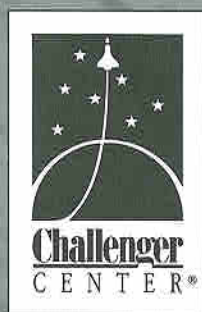


MARS

A Teacher's Activity Guide

Another in the Series of
Challenger Learning EdVentures
from



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Dear Educators

Dear Classroom Educator,

At Challenger Center, we believe that in every young mind there is a window on the universe. Encourage that window to open, and great things begin to happen. Young people become explorers. And we believe exploration is the essence of learning.

The key to opening that window and exploring new frontiers has to do with tapping a young person's natural curiosity. That curiosity is what powers the desire to ask questions and pursue answers.

To help teachers spark that curiosity, Challenger Center has assembled some of its most popular classroom activities into a series called *Learning Frontiers* using the popular space themes of Comets, Earth, Mars, and Moon. Studies have shown that space is one of the most popular and effective themes used to capture students' interest.

Since its founding in 1986, Challenger Center has used the theme of space to engage students in this pursuit and has been nationally recognized for its innovative approaches to inspiring young people to explore. But Challenger Center believes that when all is said and done, there are no tools, no programs, no techniques that will ever replace the direct intervention of a great teacher in a student's life.

That is why we hope you will find the Learning Frontiers activities engaging, relevant and—most of all—fun. These scientifically sound, educationally rich activities were developed to provide teachers with as much flexibility as possible when it comes to classroom implementation. To facilitate classroom use, teachers will find that each activity has been correlated to national education standards and is formatted to easily find objectives and key concepts.

We hope these activities will help you open your students' "windows" by using them to create new "learning frontiers" in a way that is appropriate for your classroom. Inspiring. Exploring. Learning. It's Our Mission.

Best Regards,
The Challenger Center Team



Voyage to Mars logotype is a registered trademark of Challenger Center For Space Science Education. All rights reserved.

In addition to being a great collection of classroom activities for any teacher to introduce the human exploration of Mars, this activity guide was designed to also help prepare students for Challenger Center's *Voyage to Mars*® mission simulated when used with our *Mission Prep* guide. Hundreds of thousands of students "fly" simulated missions each year at Challenger Learning Centers throughout our international network. For more information, visit www.challenger.org.

Challenger Center's Educational Pedagogy

The Challenger Center's educational pedagogy promotes scientific literacy by encouraging exploration and inquiry and exciting young people about knowledge and learning. Challenger Center believes exploration is the essence of learning. Our goal is to give teachers the tools to create a "learner-centered" environment and to provide materials that are a framework for embedding subject content in a meaningful and motivational context.

Using our interdisciplinary, inquiry-based approach that incorporates national educational standards, Challenger Center strives to:

- Increase student interest in science, mathematics, and technology.
- Give abstract concepts concrete meaning.
- Help students develop realistic processes of cooperation, communication, critical thinking, and problem solving.
- Increase student autonomy and responsibility for their own learning.
- Encourage students to develop positive perspectives about learning.
- Increase student commitment to learning.
- Help students pose questions and find pathways to answers.

Challenger Center programs are designed to reflect academic standards such as the National Science Education Standards by the National Research Council and the Curriculum and Evaluation Standards for School Mathematics by the National Council of Teachers of Mathematics.

Activity Matrix for National Science Education Standards and Curriculum and Evaluation Standards for School Mathematics (Grades 5-8)

	NATIONAL SCIENCE STANDARDS	Unifying Concepts and Processes	Systems, order, and organization	Evidence, models, and explanation	Change, constancy, and measurement	Evolution and equilibrium	Form and function	Science as Inquiry	Abilities necessary to do scientific inquiry	Understanding about scientific inquiry	Earth and Space Science	Earth in the Solar System	Science and Technology	Abilities of technological design	Understanding about science and technology	Science in Personal and Social Perspectives	Science and technology in society	History and Nature of Science	Science as human endeavor	Nature of science	Life Science	Structures and function in living systems	Regulation and behavior	NATIONAL MATHEMATICS STANDARDS	Mathematics as Problem Solving	Mathematics as Communication	Mathematics as Reasoning	Patterns and Functions	Measurement
Navigating a Spacecraft			•	•	•				•			•		•	•				•						•	•	•	•	•
Spacesuit Design			•	•	•		•					•		•	•		•												
Mars Geologic Mapping			•	•	•				•	•		•							•	•									
Mission Meals			•	•	•		•		•	•		•							•								•		•
Hydroponics			•	•	•				•	•		•		•	•		•		•	•									•
Searching for Signs of Life			•	•	•				•	•		•							•	•		•	•						•

Mars

Mars has piqued our curiosity for centuries. The fourth planet from the Sun is one of the more accessible planets to study and send spacecraft to, yet there are still many mysteries surrounding the Red Planet. What happened to the water that once existed on Mars? What resources does Mars have to offer? And, of course, perhaps the most thought provoking question, has there ever been life on Mars?

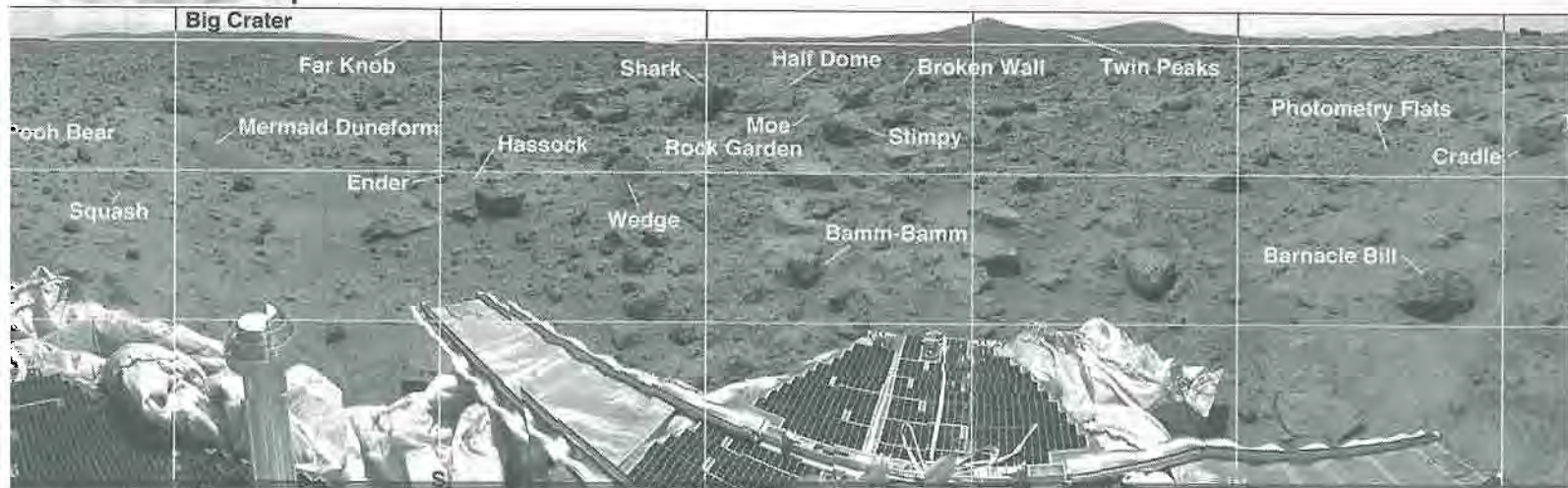
In August 1996, a team of scientists at NASA Johnson Space Center and at Stanford University announced the finding of a Mars meteorite found in Antarctica that could possibly contain bacterial fossils. No definitive conclusions about Martian life were made from the meteorite, but imagine the excitement at the concept that there could be life on another planet. People's imagination about life on Mars was sparked in 1877 when Italian astronomer Giovanni Schiaparelli announced that there were "canali" on Mars. "Canali" means "channels," in Italian, but the word was translated into English as "canals," implying that an intelligent civilization was responsible for having built the canals. While Europe and America became fixated on the possibilities of Martian life, astronomer Percival Lowell, whose first love had always been the Red Planet, became enthralled. When Schiaparelli's eyesight started to fail and he stopped observing Mars, Lowell vowed to continue the work. He drew elaborate maps of the surface of Mars showing an intricate network of canals that carried water from the melting polar caps to the drier equatorial regions. Lowell's beliefs were disproven in 1965 when the Mariner Spacecraft flew by Mars and took pictures. The

pictures showed no signs of life or canals and portrayed an atmosphere that seemed much too thin to support life.

Another Mars alarm occurred on Halloween in 1938 when Orson Welles narrated a science fiction story "The War of the Worlds," by H.G. Wells on the radio. The story described an invasion of Earth by Martians who possessed advanced technology. Millions of listeners, not recognizing the story as fiction, believed Earth was being invaded by Martians.

Over the years, a large amount of scientific data has been collected from Mars. This data has brought us closer to knowing the true nature of the Red Planet and whether or not life as we know it could have existed there. Although the cold, dry conditions on Mars may not support life now, scientists believe that Mars was warmer, wetter, and had a much denser atmosphere early in its history. Life may have existed in ancient Martian lakes or springs. If so, fossil evidence of life might be found.

Of all the planets in our Solar System, besides Earth, we have found Mars to be the most Earth-like. The rocky planet has a thin atmosphere, weather, seasons, and a day that is 24 hours and 37 minutes long. Like Earth, Mars even has two polar ice caps. Mars has a diverse and complex surface that is similar to Earth. The landscape shows unmistakable signs of past water flows over the surface, from branching networks of river channels to islands to great gouges caused by catastrophic flooding, but the liquid water seems to have disappeared. In June 2000, scientists analyzing imaging data from the Mars Global Surveyor came upon a very exciting discovery. They found areas on the



surface of Mars that look like recently formed gullies. Dr. Michael Malin, principal investigator for the Mars Orbiter Camera on the Mars Global Surveyor states that, "The features are so young that they might still be forming today. We think we are seeing evidence of a ground water supply." If liquid water does exist just under the surface of Mars, it could lead to the answer to several exciting questions. For example: could primitive life, similar to that on the Earth, exist on Mars? Is there a source of useable water for future settlements on Mars?

A source of water on Mars would alleviate one of the main problems associated with a long term settlement on Mars, the need to have enough water on Mars for people living there to survive for a long period of time. If a person is to drink about 8 cups of water a day (half a gallon), over 100 gallons would be needed for the seven to eight month trip to Mars. Additional water would be needed for the time spent there and on the return trip. If water can be extracted from anywhere on Mars whether it be the atmosphere or the ground, it would have to be used to drink, grow plants, and broken down to use the hydrogen to make rocket fuel.

In trying to figure out what happened to the water on Mars, scientists study the planet's geology and climatic history. Because there is little atmosphere and no water in liquid form on Mars, there is little erosion. This, coupled with the fact that Mars has no plate tectonics, means that the Martian surface is like a book that has recorded the planet's entire history. We want to know what happened to the water on Mars, because Mars and Earth started out very much alike. Could what happened to the water on Mars happen to Earth someday?

