ISBN-10: 073688887X
NASA photographs help readers, ages 9–12, see the beauty of each planet and the Sun. Solar System diagrams help readers visualize the planet's place in space. Kipp examines surface features, atmosphere, exploration, and other aspects of the planet Mars.

Mars (Our Solar System)
Dana Meachen Rau, Compass Point Books, 2002, ISBN-10: 0756501997
Children ages 9–12 will enjoy this well-illustrated exploration of Mars, its orbit, structure, and missions that have — or will — visit. The author offers an extensive list of websites and books for further investigation.

Mars (Planets)
Darlene R. Stille, Child's World, 2003, ISBN-10: 1592960502
Mars simply introduces the planet Mars, its size, location, climate, characteristics, and satellites. This is a great beginner's book for ages 4–8.

Mars and the Search for Life
Elaine Scott, Clarion Books, 2008, ISBN 0618766952
Despite the fondest desires of science fiction fans, everyone knows Mars isn't inhabited by little green men. In fact, Mars is a desolate, hostile world, with unbearably cold temperatures, no atmosphere to speak of, and violent dust storms. But could there ever have been life there, in some form? And if so, what happened to it? For ages 9 and up.

Mars: The Mystery Unfolds
Peter John Cattermole, Oxford University Press, USA. 2001, ISBN-10: 0195217268
Scientific evidence from Mars indicates a very different planet from the one we know today. Rather than a cold, dry planet, the Mars of the past had rivers, lakes, glaciers, and huge active volcanos. Children ages 9–12 will enjoy learning about Mars and its history — including the history of exploration.

Mars — The Red Planet
Patricia Brennan Demuth, 1998, Grosset & Dunlap (October 26, 1998), ISBN 0448418436
Delve into our observations about the fourth planet from the Sun.

Mars Rover: Curiosity (A Picture Book)
Ben H, Amazon Digital Services, 2012, ASIN: B008X5Q4O0
Written for the author's 4-year-old, this book contains 11 pages of pictures and short sentences about the Mars rover Curiosity and its journey to Mars. For ages 4–6.

Max Goes to Mars: A Science Adventure with Max the Dog
Jeffrey Bennett, Big Kid Science, 2003, ISBN-10: 0972181911
Children ages 9–12 will enjoy following Max the Dog on the first human journey to Mars. Along the way, they will learn about this mysterious Red Planet and what scientists are discovering.

Messages from Mars
Loreen Leedy and Andrew Schuerger, Holiday House, 2006, ISBN-10: 0823419541
A team of future explorers travel to Mars and report back about the journey, Mars, and comparisons between Mars and Earth. For ages 7–9.

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 ages 9–12.

Mission to Mars (Let's-Read-and-Find-Out Science 2)
Franklyn M. Branley, HarperTrophy, 2002, ISBN-10: 0064452336
Children ages 4–8 will enjoy this exploration of what it would be like to live on Mars, from the challenges of the environment to the practicalities of supporting a colony. Imaginations are invited!

Planet Mars (See More Readers Level 1)
Seymour Simon, Chronicle Books, 2006, ISBN 0811854043
Young readers view photographs of Mars from the Spirit and Opportunity rovers and receive up-to-date information in an easy to read format. For ages 6–8.

The Mighty Mars Rovers: The Incredible Adventures of Spirit and Opportunity
Elizabeth Rusch, Houghton Mifflin, 2012, ISBN 054747881X
This book tells the greatest space robot adventure of all time through the eyes — and heart — of Steven Squyres, professor of astronomy at Cornell University and lead scientist on the mission. This suspenseful page-turner captures the hair-raising human emotions felt during the adventures with two tough rovers (Spirit and Opportunity). For ages 9 and up.

The New Book of Mars
Nigel Hawkes, Aladdin Books, 1998, ISBN 0761307311
Learn about what it takes to land on Mars, the geology and geography of the Red Planet, and some of the past and possible future missions to Mars.

The Search for Extraterrestrial Life
Don Nardo, Lucent Books, 2006, ISBN 1590188322
Scientists have long suspected that the human race is not alone in the universe. Although no direct evidence for extraterrestrial life has yet been found, a great deal of circumstantial evidence suggests that it will be found in the near future. This fascinating

volume explores the scientific probabilities of extraterrestrial life and current scientific efforts to find it.For ages 12 and up.

The Search for Life in Space
Clint Twist, Gareth Stevens Publishing, 2005, ISBN 0836845579
Where is the best place in space to look for life? How can we use light rays to find invisible planets? What methods should we use to contact other beings? *The Search for Life in Space* answers these questions and more as it introduces readers to the latest technologies used in extraterrestrial research. For ages 8 and up.

The Ultimate Mars Rover
David Eckold, DK Children, 2004, ISBN-10: 075660799X
This is a great game as well as a tool for learning for children ages 9–12. Players learn about Mars as they simulate a rover mission on the surface of the Red planet.

You Are the First Kid on Mars
Patrick O'Brien, Putnam Juvenile, 2009, ISBN 0399246347
Using the most up-to-date designs and theories of what it will take to establish a base on Mars, the reader is off on an incredible journey, over 35 million miles to the Red Planet. For ages 5 and up.

Science Fiction Related to Mars

Between Planets
Robert Heinlein, Baen, 2009 (reprint edition), ISBN 1439133212
Don Harvey was attending school on Earth when his parents suddenly and urgently called him home to Mars. He had been skeptical about the talk of interplanetary war breaking out if Mars and Venus followed through on their threats to declare independence from Earth, but he was wrong. War broke out, and he was stuck on Venus, with no way of getting home. When Earth troops landed on Venus and started looking for Don and that mysterious ring, he realized that he was trapped in the center of a war between worlds that could change the fate of the solar system forever! For ages 12 and up.

Comets, Stars, the Moon, and Mars: Space Poems and Paintings
Douglas Florian, Harcourt Children's Books, 2007, ISBN 0152053727
Blast off with Douglas Florian's new high-flying compendium, which features 20 whimsical poems about space. From the Moon to the stars, from the Earth to Mars, here is an exuberant celebration of our celestial surroundings that's certain to become a universal favorite among aspiring astronomers everywhere. This book includes die-cut pages and a glossary of space terms. For ages 5 and up.

Life on Mars: Tales from the New Frontier
Jonathan Strahan, Viking Juvenile, 2011, ISBN 0670012165
Mars! The Red Planet! For generations, people have wondered what it would be like to travel to and live there. That curiosity has inspired some of the most durable science fiction, including Ray Bradbury's *The Martian Chronicles* and the work of Isaac Asimov. Now the award-winning anthologist Jonathan Strahan has brought together 13 original stories to explore the possibilities. After reading *Life on Mars*, readers will never look at the fourth planet from the Sun the same way again. For ages 11 and up.

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

Marooned! (Mars Year One)
Brad Strickland and Thomas Fuller, Aladdin, 2004, ISBN 0689864000
The year is 2085, and a new teen has arrived at Mars Experimental Station One, a colony built to test humans' ability to live self-sufficiently in an alien and hostile environment. Already in existence for 10 years, "Marsport" is a functioning city of 2000 people — with only 20 teenagers. These teens, part of the controversial Asimov Project, were hand selected from the billions on Earth and are always under the watchful eyes of the adults. Mars offers them something Earth never could. When the existence of Marsport is suddenly threatened, the group must overcome their fears and join forces, for their survival depends on nothing less. For ages 8 and up.

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

Out of the Silent Planet
C. S. Lewis, Scribner, 2003, ISBN 0743234901
Out of the Silent Planet begins the adventures of the remarkable Dr. Ransom. He is abducted by a megalomaniacal physicist and his accomplice and taken via spaceship to the Red Planet of Malacandra. Once on the planet, however, Ransom eludes his captors, risking his life and his chances of returning to Earth, becoming a stranger in a land that is enchanting in its difference from Earth and instructive in its similarity. First published in 1943. For ages 9 and up.

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

Red Planet
Robert Heinlein, Del Rey, 2006 (reprint edition), ISBN 0345493184
Jim Marlow and his strange-looking martian friend Willis were allowed to travel only so far. But one day Willis unwittingly tuned into a treacherous plot that threatened all the colonists on Mars, and it set Jim off on a terrifying adventure that could save — or destroy — them all! For ages 12 and up.

Ricky Ricotta's Mighty Robot vs. The Mecha-Monkeys from Mars
Dav Pilkey, Scholastic, Inc., 2002, ISBN 0439252962
Ricky Ricotta and his Mighty Robot are in big trouble. After crashing the Ricotta family minivan while using it as a skateboard (it's the only thing big enough for Robot), they have to earn some money quickly to pay for repairs. While they're thinking how on EARTH they are going to come up with the money . . on Mars . . . mean Major Monkey is making plans to enslave mousekind! Major Monkey has had his eye on Earth for some time now . . . and knows that the first thing he must do is get rid of that robot. Major Monkey tricks the robot into going to Mars. Now it's up to Ricky to rescue his robot and keep Major Monkey from menacing mankind. For ages 4 and up.

Robot Wars
Sigmund Brouwer, Tyndale House Publishers, 2009, ISBN 1414323093
Set in an experimental community on Mars in the year 2039, The *Robot Wars* series features 14-year-old virtual reality specialist Tyce Sanders. Life on the Red Planet is not always easy, but it is definitely exciting. Robot Wars is a repackaged and updated version of *Mars Diaries*. There are now five books in the series; each book contains two stories. These new books contain a foreword about how far science has brought us. For ages 10 and up.

The Brave Little Toaster Goes to Mars
Thomas M. Disch, Doubleday, 1988, ISBN 0385241623
A group of angry appliances, having fled to Mars to avoid becoming obsolete, now plan to take over Earth, unless the Brave Little Toaster can stop the invasion. For ages 10 and up.

The Day the Martians Came
Frederick Pohl, St. Martin's Paperbacks, 1989, ISBN 0312917813
Henry Steegman is hardly "Mr. Personality" onboard the Mars-bound Algonquin 9. Yet it is he who bungles upon the spectacular Macy's-like city beneath the Red Planet's crust. For better or worse, the name Steegman will be immortalized by a discovery that will transform millions of lives. For ages 12 and up.

The Green Book
Jill Patton Walsh, Square Fish, 2012, ISBN 0312641222
Pattie and her family are among the last refugees to flee a dying Earth in an old spaceship. And when the group finally lands on the distant planet that is to be their new home, it seems that the four-year journey has been a success. But as they begin to settle this shiny new world, they discover that the colony is in serious jeopardy. Nothing on this planet is edible, and they may not be able to grow food. With supplies dwindling, Pattie and her sister decide to take the one chance that might make life possible on Shine. For ages 8 and up.

The Martian Chronicles
Ray Bradbury, Doubleday, 2001, ISBN 096501746X
Bradbury's Mars is a place of hope, dreams, and metaphor — of crystal pillars and fossil seas — where a fine dust settles on the great, empty cities of a silently destroyed civilization. The Earthman conquers Mars . . . and then is conquered by it, lulled by dangerous lies of comfort and familiarity, and enchanted by the lingering glamour of an ancient, mysterious native race. For ages 12 and up.

There's Nothing to Do on Mars (Picture Book)
Chris Gall, Little, Brown Books for Young Readers, Hachette Book Group, 2008, ISBN 0316166847
When Davey Martin's family moves to Mars, he discovers that there's nothing to do — at least until he and his robot dog Polaris learn to seize the spirit of adventure. It's not until they've zipped around the planet on his flying scooter — climbing martian "trees," digging up "fossils," dancing in martian rain dances — that they discover a treasure that finally piques Davey's interest — a source of water on the Red Planet! For ages 5 and up.

The Worst-Case Scenario Ultimate Adventure #2: Mars! (You Decide How to Survive)
Hena Khan and David Borgenicht with Robert Zubrin, Chronicle Books, 2011, ISBN 081187124X
Join the youngest crew of astronauts ever to make the trip to Mars! Faced with fearsome dangers and difficult decisions, your choices will determine your fate on the Red Planet. Will you achieve the mission and return home to Earth safely, successfully earning the title of the youngest astronaut ever to make it to Mars? Or will you be forced to turn back early? This thrilling adventure offers 22 possible endings, but only ONE leads to the ultimate success! With eye-catching comic-book-style illustrations and information based on scientific facts related to Mars and space exploration, young readers will be over the moon with this entertaining addition to the *Worst-Case Scenario* series! For ages 9 and up.