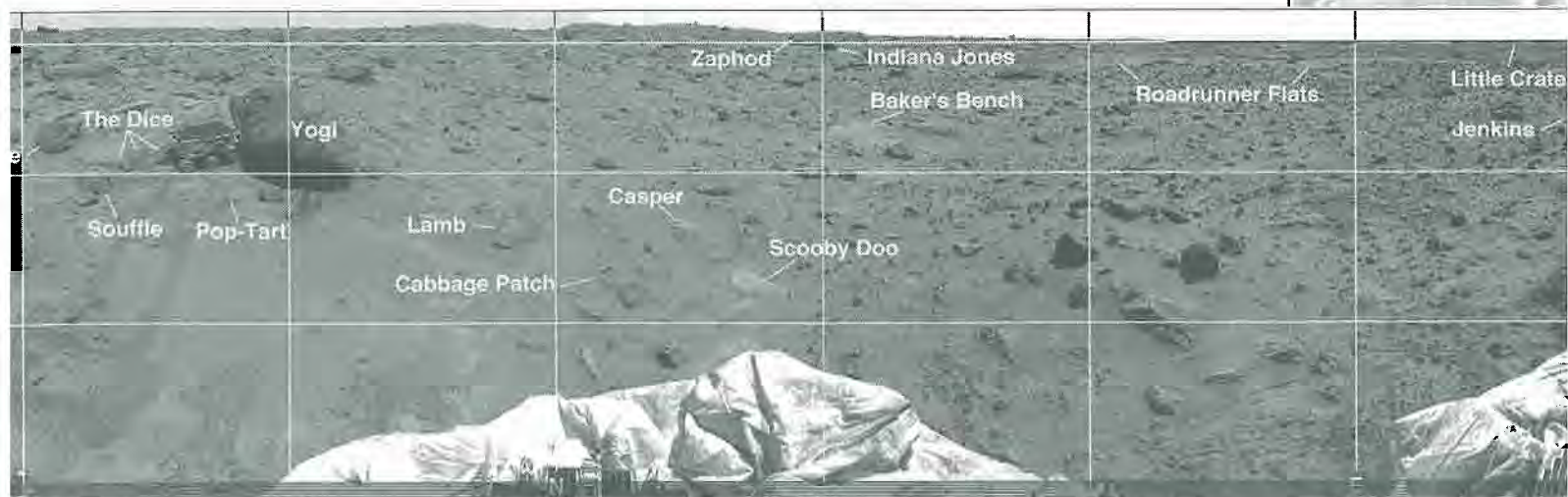
Geologic features lead to more unanswered questions. While Mars is one of the smaller rocky planets—its diameter half the size of

Earth's—some features on Mars are enormous. Olympus Mons (27 km. tall) is the largest known volcano in the Solar System; Valles Marineris is an enormous canyon system that would stretch across the continental United States. Mars seems to have a solid crust—not broken up into multiple plates—with very little movement at the surface.

We will probably see a human mission to Mars in our lifetime, but until we are fully prepared to send humans, NASA will continue with its robotic missions. Viking 1 and Viking 2, each consisting of an orbiter and a lander, launched in 1975 and sent pictures and other information a year later. The Mars Pathfinder Mission was launched in December 1996. The Pathfinder returned a wealth of information, including more than 16,000 images from a lander and 550 images from a rover. The Mars Global Surveyor program has been sending back high resolution images since it went into orbit around Mars in September 1997. The next generation of spacecraft, the Mars Surveyor program, will include an orbiter to carry out remote surface exploration and global studies. It may also include a rover and sample return vehicle.

While information continues to be acquired from the robotic missions to Mars, there are scientists and engineers designing new equipment for travelling to and living on Mars. One new technology being studied is the design of a plasma rocket. A plasma rocket would use gases heated to temperatures high enough to tear the electrons off of atoms. The atoms are then propelled by magnetic fields. A working plasma rocket could cut the travel time to Mars from seven or eight months to slightly over three months.

The continuing Mars missions and research by engineers and scientists will allow people, instead of robots, to eventually live on and explore Mars.



FACT SHEET

Mars

Distance from the Sun: Minimum: 206,000,000 kilometers
Average: 228,000,000 kilometers (1.52 times as far as Earth)
Maximum: 249,000,000 kilometers

Eccentricity of Orbit: 0.093 vs. 0.017 for Earth (0.00 is a perfectly circular orbit)

Distance from Earth: Minimum: 55,000,000 kilometers
Maximum: 401,000,000 kilometers

Year: 1.88 Earth years = 669 Mars days (sols) = 687 Earth days

Solar Day: 24.7 hours

Tilt of Rotation Axis: 25.2° vs. 23.5° for Earth

Size: Diameter: 6,789 kilometers vs. 12,756 kilometers for Earth

Surface Gravity: 0.4 (or ~1/3) Earth's gravity

Mass: 6.4×10^{26} grams vs. 59.8×10^{26} grams for Earth

Density: 3.9 grams/cm³ vs. 5.5 grams/cm³ for Earth

Surface Temperature: Cold

Average Surface Temperature: -63°C (-81°F)

Typical Range of Surface Temperature: -130°C (-200°F) to 25°C (75°F)

Atmosphere: Thin, unbreathable

Surface pressure: ~5.6 millibars, or about 1/150th of Earth's

Contains 95% carbon dioxide, 3% nitrogen, 1.5% argon, 0.1% oxygen, ~0.03% water (varies with season). Earth has 78% nitrogen, 21% oxygen, 1% argon, ~1% water 0.03% carbon dioxide.

Dusty, which makes the sky pinkish. Planet-wide dust storms periodically arise.

Surface: Color: Rust red

Ancient landscape dominated by impact craters

Largest volcano in the Solar System (Olympus Mons)

Largest canyon in the Solar System (Valles Marineris)

Ancient river channels

Some rocks are basalt (dark lava rocks); most others unknown

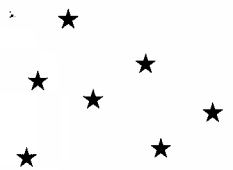
Dust is reddish, rusty, like soil formed from volcanic rock

Moons: Phobos ("Fear"), 27 x 22 x 18 kilometers

Deimos ("Panic"), 15 x 12 x 10 kilometers

MARS, THE RED PLANET, has not always had its name.

When the Babylonians wrote about Mars 3,600 years ago, it was referred to as one of the five "stars that wandered." In later history, the ancient Greeks called the Red Planet "Ares" after their god of war. When the Romans conquered Greece, they changed the name to their god of war, "Mars".



Mapping Out a Trip to Mars

Objectives

Students will:

- Create a thinking web
- Explain their knowledge of Mars

Overview

Brainstorm and create a Thinking Web that demonstrates students' knowledge of Mars and space travel. This is an opening exercise to introduce Mars to students and to assess prior knowledge.

Key Questions

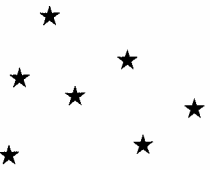
- Why visit Mars?
- What would one need to bring for a long visit to Mars?
- Given the chance to visit Mars, what would you study?

Procedures

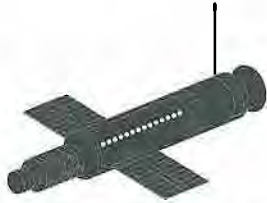
1. Reproduce student worksheet and give each student a copy.
2. Have students complete each question on the map and encourage them to draw illustrations to go with their answers.
3. You can use the students' answers as an informal method to assess prior knowledge by starting a class discussion. Students' answers will vary. Below are some examples of where to lead the discussion:

Examples of Student Responses	Discussion Points
I would bring a portable headset or computer game.	Discuss the life of batteries and recharging facilities.
I would pack a lot of pizza, or other food products.	Discuss refrigeration, cooking, and preservation of food.
I would take lots of clothes.	Discuss the environment and safety of a spacesuit
I would look for Martians.	Discuss what is life and how you might find it.
I would study the face on Mars.	Compare and contrast the difference between real objects and photographs
I would go and visit Sojourner.	Discuss past Mars missions and the use of technology.
I would visit Mars because no one has ever been there.	Discuss how curiosity about the unknown leads to exploration.





Investigating Mars



On a Trip to Mars I would take . . .

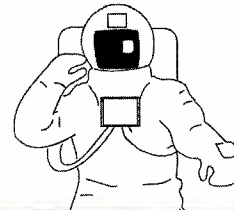


If I went to Mars I would study . . .

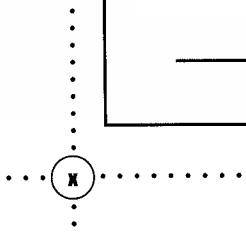
VOYAGE TO MARS



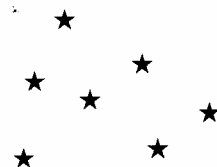
I would like to visit Mars because . . .



I know Mars has/is . . .



Navigating a Spacecraft



Background

If you've ever played a sport in which you had to throw a ball to someone who was a moving target, then you can relate to the difficulties of a rocket launch from Earth to Mars. You must throw the ball at exactly the right speed and assume where the catcher will be according to his or her running speed. In the same way, a launch from Earth to Mars must consider the speed of the spacecraft and the speed of Mars in its orbit around the Sun. To add to the complication, Earth too is moving in orbit around the Sun at a different speed. The Earth completes its solar orbit every 365 days while a Martian orbit takes 687 days. This happens for two reasons. The Earth travels faster than Mars and it orbits closer to the Sun, so it has less distance to cover.

The launch must take place when the two planets align with one another which happens every two years. Another launch factor is the rotation of Earth. The launch site must be facing the right direction. Imagine spinning in circles and having to throw the ball to the moving catcher. The ball would need to leave your hand when you are facing a certain direction in order to land in the right place.

While the launch date and time are crucial to a mission's success, survival is another major consideration for a long-duration human mission to Mars. The trip would take six months each way. During this travel time, the crew is exposed to weightlessness, radiation, and other dangers inherent to space travel. One answer to these hurdles may be to make the trips faster. However, there is a tradeoff. A faster trip would result in less exposure to radiation and other dangers, but would demand greater amounts of fuel. One might think of a long journey in a car. Driving faster will use more gas, but time will be saved. Engineers must balance speed with fuel requirements and choose the most efficient, cost-effective plan.

Topic

Plotting Trajectory

Objectives

Students will:

- Compare and contrast the location of Earth and Mars as they orbit around the Sun.
- Use data to plot the paths of spacecraft leaving Earth in the year 2018 for Mars and leaving Mars in 2020 for Earth.

Overview

In this activity students work in pairs to plot the paths (trajectories) of a spacecraft traveling between Earth and Mars in the year 2018 and returning in 2020. These paths use the minimum amount of fuel, and take about six months to travel from one planet to the other.

Key Question

What factors need to be considered when planning a mission to and from Mars?