You Are the First Kid on Mars
Patrick O'Brien, Putnam Juvenile, 2009, ISBN 0399246347
Using the most up-to-date designs and theories of what it will take to establish a base

on Mars, the reader is off on an incredible journey, over 35 million miles to the Red Planet. For ages 5 and up.

Other Suggested Science Fiction Titles

John Carter Series, E. R. Burroughs, 1912-1940, ISBN 1907960023
War of the Worlds, H. G. Wells, 1900, ISBN 1453603808
The Sands of Mars, A. C. Clark, 1965, ISBN 0553290959
Man Plus; Mars Plus, F. Pohl, 1976, 1999, ISBN 0765321785; ISBN 0671876651
Mars, B. Bova, 1992, ISBN 055356241X
Return to Mars, B. Bova, 1999, ISBN 0380797259
Moving Mars, G. Bear, 1993, ISBN 0765318237
Red Mars*,* K. S. Robinson, 1994, ISBN 0553560735
Green Mars*,* K. S. Robinson, 1995, ISBN 0553572393
Blue Mars*,* K. S. Robinson, 1996, ISBN 0553573357
The Martians, K. S. Robinson, 1999, ISBN 0553574019

Gardening

A Kid's Guide to How Flowers Grow (Digging in the Dirt Series)
Patricia Ayers, Rosen Publishing Group, Inc., 2000, ISBN 0823954625
This series provides children ages 9–12 with basic information for planting and maintaining a flower garden.

A Kid's Guide to Making a Terrarium
Stephanie Bearce, Mitchell Lane Publishers, 2010, ISBN 1584158131
Bearce introduces readers to the wonderful world of terrariums. Children ages 9–12 will learn to build their own tropical plants using minimal space and supplies.

Blue Potatoes, Orange Tomatoes: How to Grow a Rainbow Garden
Rosalind Creasy, Sierra Club Book, 1994, ISBN 0871565765
Children ages 6–9 receive gardening tips on how to grow fruits and vegetables in a variety of colors.

Container Gardening for Kids
Ellen Talmage, Bruce Curtis (Photographer), Sterling, ISBN 0806913797
Planting small gardens in containers is fun and easy for children of all ages. This book contains 25 projects using things around the house and teaches horticulture basics, such as propagation, rooting, taking cuttings, composts, and the names of plants and materials. For ages 9–12.

Edible Schoolyard: A Universal Idea
Alice Waters, Chronicle Books, LLC., 2008, ISBN 0811862801
Children ages 6–9. An organic gardening and cooking program becomes a universal idea for edible education at an urban middle school. The history and mixture of

childhood stories relating to nutrition, farming, and cooking makes this book a great read for any age.

Great Gardens for Kids
Clare Matthews and Clive Nichols, Hamlyn, ISBN 060061204X

101 Kid-Friendly Plants
Cindy Krezel, Ball Publishing, 2007, ISBN 978-1-883052-54-6
A comprehensive guide to using nontoxic flowers, vegetables, trees, and houseplants, includes seventeen gardening projects. For children ages 6 and up.

Succulents
June Loves, Chelsea House Publishers, 2005, ISBN 0791082660
Children ages 4–8 discover the amazing realm of succulents. Loves reveals the usefulness of succulents and cacti, and offers gardening tips for various types.

Related Websites

Engineering Design Process

www.theworks.org/fb/teachers/engineering_design_process.html
The Works — an engineering process page from the The Works, a hands-on museum.

www-tc.pbskids.org/designsquad/pdf/parentseducators/DS_Invent_DesignProcess_Poster_ENG.pdf
Design Squad engineering design process page from the popular and successful PBS show "Design Squad."

www.mos.org/eie/engineering_design.php
Engineering is Elementary engineering design process page.

www.nasa.gov/audience/foreducators/plantgrowth/reference/index.html
NASA engineering design processes: one for K–4 and one for grades 5–12.

Engaging Girls in STEM

www.ngcproject.org/
The **National Girls Collaborative Project™ (NGCP)** is designed to reach girl-serving STEM organizations across the United States.

www.pbs.org/teachers/scigirls/philosophy/
The **SciGirls PBS television series**, website, and outreach initiatives emphasize current research on strategies proven to increase girls' engagement in STEM. A quarter of a century of studies have converged on a set of common strategies that work, and

these have become SciGirls' foundation. The SciGirls Seven summarizes seven research-based strategies for engaging girls in STEM, including tips for putting these strategies to practice and references for additional information.

women.nasa.gov/womens-history-month/
Women@NASA is a program the highlights the achievements of women in space science and features videos and other useful resources.

www.smithsonianchannel.com/site/sn/women-in-science.do
Women in Science, Working Wonders features female scientists whose passion to save the planet makes them superheroes. Full episodes, along with comic-book versions of each show available.

www.fabfems.org/
The **FabFems** directory is a national database of women in science, technology, engineering, and mathematics (STEM) professions who are inspiring role models for young women. The FabFems directory is accessible to young women, girl-serving STEM programs, and other organizations that are working to increase career awareness and interest in STEM.

Gardening

gardencorner.net/?p=31
Garden Corner hosts information about Jade plants (as well as many other plants).

www.garden.org OR www.kidsgardening.org.
For more than 35 years, the **National Gardening Association (NGA)** has been working to renew and sustain the essential connection between people, plants, and the environment. A nonprofit leader in plant-based education, making available free educational plant-based materials, grants, and resources that speak to young minds, educators, youth and community organizations, and the general gardening community.

eartheasy.com/grow_xeriscape.htm
Website features information about Xeriscaping, landscaping using sustainable techniques to conserve water.

www.greenyour.com/home/lawn-garden/landscaping/tips/practice-xeriscaping
Tips and information for Xeriscaping.

Astrobiology

www.lpi.usra.edu/education/timeline/
The **Lunar and Planetary Institute** offers this site that provides the changes that occurred on Earth over the last 4.5 billion years in timeline form. The timeline is downloadable!

nai.arc.nasa.gov/
NASA's Astrobiology Institute website offers feature stories, most recently answered questions, and Alien Safari to help kids discover some of the most extreme organisms on our planet, and find out what they are telling astrobiologists about the search for life beyond Earth. Ages 7 and up.

quest.arc.nasa.gov/projects/astrobiology/astroventure/avhome.html
NASA's Astro-Venture helps students explore NASA careers and astrobiology research by offering activities that allow them to "search for and build a planet with the necessary characteristics for human habitation." Ages 6 and up.

www.astrobio.net/news/
Astrobiology Magazine contains tons of great articles regarding the search for life in the solar system. Appropriate for ages 10 and up.

www.seti.org/
The **SETI Institute** website contains lots of information about the search for life in the universe. Why are we searching? How are we searching? Learn about all the different missions with one goal — to find out if life exists elsewhere in the universe. This site is a little advanced and is great for ages 12 and up.

www.pbs.org/wgbh/nova/nature/lives-of-extremophiles.html
Nova: The Lives of Extremophiles; companion website for the video with information and resources.

Mars

www.enchantedlearning.com/subjects/astronomy/planets/mars/
Enchanted Learning is a great site for easy-to-understand information about the planets. Games, coloring pages, quizzes, and resources are also provided. Great for ages 5 and up.

www.kidsastronomy.com/mars.htm
Kids Astronomy is great for kids ages 5–8. It provides very basic information about Mars and its moons.

kids.nineplanets.org/mars.htm
The Nine Planets website for kids is suitable for ages 6–10. It provides very basic information about the planet's surface features, weather, ice caps, and more.

www.windows.ucar.edu/tour/link=/mars/mars.html
Children ages 8 and older can explore all about Mars with **Windows to the Universe**. All information is presented in English and Spanish and at several learning levels. Be sure to check out the numerous tours of Mars and its features and history at www.windows.ucar.edu/tour/link=/cool_stuff/tours_main.html.

www.kidsastronomy.com/mars_explorer.htm
Kids Astronomy discusses topics like the possibility of life on Mars, missions to Mars, and the future of the Red Planet. This simple text and format is great for ages 8 and older.

4hgarden.msu.edu/kidstour/zoo/
The **Microbe Zoo** is an educational resource about ecology and microbiology. The Microbe Zoo includes information about microbes and the habitats in which they dwell.

starchild.gsfc.nasa.gov/docs/StarChild/solar_system_level1/mars.html
This website discusses in basic terms different aspects of Mars such as its surface features, temperatures, atmosphere, and missions. This site is good for young audiences ages 8 and up.

spacekids.hq.nasa.gov/osskids/mars/index.htm
Is there or was there ever life on Mars? Check out this site to get all the information on why we want to explore Mars and why we think there might have been life on Mars. It's a great site for parents and children ages 12 and up.

www.nineplanets.org/mars.html
Nine Planets offers a plethora of information about Mars from its location in the solar system to information about the many missions to Mars. It discusses its land features, satellites, and much more! Appropriate for ages 12 and older.

www.psrd.hawaii.edu/Archive/Archive-Mars.html
Young adults will find these articles about Mars and the scientific research about possible life on Mars. Very informative.

www.patrawlings.com/default.cfm
Lunar bases, Mars colonies, spacecraft, and more come alive though **Pat Rawling's** fabulous art. Many of the pieces are available for use in your public programs, including those done for NASA and JPL. Check out the copyright information at www.patrawlings.com/copyright.cfm.

beamartian.jpl.nasa.gov/welcome
Be a Martian enables the public to participate as citizen scientists to assist Mars science teams studying data about the Red Planet!

athena.cornell.edu/kids/
Mars for Kids — with Bill Nye; activities and information, presented in a more dynamic style. Not kept up to date, but good stuff. Find out your weight on Mars and peruse the timeline of Mars exploration.

Mars Missions

mars.jpl.nasa.gov/missions/
Keep track of **past, present, and planned future Mars missions** through NASA's Mars Exploration Home page. Mission links, images, and educational material are presented for audiences of different ages.

marsrovers.nasa.gov/home/
Catch up on the latest news from the **Mars Exploration Rovers**, Spirit and Opportunity, at their home website. Be sure to explore the Kids site at marsprogram.jpl.nasa.gov/funzone_flash.html.

phoenix.lpl.arizona.edu/
Follow the latest rover of the **Phoenix Mission** as it investigates the polar region of Mars, searching for more information about the history of water on this nearby neighbor.

sci.esa.int/science-e/www/area/index.cfm?fareaid=9
Mars Express is a joint mission, led by the European Space Agency, with NASA instrumentation onboard. The mission's main purpose is to search for evidence of water beneath the surface. Stunning images of the surface of Mars have been returned as this spacecraft orbits the planet.

marsprogram.jpl.nasa.gov/odyssey/
Mars Odyssey is mapping the surface features and minerals on the surface of the Red Planet to help scientists understand the planet's climate and geologic history.

mars.jpl.nasa.gov/mro/
Mars Reconnaissance Orbiter is providing information about the surface, subsurface, and atmosphere of Mars. This information will help NASA identify landing sites for future missions.

mars.jpl.nasa.gov/missions/future/msl.html
www.nasa.gov/mission_pages/msl/news/msl20110722.html
The **Mars Science Laboratory** (MSL) launched in 2011. The MSL rover, Curiosity, is roaming the surface, gathering more information about the environment and history of Mars, and testing new "smart rover" technology, helping NASA plan for rover exploration of hard-to-reach locations not appropriate for human investigation.

Other interesting sites related to MSL and the Curiosity rover:
mars.jpl.nasa.gov/msl/multimedia/videos/index.cfm?v=3
www.msl-chemcam.com/
www.nasa.gov/mission_pages/mer/

www.nasa.gov/mission_pages/exploration/mmb/index.html
NASA's plans for exploring the Moon, Mars, and beyond! For the latest on spacecraft, robots, and the technology that makes our exploration of the solar system possible, check out NASA's Exploration Systems Mission Directorate at:

www.nasa.gov/directorates/esmd/home/index.html. This site contains numerous short, engaging video clips that can enhance your program.

phoenix.lpl.arizona.edu/games.php
Learn all about the Phoenix Mars Lander — where it's landing, what it's going to do while on Mars, and what we hope to discover! Lots of games and activities are also available. This site is great for ages 5 and up.

mars.jpl.nasa.gov/funzone_flash.html
Games, activities, images, and information about Mars at this Mars Rovers Site for Kids. A little dry, but surfing around will reveal some interesting pieces. Links to the most recent images and updates from those tenacious little rovers.

www.exploratorium.edu/mars/
Whether you're a teacher, a parent, or just a curious enthusiast, the collections of activities on these pages will help you delve into an exploration of Mars. We've collected sets of resources grouped around three topics: the search for life on Mars, the martian environment, and the mechanics of the Mars Exploration Rovers themselves.