Key Concepts

- Travel time, distances involved, and location of planets.

Materials & Preparation

- Student Procedure page *Plotting the Paths of Spacecraft*
- Student Sheets, *Earth to Mars* and *Mars to Earth*
- A drawing compass for each group
- Teachers Answer Key

1. Have students share familiar experiences that require aiming at a moving target. Their examples might be passing a football, catching a fly ball, driving vehicles to avoid being hit, or playing dodge ball. Lead students to discuss the how and why of the movements.
2. Have students work in pairs. They may switch jobs for each plotting exercise.

3. Hand out Student Procedure and Student Sheets.

4. Help students become familiar with the data. Check for understanding. It is essential that students understand that Earth and Mars are moving and that the tick marks on the Earth orbit represent the first of each month.

5. Help students plot the first date: June 1, 2018.

Note: When plotting the distance from the Sun, the compass point is always put on the Sun; when plotting the distance from Earth, the compass point is put in a different place each time. The point should be put on the tick mark that represents where the Earth will be located on that date.

6. Make answer keys available to students so they can check their work. If their orbits are not similar to the answer key, encourage them to redo the procedures to find out why they are different.

7. Instruct students to apply the same procedures to plot the return to Earth.

8. Closing discussion should encourage students to think about how a six-month flight affects planning trips to Mars.

Management

This activity can be completed in one class period. Reproduce student sheets and answer keys for students.

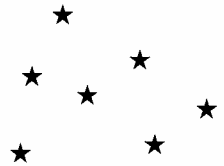
Reflection & Discussion

1. What are the orbital challenges of traveling from one planet to another?
2. What could make a spacecraft get to Mars faster?
3. What are some of the problems considered by engineers and scientists as they design trips to Mars?

Transfer/Extension

1. A minimum fuel round trip between Earth and Mars would take about one year. How would this affect planning a trip to Mars? Because of this long time in space, what must happen? What cannot happen? What might happen? These are the questions that mission planners must answer. What are other questions that might be asked about planning trips with minimum fuel orbits?
2. Research and discuss why the trajectory is not a straight line.

Navigating a Spacecraft



Key Question

What factors need to be considered when navigating a spacecraft on a mission to and from Mars?

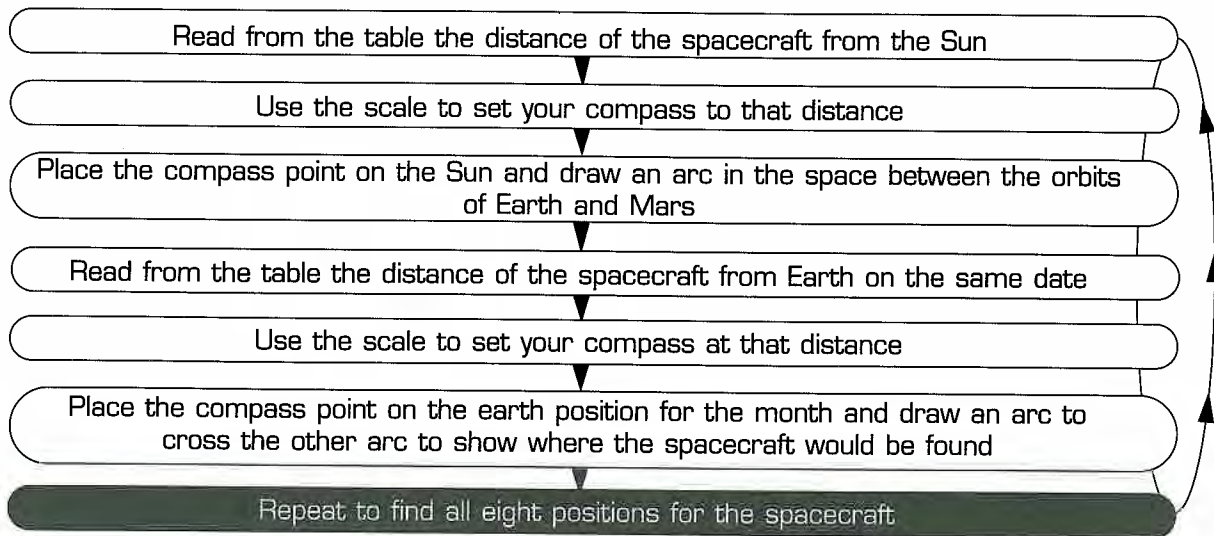
Introduction

If you wish to travel from one planet in orbit around the Sun to another, you cannot go in a straight line. This activity shows how we can find the actual path travelled by the spacecraft on its way to and from Mars

Student Procedures

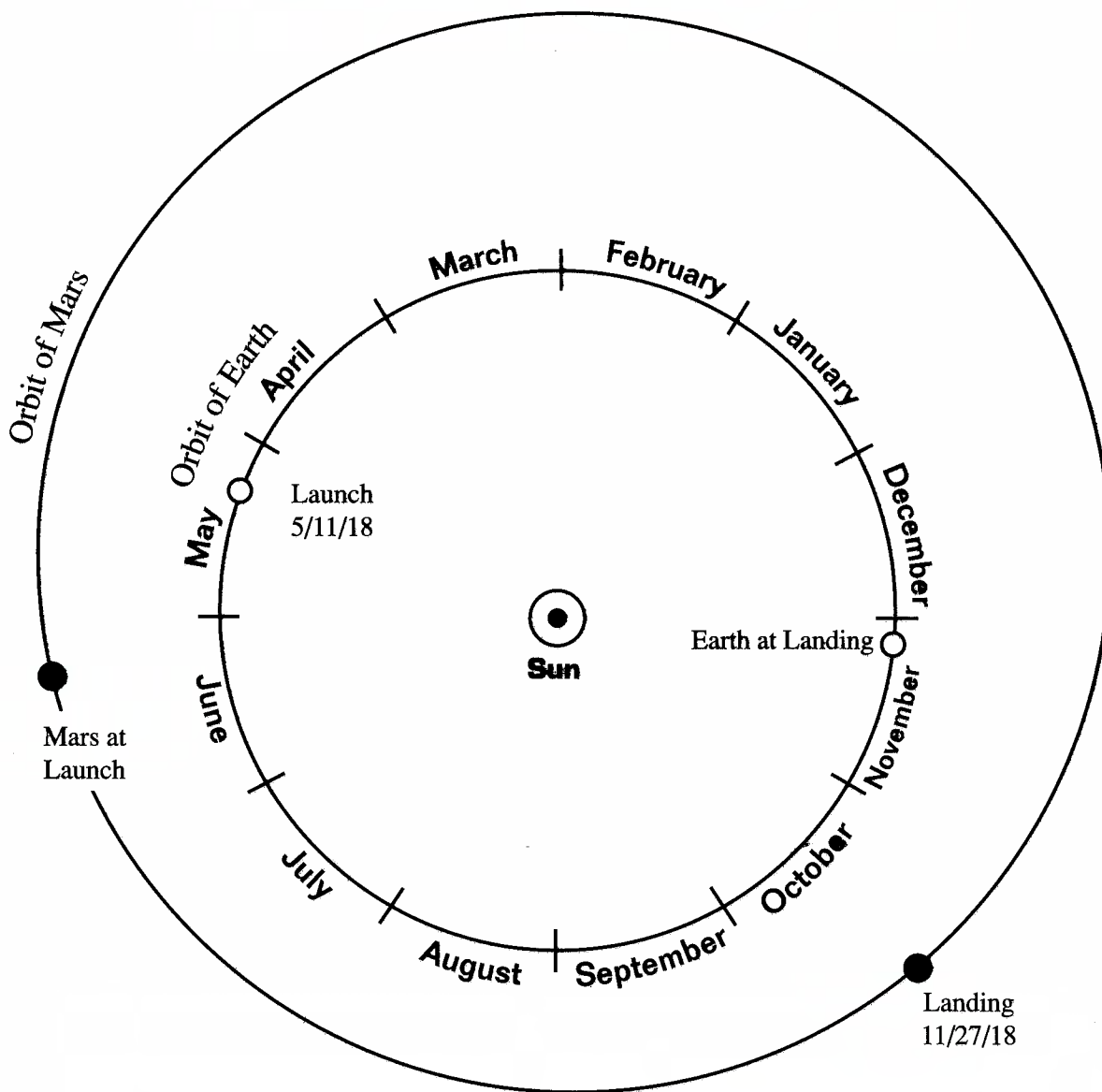
1. Locate the following on the Earth to Mars Student Sheet:
 - Earth and Mars orbital paths
 - The Sun
 - Earth and Mars positions on launch date
 - The scale in millions of kilometers (km)
 - Earth and Mars positions on landing date
 - The location of Earth on the first day of each month

2. Perform the following steps for each date in turn:



3. Draw a smooth curve through the points to show the spacecraft trajectory.
4. Apply the same method to plot the trajectory for the return journey using the data about the return trip from Mars to Earth.