Volcanos

volcano.und.edu/
Volcano World provides current, accessible information about volcanos on Earth and elsewhere in the solar system. Lots of information is provided about volcanos on Mars. There are activities and games for children ages 5 and older Be sure to take the virtual tours!

www.nationalgeographic.com/forcesofnature/interactive/index.html?section=v
National Geographic presents an overview of volcanos, how they form, and where they occur. For children ages 10 and older.

dsc.discovery.com/convergence/pompeii/interactive/interactive.html
Interactive volcano explorer from the Discovery Channel for children ages 10 and older.

www.learner.org/exhibits/volcanoes/
A fantastic site about prediction of volcanic eruptions, with information about how and where volcanos form. The text is a little advanced, but great for parents and children ages 12 and up. Several resources are provided for those who wish to delve deeper into the wonders of volcanos.

sciencebulletins.amnh.org/earth/
The American Museum of Natural History provides daily tracking of volcanic eruptions across the world for ages 12 and older.

interactive2.usgs.gov/learningweb/explorer/topic_hazards_volcanoes.asp
U.S. Geological Survey's Earth Science Learning Lab includes lots of information about

volcanos and volcano monitoring, as well as links to sites for further exploration for ages 12 and older. A teacher's guide includes several lesson plans about volcanos, eruptions, and impacts on humans (interactive2.usgs.gov/learningweb/teachers/volcanoes.htm).

Plate Tectonics

Discovering Plate Boundaries
www.geophysics.rice.edu/plateboundary/
Discovering Plate Boundaries is a data-rich inquiry activity in which children explore the processes that occur at plate boundaries (volcanos, earthquakes, formation and destruction of the sea floor, and the related physical features).

Whirlwind URL Tour

NASA's Science Mission Directorate
science.hq.nasa.gov/missions/index.html
Explore past, present, and future missions that are revealing new insights into Earth, our Sun, the solar system, and the universe.

NASA's Exploration Mission Directorate
www.nasa.gov/directorates/esmd/home/index.html
The latest news on getting into space — the rockets, the modules, the missions . . . and more! Lots of videos.

Check Out Our Plans for the Moon, Mars, and Beyond
www.nasa.gov/mission_pages/exploration/mmb/index.html

Pat Rawlings Images
www.patrawlings.com/default.cfm
Great site for beautiful illustrations of space travel, lunar bases, Mars outposts, and more. You are invited to use the images copyrighted by NASA and in the public domain.

NASA's (actually the Jet Propulsion Laboratory's) Solar System Ambassadors
www2.jpl.nasa.gov/ambassador/NM.html
Need some expertise for your space programs? Contact a Solar System Ambassador near you!

NASA's Education Portal
education.nasa.gov/home/index.html
Lots and lots and lots and lots of resources and opportunities for involvement. Pour a cup of tea and spend some time here when you can.

NASA Informal Education Resources
education.nasa.gov/divisions/informal/overview/
R_NASA_and_Afterschool_Programs.html
GREAT resources for the library and other out-of-school-time learning programs, created by the American Museum of Natural History.

NASA's Year of the Solar System: New Worlds, New Discoveries
solarsystem.nasa.gov/yss/
Celebrates the amazing discoveries of numerous NASA missions as they explore our planetary neighbors and probe the outer edges of our solar system. The Year of the Solar System extends from October 2010 to August 2012 and focuses on a different subject each month — weaving together activities, resources, and ideas that public program providers, teachers, clubs, and organizations can use to engage audiences.

NASA's 50 Years of Solar System Exploration
solarsystem.nasa.gov/50th/
Five decades of amazing solar system exploration began in December 1962 when Mariner 2 flew past Venus, the first successful mission to another planet. Browse the galleries to learn more about key moments in solar system exploration.

Lunar and Planetary Institute Education Pages
www.lpi.usra.edu/education/
Home to the *Explore* Program and other educational resources. Check out the Solar System Time Line — and Family Space Days resources.

Lunar and Planetary Institute's Featured Astrobiology Resources
www.lpi.usra.edu/education/fieldtrips/2007/resources.shtml
Featured links to Astrobiology resource websites.

Explore Home Page
www.lpi.usra.edu/education/explore/
Links to present and past Explore Newsletters and several other Explore! modules, such as Health in Space, Mars, Rockets, Comets, and more (www.lpi.usra.edu/education/explore/explorations.shtml).

Explore! Mars: Inside and Out
www.lpi.usra.edu/education/explore/mars/
Hands-on activities, background information, and suggested books and websites for further exploration.

Rock Information

Ward's Natural Science Company (note: other science supply companies also have rock samples)

Basalt: www.wardsci.com/product.asp_Q_pn_E_IG0004711_A_Basalt
Vesicular Basalt (gas pocket "holes"):
www.wardsci.com/product.asp_Q_pn_E_IG0004713_A_Basalt+%28Vesicular%29

Flood Basalt:
www.wardsci.com/product.asp_Q_pn_E_IG0004710_A_Basalt+%28Flood%29

Actual Impact Breccia from Earth:
www.wardsci.com/product.asp_Q_pn_E_IG0003107_A_Impact+Breccia

Basalt Breccia:
www.wardsci.com/product.asp_Q_pn_E_IG0004668_A_Breccia+%28Basalt%29

Volcanic Breccia:
www.wardsci.com/product.asp_Q_pn_E_IG0004671_A_Breccia+%28Volcanic%29

Lunar and Mars Soil Simulant can be ordered from Planet LLC:
www.planet-llc.com/pages/store/simulant.htm

Related Videos and TV Shows

***Alien Planet*.** Discovery Channel, 2005, ASIN B0009VRHLA
What happens when we find life outside our own planet? This video brings viewers on a virtual mission of the future. Right now, the search for planets with "life signatures" goes on. These efforts are global, and experts tell us on camera how this search for life is progressing around the world. No longer just the domain of science fiction, what could alien life really look like? *Alien Planet* dramatizes an exciting — and possible — answer.

Are We Alone? Discovery Channel, 2009, #267233
Explore answers to the ultimate question — Are we, in fact, alone? Scientists visit the most treacherous and strange regions on the planet, to find clues to the puzzle. This video shows how state-of-the-art technology has taken us closer than ever to the hotly debated answer. Is there life beyond Earth? Could the bizarre, hellish worlds of our solar system actually harbor alien life?

Charles Darwin and the Tree of Life. BBC Worldwide, 2009, ASIN B002MIK0UI
This documentary was made to celebrate the 200th anniversary of the birth of Charles Darwin and the 150th anniversary of the publication of *On the Origin of Species*. New and spectacular wildlife footage of fascinating animal behavior brings the theory to life, and fresh evidence and new discoveries reveal how Darwin's work is endorsed and expounded by today's cutting-edge science. A labor of love for David Attenborough, a man who has been at the forefront of natural history programming for decades, this

fascinating program explores why Darwin’s theory is more important now than ever before.

First Steps on Mars: The Search for Life. Global Science Productions, 2005, ASIN B0007VNPF4
This program presents what the first manned mission to Mars might entail, using computer animation and interviews with scientists.

Five Years on Mars. National Geographic, 2010, ASIN B0031L5CSU
When the NASA rovers Spirit and Opportunity touched down on Mars in 2004, they weren’t expected to last long — perhaps 90 days, or 6 months at most. But 90 days stretched into 5 years, and a short-term science mission searching for evidence of water has turned into one of the greatest adventures of the Space Age. The rovers have trekked miles across hostile plains, climbed mountains, ventured in and out of deep craters, and survived dust storms as well as mechanical failures. This is the amazing story of two rovers that have explored vast reaches of Mars and may be among some of the greatest explorers in history. Bonus Program: *Is It Real? Life on Mars.*

Mars Rising. E1 Entertainment, 2010, ASIN B0037FFB9A
Narrated by William Shatner, shot in high definition and featuring contributions from more than 300 scientists and experts (including *Avatar* filmmaker James Cameron), this six-part documentary series explores the challenges behind a potential manned mission to Mars — possibly the most dangerous expedition of the 21st century.

Mars: The Quest for Life**.** Discovery Channel, 2008, ASIN B001PPLJNQ
This documentary from the Discovery Channel provides a unique peek into an otherworldly adventure. Documenting events taking place in 2008, *Mars: The Quest for Life* captures every moment as senior research scientist Peter H. Smith and his crew struggle to ensure their Phoenix lander sets down on the surface of the Red Planet safely and securely. Then come the exciting implications: What can this information-gathering spacecraft reveal to humanity about life on Mars? The program includes never-before-seen footage of Phoenix’s triumphant landing.

NOVA: Finding Life Beyond Earth. NOVA/PBS, 2011, ASIN B005KLOPGY
Scientists are on the verge of answering one of the greatest questions in history: Are we alone? *Finding Life Beyond Earth* immerses audiences in the sights and sounds of alien worlds, while top astrobiologists explain how these places are changing how we think about the potential for life in our solar system. We used to think our neighboring planets and moons were fairly boring — mostly cold, dead rocks where life could never take hold. Today, however, the solar system looks wilder than we ever imagined. Powerful telescopes and unmanned space missions have revealed a wide range of dynamic environments — atmospheres thick with organic molecules, active volcanos, and vast saltwater oceans. This ongoing revolution is forcing scientists to expand their ideas about what kinds of worlds could support life.

NOVA: Is There Life on Mars? Reports from the Phoenix Lander. NOVA/PBS, 2009, ASIN B001MWGZ40
NASA's twin robot explorers, Spirit and Opportunity, far outlasted the planned lifespan of their mission on Mars. And since May 25, 2008, they've had company: NASA's Phoenix probe, which dramatically "tasted" water ice on the planet. This program showcases the latest scientific results from the rovers and Phoenix, which have revealed provocative new clues in the tantalizing search for water and life on the Red Planet.

Phoenix Mars Mission: Onto the Ice**.** Arizona Public Media/PBS, 2010, ASIN B004DFHX8K
Following on from *Phoenix Mars Mission: Ashes to Ice*, this documentary tells the story of the Phoenix lander from its arrival on the martian surface through the completion of its mission.

Phoenix Mars Mission: Ashes to Ice. PBS, 2008, ASIN B003J7HO8M
The Phoenix Mars Mission blasted off to Mars in August 2007. This film chronicles the meticulous preparation through blastoff of the Phoenix Mars lander, which landed on the martian surface on May 25, 2008. Once on the surface, scientists from around the world gathered to search for water in the form of ice under the planet's surface.

Roving Mars. Walt Disney/Buena Vista Home Entertainment, 2007, ASIN B000FIMG40
For centuries human beings have contemplated Earth's nearest planetary neighbor, Mars, dreaming impossible dreams of exploring its surface and divining its mysteries. Through the eyes of the Mars rovers Spirit and Opportunity, viewers can now see Mars in a way that no one ever has. This important expedition accomplished far more than the simple transmission of thousands of martian images. The rovers discovered traces of ice within the rocks of Mars and marked clear proof that water once ran on the surface — a giant leap forward in answering that most haunting of questions: Is there life on Mars?

Welcome to Mars. NOVA/PBS, 2005, ASIN B0007GP79G
Mission Control and its two robotic explorers face a daunting task to find proof that liquid water, the essential ingredient of life, once existed on Mars. This video presents a compelling inside story of triumph and technical ingenuity, full of scientific and human drama, with stunning images from an alien world.