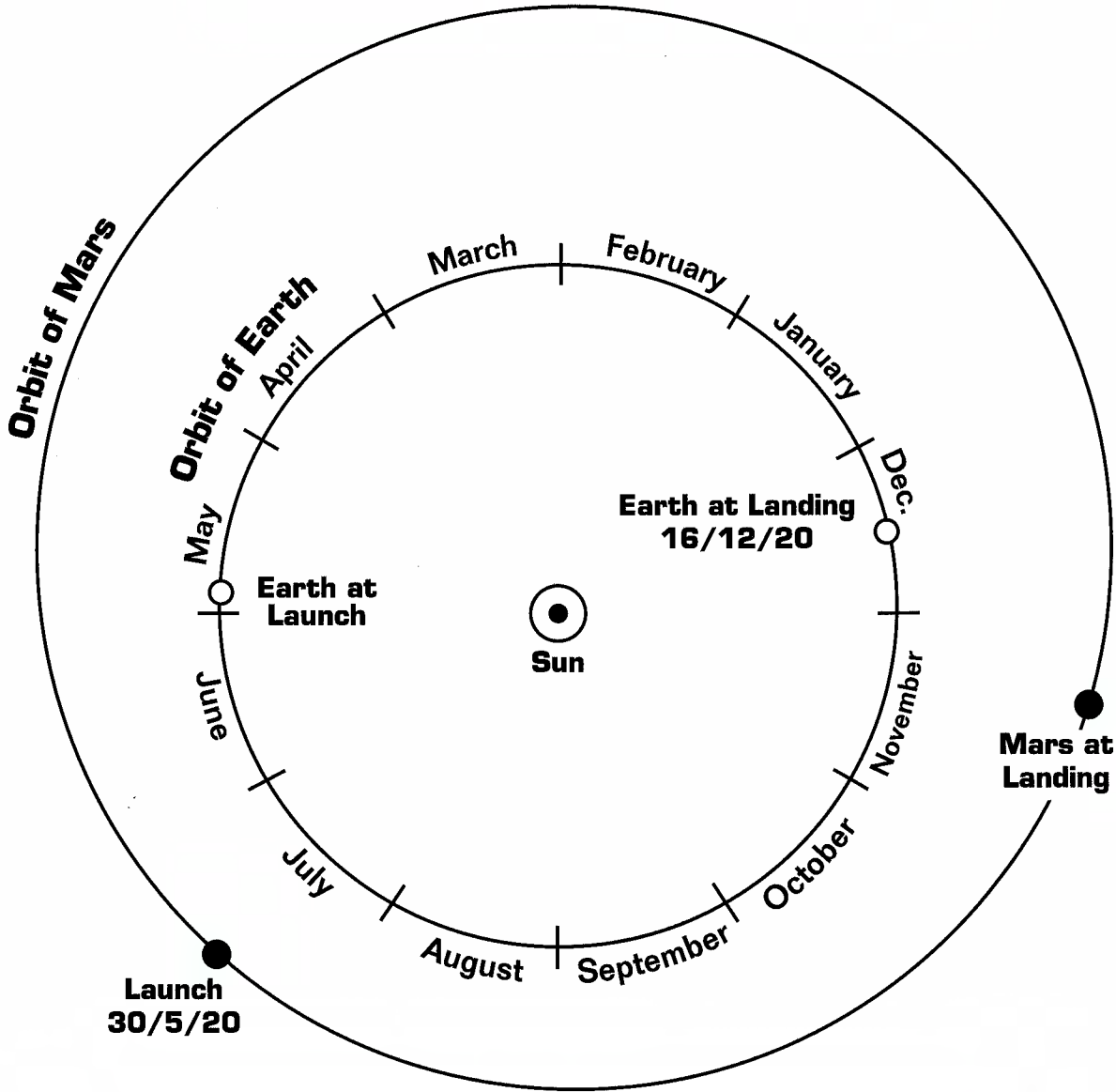
Earth To Mars



Data Table

Date	Distance from Sun (million km)	Distance from Earth (million km)
May 11, 2018 (Launch from Earth)	150	0
June 1	163	18
July 1	167	28
August 1	175	40
September 1	182	53
October 1	191	70
November 1	207	92
November 27 (Landing on Mars)	216	143

Mars to Earth



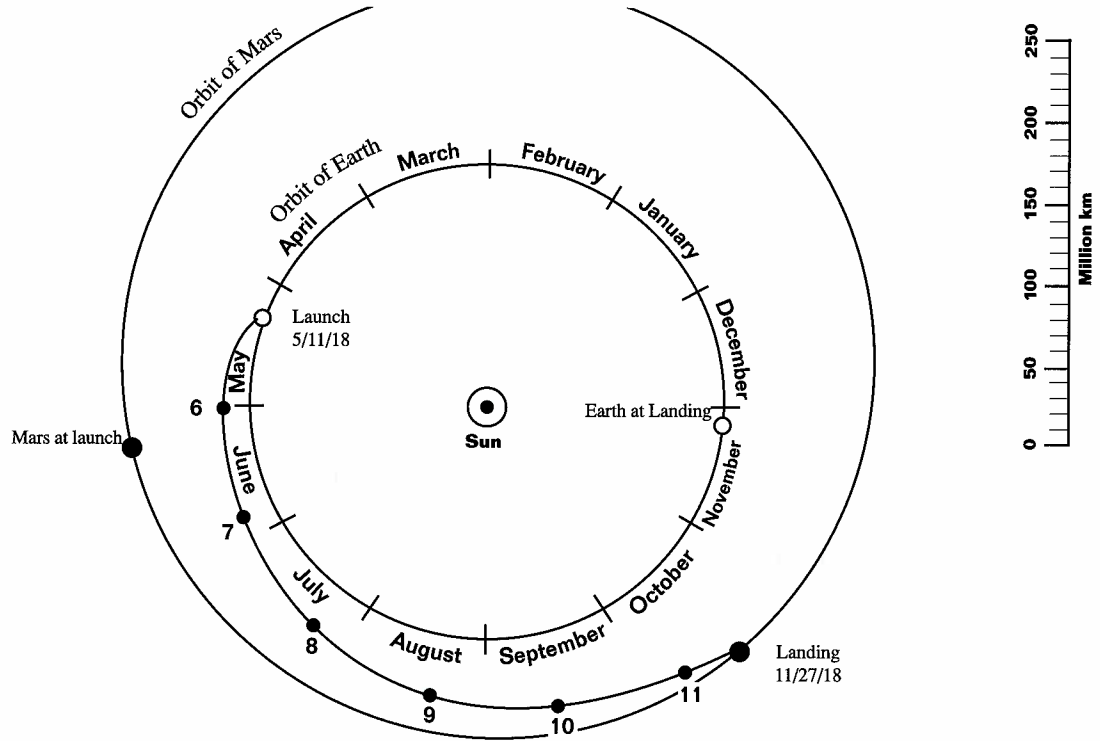
Data Table

Date	Distance from Sun (million km)	Distance from Earth (million km)
May 30, 2020 (Launch from Mars)	206	155
July 1	198	117
August 1	193	92
September 1	192	73
October 1	191	52
November 1	182	40
December 1	158	15
December 16 (Landing on Earth)	147	0

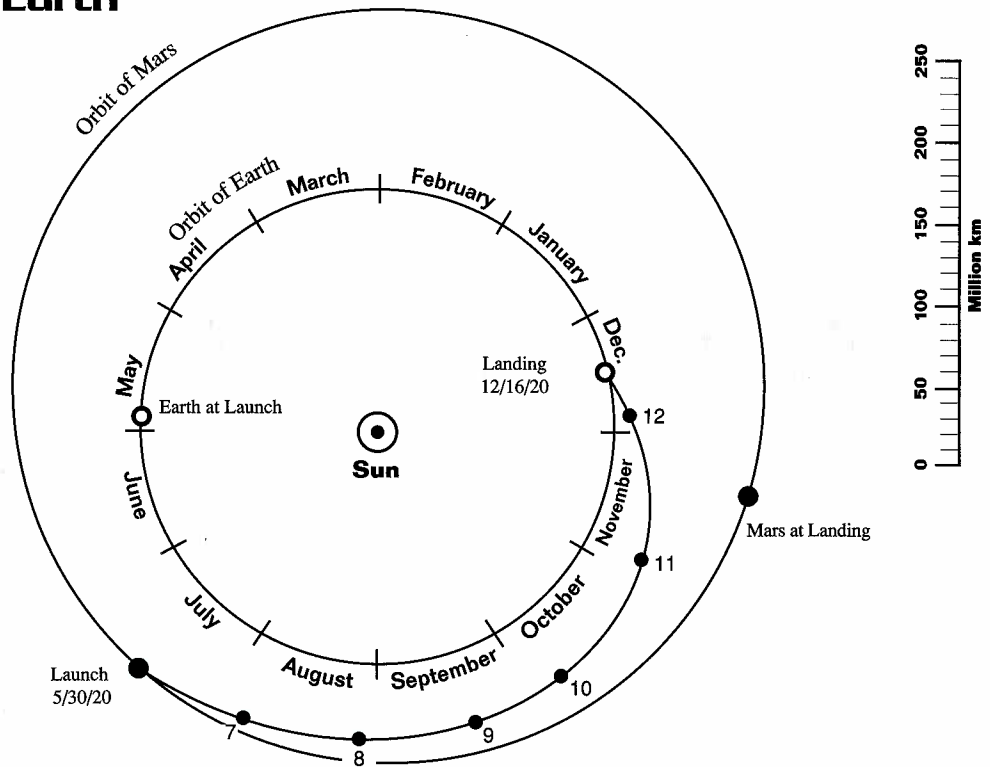


Answer Key

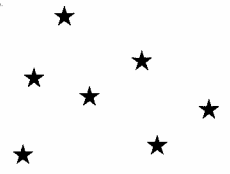
Earth to Mars



Mars to Earth



Spacesuit Design



Background

When traveling to a land of warmer or colder climates, one considers what clothes to pack for these environmental conditions. If the destination happens to be the top of Mt. Everest or the bottom of the ocean floor, the change in conditions must be accounted for. At the top of Mt. Everest, climbers bring oxygen to breathe, dress for extreme weather, and take weeks to acclimate to higher elevations. In the same way deep-sea divers must consider changes in environmental conditions as well. But what happens when a human leaves the Earth? What environmental needs must be brought along?

Space travelers wear a spacesuit in order to bring along elements of Earth's environment needed for survival: oxygen, appropriate air pressure, moderate temperatures, and protection against the Sun's rays. On Earth, our atmosphere absorbs much of the Sun's harmful rays. In space and on planets with thin atmospheres there is little protection from the Sun's harmful rays. The spacesuit provides this protection for astronauts, keeping them safe from radiation. Harmful radiation can result in skin damage, hair loss, vomiting, cataracts, infertility, cancers, birth defects, and death.

The vacuum of space is another harsh environmental condition. An unprotected body that is exposed to the vacuum of space quickly perishes. Fluids in the body quickly begin to boil from the lack of air pressure. Bubbles would form in the bloodstream and tissues. Capillaries and other fragile tissues would rupture, and newly formed gases would begin to diffuse out of the body into space. Skin and tissue would retain gases for a time, resulting in a condition that looks like swelling. As the gases exit the body it becomes "freeze-dried." The lack of oxygen would render the unfortunate individual unconscious in 15 seconds. Permanent brain damage would occur in as little as 4 minutes, and death would follow shortly thereafter.

Also the temperatures in space are extreme. At low temperatures, the human body suffers from hypothermia. In very warm environments, the body suffers heat exhaustion or heat stroke. Physical and mental abilities become impaired. Within the shade of a planet or a space structure, temperatures can drop below -100° C. On the sunlit side of objects in space (at Earth's distance) temperatures can climb to over 120° C. Debris from other space missions, as well as meteroids, travel at high enough speeds to damage spacesuits and spacecraft.

Topics

Spacesuit Design
Mars Environment
How spacesuits must be adapted depending on the planetary characteristics

Objectives

Students will:

- Research the environment of Mars.
- Identify necessary spacesuit features for Mars.
- Analyze necessary spacesuit features for Mars.
- Make decisions about necessary spacesuit features for Mars.
- Conceptualize necessary spacesuit features for Mars.
- Design a blueprint of a Martian spacesuit.
- Use criteria to determine whether a spacesuit offers enough protection on Mars.

Overview

Teams will analyze conditions on Mars to evaluate and establish criteria for designing spacesuit features and then draw and label a spacesuit design.

Key Question

What functions does a spacesuit need to have for a mission to Mars?

Key Concepts

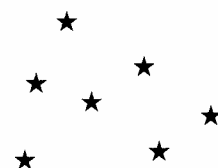
- Space is a hostile environment that cannot support human life.
- Humans must have oxygen, air pressure, moderate temperatures, and protection from space debris and harmful radiation in space to survive.
- The spacesuit must also provide features to handle body functions and communicate with the crew on board the spaceship.
- Spacesuits function to bring part of Earth's atmosphere to space with the astronaut. They allow humans to survive in environments that have little or no air, extreme temperatures, little or no atmospheric pressure, harmful solar rays, and space debris. (See background for details.)

Materials & Preparation

- Student Sheets
 - Assorted drawing materials
1. Use a thinking web for students to discuss harsh environments on Earth (e.g., the desert, at the top of Mt. Everest, the deep sea, Antarctica, etc.). Describe what makes each place inhospitable to humans, adding lines to the appropriate circles for each place. How do humans adapt to live in these harsh environments?
 2. Use a thinking web to describe the harsh environment of space.
 3. Compare and contrast harsh environments on Earth to those of space using a Venn diagram.
 4. How does the Space Shuttle spacesuit allow astronauts to adapt to the harsh conditions of space? Discuss the Spacesuit Fact Sheet.
 5. **Conditions on Mars:** Use the Mars Sheet at the beginning of the book to identify inhospitable conditions on the Red Planet. Students need to identify these conditions on Mars so they can plan spacesuit features to counteract these conditions. Use the *Conditions on Mars* chart on the Student Worksheet.
 6. **Pick a Mission:** Students are now ready to design a team spacesuit to function on Mars. Organize students into teams. Tell them that each team needs to pick a mission where astronauts will perform specific tasks. Have

them define the types of tasks they will need to do on their mission. Here are some suggested missions, but students can research and come up with their own:

- Climbing and rappelling in the canyon Valles Marineris to do geological surveys.
 - Flying to the top of the giant volcano Olympus Mons to study the caldera.
 - Examining rocks and digging for fossils on what appears to be a dry river channel.
 - Going to the poles to cut ice and melt it for water.
 - Tinkering with Mars Sojourner or one of the Viking landers to get it to run again.
7. **Spacesuit Design Criteria:** Based on the mission each team chooses, they should design a spacesuit that will function safely on Mars and perform specific tasks. Spacesuits need to:
 - Function on Mars.
 - Have features needed to accommodate human body functions.
 - Take into account Mission Control needs.
 - Allow astronauts to perform mission tasks.
 8. **Body Functions:** Have students focus on body functions that the spacesuit needs to accommodate using a thinking web to brainstorm. Then have them identify the most important spacesuit features needed to meet each body function using the *Spacesuit Features for Body Functions* chart.
 9. **Mission Control:** Mission Control plays a critical role in keeping astronauts safe and helping them complete tasks during extra-vehicular activities (EVA's), or spacewalks. Spacesuits need to have special features so that Mission Control can be sure the suits are functioning well. They also need to communicate with and identify the astronauts. Note that if the astronauts are far away (e.g. Mars), there will be a substantial time delay between when communications are transmitted and when they are received. Depending on where Mars is in its orbit, the delay could be between 5 and 20 minutes. Have students make a thinking web of



interactions Mission Control must have with the astronauts and the conditions they need to monitor. Again, pick the most important features in the *Spacesuit Features for Mission Control* chart.

10. Have students go through the two charts for Body Functions and Mission Control. Circle the top ten functions their spacesuit designs need to accommodate. List the spacesuit features that will address them in the *Master Spacesuit Parts* chart. Do the items on the list address the inhospitable conditions on Mars completed in the first chart?
11. Now teams are ready to design their spacesuits. Have each team draw a blueprint of their spacesuit and label the parts.
12. Have the class discuss the appropriateness of each suit, giving positive feedback and suggesting any improvements needed. Compare and contrast their suits with the Space Shuttle spacesuits using a Venn diagram.

Management

This lesson can be done over two to five class periods, depending on how involved you want your students to be in the spacesuit design. Students should complete the spacesuit features for Mars in the first class and features for the body and Mission Control in the second. Use one to two classes to work on blueprint designs. The last session should have students share their designs and make comparisons to the Space Shuttle spacesuit.

Reflection & Discussion

1. Why do humans need to wear spacesuits on Mars? *Humans must have air, atmospheric pressure, moderate temperatures, and protection from Martian dust.*
2. How is movement in space different from movement on Earth? *It depends where you are in space. On the Space Shuttle, which feels like a gravity-free environment, everything seems to float, so you have to change the way you do things.*

3. What does a spacesuit have to include? *Spacesuits must have systems for breathing, air pressure, temperature control, walking, identification, and food storage, among others.*
4. How can a spacesuit make work harder to complete? *Spacesuits are bulky because of the many systems they carry. The pressure inside the suit can make the suit stiff and hard to bend.*
5. Why don't astronauts have to wear spacesuits inside of a spacecraft? *The spacecraft provides the necessary oxygen, temperature, and air pressure while astronauts travel inside it.*
6. How does a spacesuit worn in space differ from those needed for Mars? *Spacesuits for Mars must function in temperatures that do not rise above freezing. Fine dust particles could affect visibility and leak into suit joints. Mars has some atmosphere, but the suit will still need to supply oxygen.*

Transfer/Extension

1. Design spacesuits to accomplish specific activities on Mars: taking soil samples, climbing canyons, operating a Martian rover, and assembling habitats.
2. Spacesuits have similar features to the suits worn by deep-sea divers. Have students compare and contrast the components of deep-sea diving suits and spacesuits.
3. Take students to a local museum to see a real spacesuit, or surf the Internet for pictures of real spacesuits. See the websites listed at the end of the activity guide.
4. Have students research the history of the spacesuit and compare and contrast the first spacesuit to those worn by astronauts today.
5. Conduct spacesuit activities from "Suited for Spacewalking," by NASA, 8 from NASA Spacelink at: <http://spacelink.nasa.gov>.
6. Compare and contrast the differences between Russian and American spacesuit designs.

Space Shuttle Spacesuit

Helmet

- has a hard shell to protect against space debris.
- has lamps for light to see in the dark.
- has special glass to keep out harmful solar rays.
- has a microphone and listening piece for communication.

Food Bar & Drink Bag

- are built in to the side of the helmet in case astronauts get hungry or thirsty. The food is wrapped in edible paper.

Gloves

- have layers to protect against space debris and keep astronaut warm or cold.
- are flexible for working.

Space Boots

- are airproof and insulated to protect feet.
- have special soles depending on where astronauts will walk.

Pressure Control Garment

- looks like long underwear.
- inflates to create pressure.

Temperature Control Garment

- looks like long underwear.
- has many layers for warmth.
- has tubes of flowing water to take away extra heat.

Hard Outer Torso

- has a top and bottom that connect to be airproof.
- is made of many layers to keep astronaut warm and safe from space debris.

Display and Control Module

- has buttons for power and to monitor all spacesuit functions.

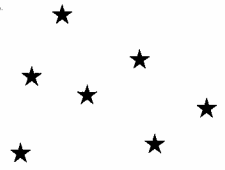
Life Support System

- has oxygen tanks and power battery.
- can fasten to a mobility unit that lets astronauts move around.



STUDENT WORKSHEET

Martian Spacesuit



Student Procedures

1. Research the conditions on Mars and complete the chart below.

Conditions on Mars	
Condition	Problem
Write a phrase to describe the conditions on Mars.	Describe what the condition does to the human body.
Atmosphere?	
Space debris?	
Temperature?	
Pressure of Atmosphere?	

2. Brainstorm and create a thinking web for body functions that will need special spacesuit features.
3. List the body functions and spacesuit features in the chart *Spacesuit Features for Body Functions*.

Spacesuit Features for Body Functions	
Body Function	Spacesuit Part
Use an -ing word (For example: Seeing).	List the spacesuit part to take care of the function.

4. Brainstorm and create a thinking web for Mission Control spacesuit needs.

STUDENT WORKSHEET

5. List the Mission Control needs and the spacesuit features on the *Spacesuit Features for Mission Control* chart.

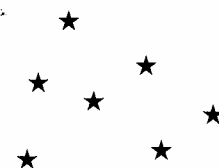
Spacesuit Features for Mission Control	
Mission Control Issue List conditions Mission Control needs to monitor.	Spacesuit Part List a spacesuit part to take care of the function.

6. Look at all three charts. Go through each chart and put an "x" by each spacesuit feature that you list more than once. Complete the *Master Spacesuit Parts* chart.

Master Spacesuit Parts	
Spacesuit Part List at least ten spacesuit parts you will draw.	Part Features Describe the features and function of each part.

7. Draw a diagram of your spacesuit design. Be sure to label all the parts and explain their function. Attach a page with the name of your team members and the date. Describe your mission to Mars.

Mars Geologic Mapping



Background

What does the top of your desk look like? Are there random piles of papers or is everything precisely filed away in a tidy fashion? How far back in your history can you go by just looking at the top of the desk? In a way, we can tell a lot about a person's personality and habits and even history by looking at the top of his or her desk. In the same way, we can tell a lot about a planet, such as Mars, by mapping out its surface.

Studying "superposition" allows scientists to study the layers on the surface of Mars to help determine which events occurred in what order and which areas are older than others. Most of the time younger geologic features are on top of older geologic features. Scientists called photogeologists study surface images of planets to find out the age and geologic history of a planet.

By studying other planets, we can learn more about our own planet. Each world is unique with its own weather patterns, atmosphere, and surface conditions, yet all the different characteristics arise from the same laws of nature. Since all of the planets were formed at the same time, studying their characteristics is like looking at a scrap book of the family of planets to which Earth belongs.

Topics

Geologic History of Mars

Feature Mapping

Comparative Planetary Geology

Objectives

Students will:

- Interpret photographic details of a Martian surface image.
- Design and create a simple features map.
- Interpret the geologic history of a part of Mars' surface.
- Analyze and discuss the sequencing of Mars' geologic history.

Overview

Students will approach studying the surface of Mars in the same way as photogeologists. After drawing a simple features map, they will have the tools to state the general geologic history of a part of Mars' surface. Students focus on the evidence showing river channels that once flowed and caused erosion.

Key Question

How can we determine the geologic history of Mars?

Key Concepts

- By studying features in relation to one another, the relative geologic age can be inferred.
- Comparing features on Earth to similar features on Mars, we can infer the origins of the feature and the geologic history of the area.

Materials & Preparation

- Photo of Mars' surface showing outflow channels emptying into northern plains of Chryse Planitia. Photo also available on the World Wide Web at: <http://cass.jsc.nasa.gov/expmars/channels.html> (provide enough photos for each pair of students)
- Transparencies, one per group
- Clear tape
- Map of Mississippi River Delta or a local river delta
- Color overhead markers (red, green, and blue needed for each group)

Procedures

1. Secure a transparency to the top of the Mars photo with transparent tape.
2. Tell students that this is a spacecraft photograph of an area on Mars around 20 N latitude and 55 W longitude, at the northern edge of Chryse Planitia. The image shows

impact craters and river channels. The area is about 200 kilometers across.