Other Media

Earth and Mars: As Different as They Are Alike poster
NASA/Jet Propulsion Laboratory, EW-2002-06-009-JPL/02, 2001.
The front and back of the poster are available to be downloaded and printed.
mars.jpl.nasa.gov/classroom/pdfs/EarthMars_poster_front.pdf
mars.jpl.nasa.gov/classroom/pdfs/EarthMars_Poster.back.pdf

***Astrobiology poster*.**
NASA/Ames Research Center, EW-2004-07-001-ARC, 2004.
Small and large formats are available to be downloaded and printed.
nai.arc.nasa.gov/poster/poster_images/poster_small.pdf
nai.arc.nasa.gov/poster/poster_images/poster_large.pdf

***Biology in Space Bulletin Board Set*.**
NASA, CORE item number 300.1-55AA, 2007.
This bulletin board layout is designed for a 4" × 5" space and includes *a Life: What Is It? Where Is It? How Do We Find It?* poster, an Engineering Design Challenge flier, and a space shuttle mission STS-118 crew lithograph and patch decal. This bulletin board set is available online from NASA Central Operation of Resources for Educators (CORE).
corecatalog.nasa.gov/item.cfm?num=300.1-55AA

***Destination Mars: Activity Packet — Lesson 5: Searching for Life on Mars*.**
NASA/Johnson Space Center, 2002.
This lesson from Destination Mars contains four exercises within four activities that have been grouped to encourage students to think about the characteristics of life and about the possibility of looking for life on Mars.
http://ares.jsc.nasa.gov/ares/education/program/DestMars/destmarsLes5.pdf

***Astrobiology: The Story of Our Search for Life in the Universe graphic novel*.**
NASA Astrobiology Program, Issue 1: NP-2010-09-681-HQ, Issue 2: NP-2011-01-695-HQ, 2010 and 2011.
This graphic novel was commissioned to celebrate 50 years of exobiology and astrobiology research at NASA. Issues 1 and 2 are available online.
https://astrobiology.nasa.gov/articles/astrobiology-graphic-novel-issue-2/

***ExoQuest CD-ROM*.**
NASA, CORE item number 400.1-36A, 2001.
Are we alone in the universe? This multimedia educational product developed at NASA Classroom of the Future™ uses this question as a framework for integrating current research in astrobiology into the grade 7–9 curriculum. This CD-ROM is available online from NASA Central Operation of Resources for Educators (CORE).
http://corecatalog.nasa.gov/item.cfm?num=400.1-36A

***Solar System Exploration Kit*.**
NASA, CORE item number 300.1-63P, 2004.
This kit includes posters, lithographs, bookmarks and other items. This solar system exploration kit is available online from NASA Central Operation of Resources for Educators (CORE).
http://corecatalog.nasa.gov/item.cfm?num=300.1-63P

Spanish Language Space and Planetary Science Resources

Auroras! Luces Misteriosas en el Cielo
stargazers.gsfc.nasa.gov/pdf/products/books/aurora_sp.pdf
This coloring book for grades K–4 explores auroras and what causes them.

Ciencia@NASA (ciencia.nasa.gov/)
Headline News at NASA. Additional NASA Spanish language sites can be found at www.nasa.gov/about/highlights/En_Espanol.html.

Cindi En El Espacio
cindispace.utdallas.edu/education/Cindi_comic_spanish_cc4.pdf
Spanish version of the Cindi in Space comic book — the story of the android spacegirl Cindi and her two dogs who explain the purpose of the CINDI instrument as part of the C/NOFS mission and the science involved.

Enciclopedia de Agujeros Negros
blackholes.radiouniverso.org
The black hole website from the University of Texas.

GLOBE Project
www.globe.gov/fsl/welcome/welcomeobject.pl?&lang=es&nav=1
Elementary- through high-school students make local environmental measurements and send their data, via the Internet, to the GLOBE Student Data Archive.

La Exploración de la Magnetosfera Terrestre
(www-istp.gsfc.nasa.gov/Education/MIntro.html)
Detailed content enables educators to explore the Earth's magnetosphere. Activities and a plethora of additional resources support classroom learning.

NASA Kids Science News Network in Spanish
ksnnsp.larc.nasa.gov/intro.html
These one-minute newsbreaks for elementary students feature children teaching mathematics, science, technology, and facts about NASA. Activities, a glossary, quizzes and resources for each topic are available.

Nuestra Propia Estrella: el Sol
stargazers.gsfc.nasa.gov/pdf/products/books/our_very_own_star_sp.pdf
An informative coloring book about the Sun, our very own star, for grades K–4. An animated version can be found at stargazers.gsfc.nasa.gov/pdf/products/books/Sun_booklet_Spanish.htm.

Space Place en Español
spaceplace.nasa.gov/sp/kids/

Children ages 5–10 will enjoy this interactive exploration of Earth, the solar system, and beyond. Games, animations, puzzles, activities, and classroom lessons are available.

Spanish Language Astronomy Materials Education Center
http://www.astronomyinspanish.org/
The National Optical Astronomy Observatory offers a searchable database of Spanish language educational books, media, and periodicals, broken down by grade level.

Spitzer — El Telescopio Espacial (www.spitzer.caltech.edu/espanol/)
Images, news, and information about the Spitzer mission.

Tormentas Solares (www-istp.gsfc.nasa.gov/istp/outreach/cmeposter/spindex.html)
Storms from the Sun shares content for high-school students and educators, about our dynamic star and how it influences Earth. Missions and current solar activity are highlighted.

Universo! (radiouniverso.org)
From the University of Texas' McDonald Observatory, this website contains the daily Universo radio show, the guide to the solar system, K–12 activities, and more.

Windows on the Universe (www.windows.ucar.edu/spanish.html)
This rich website shares information about Earth, our solar system, and universe in an accessible and engaging manner on multiple learning levels. Educator resources include lesson plans and supporting content.

Extensions

Imagine Mars
imaginemars.jpl.nasa.gov/index2.html
Imagine Mars offers lots of activities, webcast information, resources, and lots more for grades 3 and up.

Mars Exploration: Fun Zone!
mars.jpl.nasa.gov/funzone_flash.html
This kids site for ages 4 and up provide games, activities, images, and information about Mars. Also included are links to the most recent images and updates from those tenacious little rovers.

Mars and Earth Curriculum Package
www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Mars_and_Earth_Educator_Guide.html
The American Museum of Natural History offers Mars and Earth, a curriculum package of nine activities for 5–9-year-olds intended for informal educational environments. Children explore Mars and Earth through hands-on scientific investigations that range from comparing images to creating comics strips that tell of their imaginary voyage.

Destination: Mars
ares.jsc.nasa.gov/Education/activities/destmars/destmars.cfm
Destination: Mars is a group of activities that focuses on the surface features of Mars, including volcanos and channels, as well as the possibility for life on Mars. These activities are appropriate for ages 10 and up.

Fingerprints of Life
ares.jsc.nasa.gov/Education/websites/astrobiologyeducation/index.html
Fingerprints of Life is dedicated to investigating the possibility of past or present life in extreme environments, such as Mars. Classroom activities and the ties to the standards are available. Online resources are also available through the site. The activities are appropriate for ages 10–13.

ASU Mars Educational Resources
marsed.mars.asu.edu/resources-mars_activities
Arizona State University's Mars educational resources. A plethora of lesson plans and theme-based units will allow extensive exploration of Mars and the formation of its surface features. Be sure to check out the Mars Activity Book (marsed.mars.asu.edu/files/MSIP-MarsActivities_0.pdf), which contains numerous inexpensive activities.

Mars Student Imaging Project (MSIP)
msip.asu.edu/whatismsip.html
Through the Mars Student Imaging Project, teams of students grades 5 through college sophomore level actually work with NASA scientists, mission planners, and educators to propose a site on Mars for the THEMIS visible wavelength camera onboard the Mars Odyssey spacecraft to collect data. The experience is free and is not restricted to classrooms. Community groups also can propose!

Planet Hunters
www.planethunters.org/
Planet Hunters is a citizen science project collaboration between Yale University and the Zooniverse. Users help in the search for new planets around distant stars by analyzing lightwaves. The lightcurves provided on the site are from the publicly released data obtained by NASA's Kepler mission.

Related Games and Simulations

KODU: Mars Edition
www.kodugamelab.com/search?query=mars+edition
Created by KODU Game Lab in partnership with NASA Mars Public Engagement Program and Microsoft, this game allows students grades 5–8 to create worlds that reflect the Mars terrain and program a virtual model of the Curiosity rover as it searches for habitats on Mars. KODU Game Lab makes programming fun and approachable for novices through a tile-based (visual) user interface, engaging characters, and simple

three-dimensional terrain editing. A number of corresponding lesson plans may be found on the website.

Outreach Suggestions

National Girls Collaborative Project
www.ngcproject.org
The National Girls Collaborative Project™ (NGCP) is designed to reach girl-serving STEM organizations across the United States.

Aspire
aspire.swe.org
This Society of Women Engineers (SWE) K–12 outreach program offers resources and events designed to share the excitement of engineering with girls in grades K–12.

National Engineers Week Foundation
www.eweek.org
As part of its signature program of over 60 years, ENGINEERS WEEK®, this foundation hosts Introduce a Girl to Engineering Day® and Discover Engineering Family Day. Students in 6th, 7th, and 8th grade can also participate in the Annual Future City® Competition, where teams work with educators and engineer mentors to design a city 150 years in the future using SimCity™ 4 Deluxe software.

Correlations to National Standards

The activities in this module support several nationally recognized technology standards, including the list below, which are quoted from the *National Science Education Standards* (National Academies Press, 1996).

National Science Education Standards

Grades K–4

Science as Inquiry — Content Standard A
Understandings About Scientific Inquiry
Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.
Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations.
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.

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.

Physical Science — Content Standard B
Properties of Objects and Materials
Objects have many observable properties, including size, weight, shape, color, temperature, and the ability to react with other substances. Those properties can be measured using tools, such as rulers, balances, and thermometers.
Materials can exist in different states — solid, liquid, and gas. Some common materials, such as water (or rock), can be changed from one state to another by heating or cooling.

Life Science — Content Standard C
The Characteristics of Organisms
Organisms have basic needs. For example, animals need air, water, and food; plants require air, water, nutrients, and light. Organisms can survive only in environments in which their needs can be met. The world has many different environments, and distinct environments support the life of different types of organisms.

Life Science — Content Standard D
Properties of Earth Materials
Soils have properties of color and texture, capacity to retain water, and ability to support the growth of many types of plants, including those in our food supply.

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

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

History and Nature of Science — Content Standard G
Science as a Human Endeavor
Although men and women using scientific inquiry have learned much about objects, events, and phenomena in nature, much more remains to be understood. Science will never be finished.

Grades 5–8

Science as Inquiry — Content Standard A
Abilities Necessary to Do Scientific Inquiry
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.

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 collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models.
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.
Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses

such explanations until displaced by better scientific ones. When such displacement occurs, science advances.

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

Physical Science — Content Standard B

Transfer of Energy

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

Life Science — Content Standard C

Regulation and Behavior

All organisms must be able to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment. Extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient to allow its survival. Fossils indicate that many organisms that lived long ago are extinct. Extinction of species is common; most of the species that have lived on Earth no longer exist.

Life Science — Content Standard C

Structure and Function in Living Systems

Reproduction and Heredity

Reproduction is a characteristic of all living systems; because no individual organism lives forever, reproduction is essential to the continuation of every species. Some organisms reproduce asexually. Other organisms reproduce sexually.

Science and Technology — Content Standard D

Earth in the Solar System

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

Earth's History

Fossils provide important evidence of how life and environmental conditions have changed.

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

Structure of the Earth System
Landforms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruption, and deposition of sediment, while destructive forces include weathering and erosion.
Water covers the majority of Earth's surface.

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 benefits.

History and Nature of Science — Content Standard G
Nature of Science
Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science, there is much experimental and observational confirmation. Those ideas are not likely to change greatly in the future. Scientists do and have changed their ideas about nature when they encounter new experimental evidence that does not match their existing explanations.

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

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

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 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.

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 (http://www.astroleague.org/) or search at Sky and Telescope (http://www.skyandtelescope.com/community/organizations). Let them know which planets or other objects you 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 (http://stardate.org/), 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/).

   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 http://www.sunrisesunset.com/ 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 (http://www.skymaps.com/downloads.html) or simple sky wheels (http://www.lawrencehallofscience.org/starclock/skywheel.html) are available free from a variety of websites, including the links offered here; note that the sky wheels require assembly but work year-round.

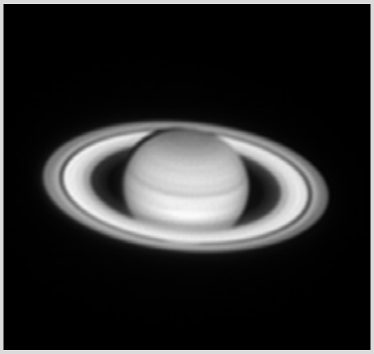
11. **Review the information below in preparation for discussing the night sky with visitors.**

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.