3. Show students an example of a crater with a continuous, sharp-edged, unbroken rim. Note that they should draw the rim and not the fairly flat interior. See drawing on student sheet.
4. Have students carefully outline the rims of all sharp-edged craters with the red marker.
5. Show students an example of a crater with an uneven, eroded, broken rim. See student sheet.
6. Have students carefully outline the rims of all eroded craters with the green marker.
7. Show students an example of a river channel.
8. Have students color (not outline) all channels blue. They may try to show both sides of the channel. Have them put a single line in the middle of the channel.
9. Have students lift the transparencies and examine them. Ask the student what they have made.

Management

- Attach transparencies to the top of each map before class using transparent tape
- Become familiar with the important features in the Mars photo.
- This activity can be modified for individuals, pairs, or large groups. This activity should take one class period.

Reflection & Discussion

1. Which are older: river channels or green craters? How do you know?

Green craters are older. When a river channel met a green crater the water broke through the rim, entered the crater, broke out somewhere else, and kept going.

2. Which are older: river channels or red craters? How do you know?

River channels are older. When an impact formed a red crater on top of a river channel the crater covered the channel, but the crater was not eroded.

3. Classify the features by their age (oldest, medium age, youngest).

Green craters are oldest, river channels are of medium age, and red craters are youngest. Based on the data from questions 1 and 2, the green craters were there before the channels, and the channels were there before the red craters.

4. What caused the difference in size between the young craters and the older craters?

Most of the big meteorites hit a long time ago. Later, mostly smaller meteorites were left. The earlier meteorites were very large pieces of planetary material that were still being pulled together through the process of Solar System accretion (gathering of material into planetary bodies). As time passed, the impacts were caused by the smaller pieces of material left over from the accretion process, thus making smaller craters.

5. Does the land slope? If so, explain why and in which direction.

The land slopes downwards from the west to the east. River channels combine as you go downhill. A map of the Mississippi River or some other terrestrial river basin may be used as a comparison. These Mars channels do not show a delta formation as some may suggest.

6. How does the surface of Mars compare to the surface of Earth?

Students answers will vary.

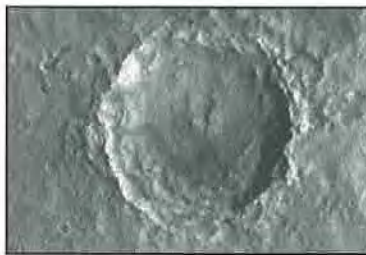
Transfer/Extensions

1. Have students find other images of Mars' surface on the World Wide Web. Create feature maps for these areas and determine their geologic history.
2. Have students find images of Vallies Marenaris and the Grand Canyon on the World Wide Web and compare them.

Mars Geologic Mapping

The area in the image of Mars is about 200 kilometers across and shows impact craters and river channels. Mark each feature on the photograph using the examples below.

- Craters with continuous, sharp-edged, unbroken rims. Outline the rims of each one with a red marker.
- Craters with uneven, eroded, broken rims. Carefully outline the rims of all such craters with a green marker.
- River channels. Color (do not outline) all channels with a blue marker.



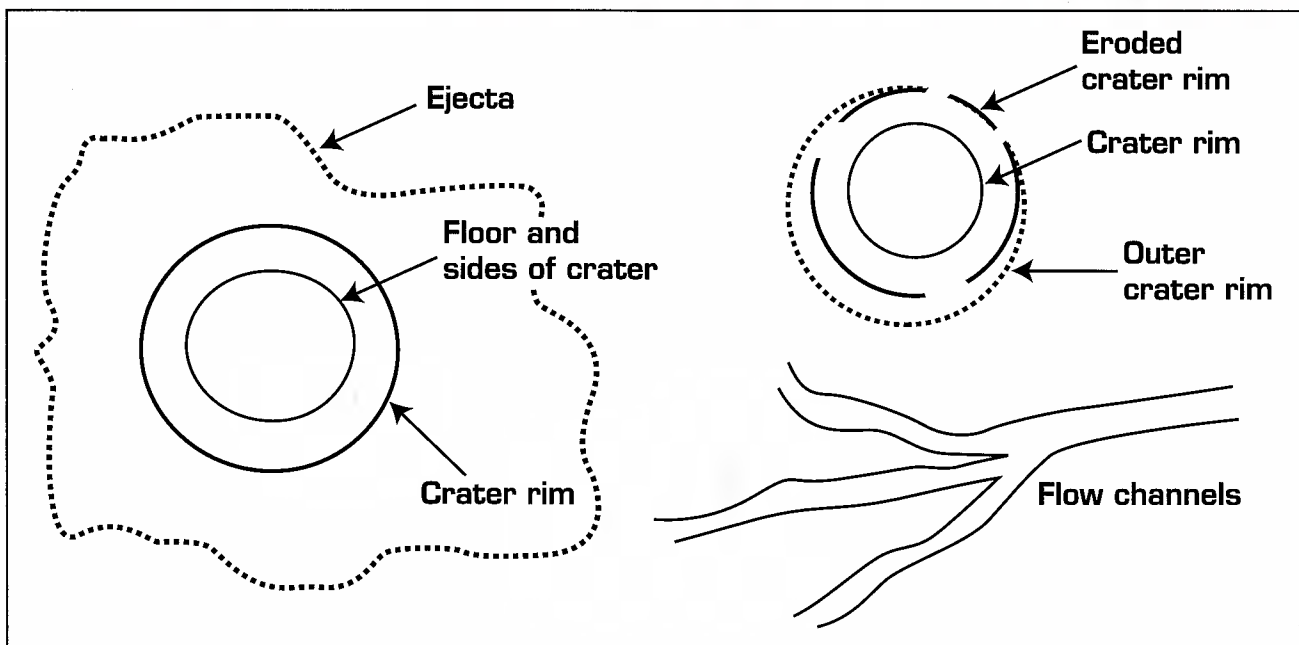
line in red



line in green



line in blue



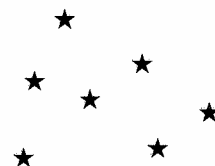
STUDENT WORKSHEET



Chryse Planitia

TEACHER'S GUIDE

Mission Meals



Background

We may take for granted our daily intake of food. To many of us here in the United States, food is easy to come by, easy to transport, and easy to prepare. But what if a person is traveling to the Moon or to Mars. What is taken into consideration for a long car ride? Packing food that will not go bad, that will be nutritious, and will taste good is important. Providing food for astronauts on space travel offers some unique challenges. All of the food would need to be planned for in advance; there needs to be little or no preparation. Astronauts have an extremely limited amount of space, and weight must be taken into account as well; the food must be light-weight. The food for space travel is prepared to meet these demands. Dehydrating food is one way to meet these criteria. Another advantage is that most of the vitamins stay intact, which is imperative for the nutritional needs of an astronaut.

Each day the human body requires a balanced diet of a variety of foods to ensure health. This balanced diet includes a variety of nutrients: 6 to 11 servings of carbohydrates, 2 to 4 servings of fruit, 3 to 5 servings of vegetables, 2 to 3 servings of proteins, 2 to 3 servings of dairy products (or other source of calcium), and a minimal amount of fats, oils, and sweets. Meeting the daily needs of nutrition for the human body while keeping food light-weight and tasting good are all challenges in planning meals for astronauts who will spend a long period of time in space. To meet the challenge of planning mission meals, NASA prepares food in five different ways. They are:

1. Rehydratable (all water has been removed), for example, scrambled eggs.
2. Thermostabilized (heat processed or cooked at moderate temperature and sealed in cans), for example, peanut butter.
3. Irradiated (preserved by exposure to ionizing radiation), for example, breads, rolls, meat.

4. Intermediate moisture (process where part of the water has been removed), for example, dried fruit.
5. Natural food (packaged without any additional processing by NASA), for example, nuts and cookies.

Topics

Food preservation
Menu planning

Objectives

Students will:

- Calculate the percent of water found in a fruit/vegetable slice.
- Plan a well-balanced mission meal of space food using the Food Pyramid and the existing Shuttle Foods List.

Overview

Students will plan meals needed for a voyage to Mars. They will decide what types of foods are lightweight but nutritious and easy to prepare. Students will also determine how and why food is preserved. Using the Food Pyramid and the Shuttle Foods List, students will prepare a five-day mission menu for a balanced diet.

Key Question

Why is dehydration used to prepare some foods for space travel?

Key Concepts

- By removing water from some foods, they take up less room for space travel, and are preserved for longer missions.
- Each day humans need a variety of foods for a balanced diet.
- The suggested servings needed to make a balanced diet are supplied by the USDA's Food Pyramid.

Materials & Preparation

- Various fruits and vegetables (apples work best)
- Several .5 meter pieces of string and/or wax paper
- A paring knife
- Small paper clips
- Paper towels
- Balances
- Student Sheets
- Food Pyramid
- Shuttle Food List
- Space Shuttle menu

Part 1: Rehydratable Food

1. Begin the discussion by asking the class to describe the kinds of food they typically eat. Compare the kinds of food they eat for lunch with the kinds of food the astronauts eat. Astronauts generally eat foods such as trail mix, dehydrated potatoes, and dehydrated meats. Why does food that is eaten in space need to be different than the food we eat on Earth?
2. Explain that about one-third of the food eaten on the Space Shuttle is rehydratable. When food is dehydrated, the water is removed. Ask students why astronauts use food prepared in this way and other ways such as thermo-stabilized, irradiated, and intermediate moisture. Before rehydratable food is eaten, the water is replaced. Have students name some dehydrated foods that are rehydrated before they are eaten (beans, pasta, powdered drinks).
3. Peel and cut large slices of fruits and vegetables brought in by students.
4. Each group should have three slices of each fruit or vegetable for the experiment. Measure the weight of each slice and record.
5. Give students the Mission Meals Part 1 Student Data Table.

6. Students need to predict which food will lose the most weight over the period of one week and record their predictions on the student data table.
7. Food slices should be spread out on a piece of wax paper and placed under a lamp. Use a dehydrator if available, in which case it's all right to eat the food. Otherwise be sure not to eat the food.
8. Over the course of one week, measure the weight of each food slice and record.
9. Use the following formula to calculate the percent water content of each fruit/vegetable slice.
Total Mass Loss X 100/Original Mass

Part 2: Menu Planning

1. Give each group a copy of the Food Pyramid and a copy of the Shuttle Foods List.
2. Students are to use the Food Pyramid and the Shuttle Foods List to create a balanced menu for one week.

Management

Ask students to bring in various fruits and vegetables that can easily be dehydrated. Activity can be completed in two 30-minute periods, one week apart.

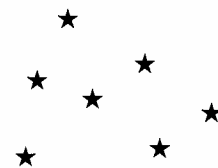
Reflection & Discussion

1. How do foods lose water when they are dried?
2. From our results, which food lost the most water?
3. Since the human body is more than 2/3 water, how do we replace water we lose through sweating, etc.? How will this affect our bodies during long flights in space?
4. What is the benefit of using rehydratable food?

Transfer/Extension

1. Design a balanced menu using the Shuttle Foods List for a long duration mission of one month.

Mission Meals Part 1

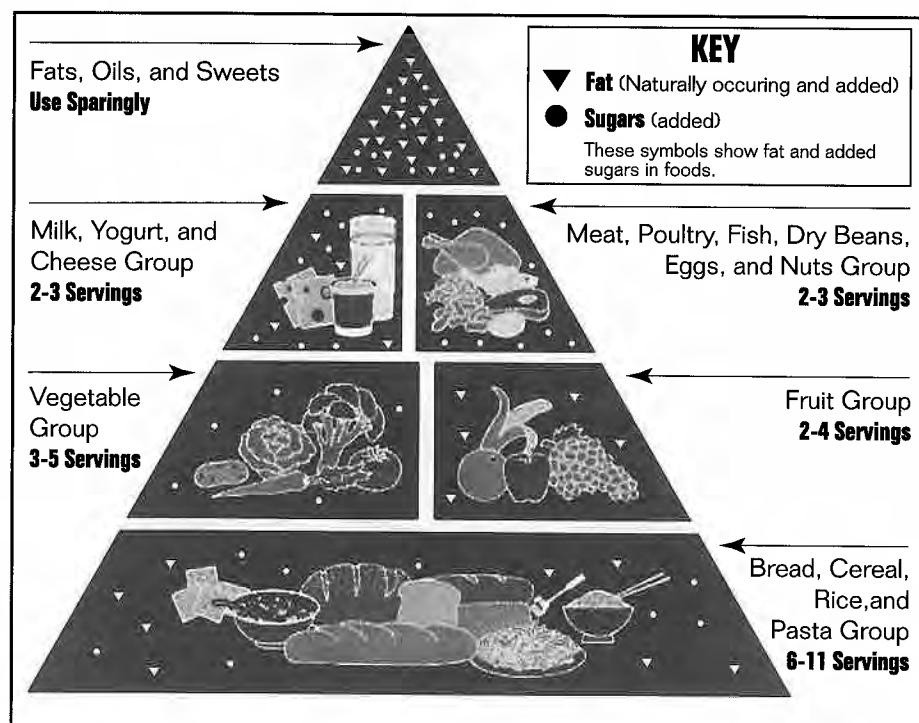


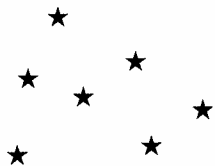
Student Data Table

Fruit or Vegetable	Original Weight	Predicted End Weight	Weight After Day 2	Weight After Day 3	Weight After Day 4	Weight After Day 5	Total Weight Loss (Original Weight - Day 5 Weight)	Percent Water (Total Mass Loss x 100 / Original Mass)

Questions & Conclusion

1. How do foods lose water when they are dried?
2. From our results, which food lost the most water?
3. Since the human body is more than 2/3 water, how do we replace water we lose through sweating, etc.? How will this affect our bodies during long flights in space?





Mission Meals Part 2

Design a week of mission meals for yourself using the Shuttle Foods List and Food Pyramid. Be sure that your meals meet the Recommended Daily Allowance for each day. Follow the steps listed below:

Student Procedures

1. Convert your weight into kilograms (your weight in pounds multiplied by .45 equals your weight in kilograms) and your height into centimeters (your height in inches multiplied by 2.54 equals your height in centimeters).
2. Figure your Basal Energy Expenditure (BEE). It is an estimate of your daily energy or calorie needs based on your height, weight, age, and sex:

For men, the B.E.E. = $[66.5 + (13.8 \times W) + (5.0 \times H) - (6.8 \times A)]$

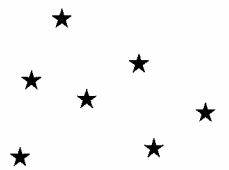
For women, the B.E.E. = $[655.1 + (9.6 \times W) + (1.9 \times H) - (4.7 \times A)]$

W = weight in kg, H = height in cm, A = age in years

3. Make a menu for 1 week so that the total daily caloric intake is 1.7 times the BEE for men and 1.6 times the BEE for women. Plan carefully so that you do not exceed the recommended number of servings for each food group.

Meal	Food	Fat (g)	Weight (g)	Protein (g)	Carbohydrate (g)	Calories
Breakfast						
Lunch						
Dinner						
Snacks						
Total						

Shuttle Foods List



Food (single serving)	Fat (g)	Protein (g)	Carbohydrate (g)	Weight (g)	Calories
Almonds	24.70	11.70	1.830	45.00	276.0
Apple cider	0.000	0.000	31.40	28.70	113.0
Apple jelly	0.000	0.000	18.10	14.20	37.60
Asparagus	0.120	2.810	2.640	8.400	22.90
Banana pudding	4.370	2.670	30.70	142.0	173.0
Beef goulash	5.660	29.60	19.30	255.0	247.0
Beef patties	12.30	17.20	2.350	34.00	189.0
Beef stroganoff	11.70	8.120	13.90	34.00	186.0
Beef tips w/mushrooms	4.230	36.10	7.220	255.0	212.0
Beef w/ spicy sauce	12.50	22.00	15.60	227.0	263.0
Blueberry yogurt	1.720	4.300	31.00	135.0	156.0
Bran flakes	0.465	6.670	28.20	43.50	144.0
Breakfast roll	16.60	5.620	50.90	100.0	375.0
Broccoli au gratin	8.010	6.950	8.710	30.00	135.0
Brownie	10.90	2.620	37.80	57.00	260.0
Butter cookies	7.780	2.290	25.80	37.00	182.0
Candy-coated chocolate	5.950	1.940	21.20	30.00	146.0
Cashews	22.10	9.850	8.800	45.00	273.0
Cheese spread	13.90	4.370	1.080	36.00	147.0
Cherry drink w/a/s	0.000	0.000	0.960	1.200	4.430
Chicken cacciatore	1.890	36.50	.600	255.0	194.0
Chicken consume	0.306	0.435	1.760	5.000	11.60
Chicken salad spread	28.30	22.90	17.00	212.0	416.0
Chicken a la king	15.60	28.70	11.40	227.0	300.0
Chocolate pudding	4.300	3.860	31.70	142.0	181.0
Cocoa	0.960	2.800	44.60	50.50	198.0
Cornflakes	0.024	4.460	32.90	40.00	150.00
Creamed spinach	3.140	3.290	7.500	18.00	71.50
Diced peaches	0.000	0.770	23.50	128.0	97.30
Diced pears	0.000	0.240	26.40	128.0	106.0
Dried apricots	0.000	2.470	29.90	62.00	130.0
Dried beef	0.620	10.50	1.340	30.00	53.10
Dried peaches	0.000	2.690	35.00	62.00	151.00
Dried pears	0.000	1.020	38.50	62.00	158.0
Frankfurter	25.60	15.80	1.810	122.0	300.0
Fruit cocktail	0.000	0.435	25.20	128.0	102.0
Graham crackers	3.220	2.370	22.50	32.00	128.0
Granola	9.610	12.40	50.90	80.00	339.0
Granola bar	5.790	2.010	22.90	35.00	152.0
Granola w/raisins	9.030	11.50	52.30	80.00	336.0
Grape drink	0.000	0.000	29.90	30.00	119.0
Grape jelly	0.000	0.026	10.00	14.20	40.20
Grapefruit drink	0.000	0.020	31.70	32.20	127.0
Grits	0.267	2.530	26.20	34.50	117.0
Ham	8.280	27.80	3.860	142.0	202.0
Ham salad spread	11.90	19.40	20.90	212.0	269.0
In-suit fruit bar	0.000	0.576	38.40	50.00	156.0
Italian vegetables	5.700	3.140	13.00	30.00	116.0
Ketchup	0.000	0.234	2.320	9.000	10.20
Lemonade	0.000	0.000	20.90	21.00	83.40
Lemonade w/a/s	0.000	0.000	1.690	1.900	7.110
Lemon-lime drink	0.000	0.000	20.60	21.50	82.30

STUDENT WORKSHEET

Food (single serving)	Fat (g)	Protein (g)	Carbohydrate (g)	Weight (g)	Calories
Macadamia nuts	29.50	4.230	2.790	45.00	294.0
Macaroni & cheese	7.520	9.700	18.20	40.00	179.0
Mayonnaise	10.20	0.138	0.000	12.10	92.30
Meatballs (spicy)	17.30	22.40	34.40	227.0	384.0
Mexican scrambled eggs	14.20	12.90	5.780	36.00	202.0
Mushroom soup	10.50	3.330	9.340	27.00	145.0
Mustard	0.094	0.113	0.133	2.400	1.820
Noodles & chicken	5.150	5.190	15.45	28.00	129.0
Oatmeal w/ brown sugar	1.390	5.710	32.50	46.10	166.0
Oatmeal w/ raisins	1.370	6.340	32.60	47.20	168.0
Orange juice	0.000	1.310	21.60	24.00	91.70
Orange mango drink	0.000	0.000	33.30	33.60	133.0
Orange/grapefruit drink	0.000	0.026	30.20	30.60	121.0
Orange drink	0.000	0.030	27.80	28.10	111.0
Peach drink	0.000	0.084	33.20	33.60	133.0
Peach yogurt	1.910	4.860	28.30	135.0	150.0
Peaches lite	0.000	0.560	16.50	128.0	67.80
Peanuts	21.80	12.90	8.190	45.00	280.0
Pineapple drink	0.000	0.000	33.20	33.60	133.0
Pineapples	0.000	0.380	17.30	128.0	70.90
Potato pattie	5.980	1.760	16.20	27.00	126.0
Potatoes au gratin	5.250	4.410	16.30	30.00	130.0
Raspberry yogurt	1.670	4.510	29.90	135.0	152.0
Rice and chicken	5.290	3.650	22.80	34.00	154.0
Rice crispies	0.040	4.670	32.70	40.00	150.0
Rice pilaf	2.420	2.120	18.70	25.00	105.0
Salmon	10.10	22.30	0.000	112.0	180.0
Sausage pattie	14.40	14.30	2.860	34.00	198.0
Scrambled eggs	14.10	12.60	5.160	34.50	198.0
Seasoned scrambled eggs	12.50	13.10	6.240	35.00	190.0
Shortbread cookies	7.010	2.100	19.10	30.00	148.0
Shrimp cocktail	0.986	14.50	15.80	35.00	130.0
Spaghetti w/meat sauce	2.900	7.130	17.10	30.00	115.0
Strawberries	0.026	0.785	19.80	23.80	82.60
Strawberry yogurt	1.740	4.630	29.80	135.0	154.0
Sweet 'n' sour chicken	3.100	21.20	10.20	36.00	153.0
Tabasco sauce	0.000	0.019	0.043	2.600	0.260
Taco sauce	0.000	0.150	1.320	10.60	5.940
Tapioca pudding	4.360	3.440	33.30	142.0	186.0
Tea	0.000	0.000	0.743	1.000	3.100
Tea w/sugar	0.000	0.000	13.30	13.50	53.10
Teriyaki chicken	3.080	22.70	6.780	36.00	145.0
Tortilla flour	2.330	2.420	15.40	30.00	92.10
Trail mix	14.10	4.140	24.20	50.00	240.0
Tropical punch	0.000	0.000	24.90	25.00	99.80
Tuna	0.770	23.00	0.000	96.00	98.90
Tuna salad spread	27.10	21.20	18.80	212.0	403.0
Turkey & gravy	15.50	31.40	8.510	227.0	300.0
Turkey tetrazzini	4.190	7.070	13.10	27.00	119.0
Vanilla instant breakfast	1.700	9.360	41.10	56.00	219.0
Vanilla pudding	3.820	2.800	34.10	142.0	182.0
Whole wheat bread	1.220	2.690	12.70	28.00	68.60

Source: Shuttle Food Lab, Johnson Space Center

Hydroponics



Background

Look in your refrigerator at the amount of food needed for just one week. Consider that when humans go to Mars the trip will take more than a year. Packing a year's supply of food could easily tax the spacecraft's available space and weight requirements. It would be practical for the crew to grow their own food along the way. One form of farming that is being considered for long duration missions is hydroponics, the science of growing plants in a solution of water and nutrients instead of soil. Growing plants in water has two main advantages. One is the availability of water, as water is a by product of a spacecraft's fuel cells. Secondly plants grown in a hydroponic manner can be grown closer together, requiring less room than plants grown in soil beds.

Although hydroponics offers many advantages for long duration missions, other methods of growing plants are being tested. Growing plants in gel packs is one new method that is currently being researched. Particular crops are being tested to determine how much oxygen they give off, and how much food they can provide. Wheat has been established as a main crop choice for future space travel.

Topic

Hydroponic Gardening

Objectives

Students will:

- Investigate the necessary conditions to grow food for a long duration mission.
- Design and construct a controlled environment to grow plants without the use of soil.

Overview

Providing food for long duration missions is a major concern of many scientists. The safe growth of food is imperative. In this activity students will grow plants without soil in a nutrient rich solution.

Key Question

Why are scientists experimenting with hydroponics to grow plants for long duration missions?

Key Concepts

- Hydroponics is the science of growing plants using a solution of water and nutrients instead of soil.
- Because of the amount of space, weight limitations, and time involved in long duration missions, alternatives will have to be developed for growing food crops.

Materials & Preparation

- Gallon milk containers (2 per garden)
- Gravel (enough to fill each garden)
- 1 plastic hose per garden (1 meter long)
- Epoxy glue
- Commercial nutrient solution mix (enough to make about 1 gallon per garden)
- Lettuce seeds
- Hydroponic growing cubes (available in most gardening stores, 4 per garden)
- Plant light with timer
- Scissors

1. Cut the top off of two 1 gallon milk containers.
2. Connect the two containers using one piece of hose. To do this, put a hole in the side of the containers, about an inch above the bottom.
2. Insert one end of the hose into each hole and seal the edges with epoxy glue.
4. Label one container "Garden" and the other "Nutrient Solution."
5. Fill the container labeled "Garden" 3/4 full with gravel.
6. Place one seed in each growing cube and place them in the container labeled "Garden." Space the cubes evenly throughout the container and make sure they are nestled securely in the gravel.

7. Fill the nutrient solution container 3/4 of the way with nutrient solution.
8. Place the gardens under the light and set the light timer for 16 hours every day so that the plants receive a consistent amount of light every day.
9. Feed the plants twice a day once in the morning and once in the evening. To do this, raise the solution container above the garden so that the nutrient solution flows into the garden. Let the solution remain in the garden for fifteen minutes and then lower the solution container below the garden so that the solution drains out of the garden.
10. Have students keep a two week journal. Students should observe their plants daily, recording changes in root development, measuring and recording plant size, describing the overall condition of the plant, recording any changes in growing conditions (if the light goes out or a student forgets to feed the plant, this should be recorded) Students should also include a daily drawing of the plant.
11. At the end of the two weeks have students answer the reflection and discussion questions as their final journal entry.

Management

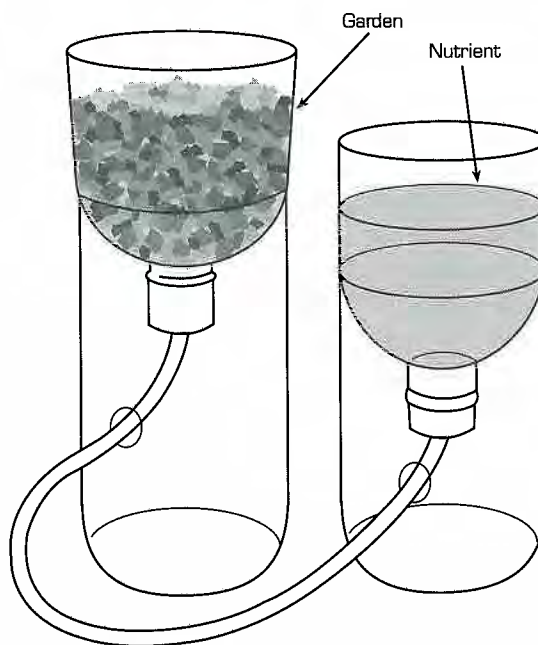
Students will observe all safety procedures and policies including, but not limited to, personal safety and safe handling of materials. This activity will take one to two classes to assemble. Students will then make observations for two weeks. To simplify this activity, hydroponics kits can be ordered from a science catalog.

Reflection & Discussion

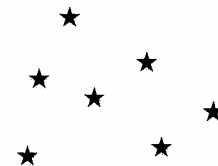
1. Did all plants grow at the same rate by the end of the observation period? Why or why not?
2. Why do you think lettuce seeds were chosen for this experiment?
3. Other than providing food, what important elements do plants provide for a long duration mission?

Transfer/Extensions

1. Challenge: Design and construct a hydroponic garden containing all the necessary vegetables you think are needed for the journey to Mars.
2. Calculate how much food you would need according to your age and weight. This information can be obtained by looking at a nutrition chart.
3. What foods have you chosen to take and why?



Hydroponics



Materials to make your own hydroponic garden

- 2 large clear plastic tubs or 2 liter soda bottles
- gravel (enough to fill one container)
- 1 meter of plastic hose
- epoxy glue
- 2 liter soda bottles
- 1 gallon of nutrient solution
- lettuce seeds
- hydroponic growing cubes
- Scissors

Student Procedures

1. Cut the top off of two soda bottles.
2. Connect the two containers using one piece of hose. To do this, put a hole in the side of the containers, about an inch above the bottom.
3. Insert one end of the hose into each hole and seal the edges with epoxy glue.
4. Label one container "Garden" and the other "Nutrient Solution."
5. Fill the container labeled "Garden" 3/4 full with gravel.
6. Place one seed in each growing cube and place them in the container labeled "Garden." Space the cubes evenly throughout the container and make sure they are nestled securely in the gravel.
7. Fill the nutrient solution container 3/4 of the way with nutrient solution.
8. Place the gardens under the light and set the light timer for 16 hours every day so that the plants receive a consistent amount of light every day.
9. Feed the plants twice a day, once in the morning and once in the evening. To do this, raise the solution container above the garden so that the nutrient solution flows into the garden. Let the solution remain in the garden for fifteen minutes and then lower the solution container below the garden so that the solution drains out of the garden.

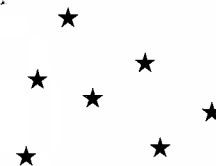
STUDENT WORKSHEET

10. Keep a two week journal. You should observe the plants daily, record changes in root development, measure and record plant size, describe the overall condition of the plant, record any changes in growing conditions (if the light goes out or you forget to feed the plant, this should be recorded) You should also include a daily drawing of the plant.
11. At the end of the two weeks answer the reflection and discussion questions as the final journal entry.

Reflection & Discussion

1. Did all plants grow at the same rate by the end of the observation period? Why or why not?
2. Why do you think lettuce seeds were chosen for this experiment?
3. Other than providing food, what important elements do plants provide for a long duration mission?

Searching for Signs of Life



Background

One question we all ponder is whether or not we are alone in the Universe. Mars is one of many places where we might find an answer. Being the most similar to Earth, Mars has water vapor and permafrost on the surface. At one time, Mars had an abundance of flowing water. It is these places where there is or was water that the possibility of life exists.

When scientists go in search of life it is not necessarily a quest for large human-like beings or even life that can be seen with the naked eye. Most scientists expect that we are much more likely to find microscopic evidence, such as bacteria, or fossilized bacteria. The most recent prospect for life on Mars is centered around the Martian meteorite, ALH84001. The meteorite, found in Antarctica, dates back to an early period on Mars when the conditions were much wetter and more suitable for life. Formations in the rock suggest that it may contain a fossilized form of bacteria.

Scientists would like to study rock samples from areas that appear to be dried riverbeds. Collecting rock samples is one goal of future Mars missions. In the past, however, we have looked for life in the soil on Mars. When Viking 1 and 2 landed on Mars in 1976, the landers analyzed the Martian soil in search of carbon based life. Analysis of some soil samples seemed to indicate lifelike characteristics. However, scientists did not find evidence of organic matter. They found unusual geochemistry which had some lifelike characteristics, but they did not find life.

Topic

Soil Analysis

Objectives

Students will:

- Conduct a simulated experiment with soil samples similar to the experiments on the Mars Viking Lander.

- Identify relationships between the soil samples using an operational definition of life.
- Make an inference about the possibility of life on Mars based on data obtained.

Overview

Students will analyze soil samples. They will use the given definition of life to determine whether there are any signs of life in three different soil samples. Teams will make observations, draw pictures as they collect data from the samples, and draw conclusions.

Key Question

What characteristics must be present to determine if life exists?

Key Concepts

- The fundamental criteria for indicating life is: metabolic processes, exchange of gases, reproduction, and continued reaction to stimuli.

Materials & Preparation

- Dictionaries and encyclopedias
- Sand or sandy soil
- Three baby food jars or beakers per group
- 5 ml of sugar (sugar water will be added to all soil samples)
- Instant active dry yeast
- Alka-seltzer® tablets, crushed
- Hot water—enough to cover the top of the soil in all jars
- Goggles—1 per student
- Cups for distributing the water—1 per group
- Magnifying lens—1 per group or individual
- Student sheets—1 per student

Advanced Preparation

1. Label all jars: label 1/3 "A," label 1/3 "B," label 1/3 "C."
2. Fill all jars 1/4 full of soil (3 jars per team).
3. Mix one half pack of instant active dry yeast into the soil in jars labeled "B."
4. Mix one powdered Alka-seltzer® into jars labeled "C."
5. Give each group a set of three jars, magnifying lens, and the chart from previous activity.

Part 1

1. Divide students into cooperative groups before beginning the lesson.
2. Explain to students that their job is to come up with fundamental criteria for indicating life.
3. Have students conduct research on the characteristics of living and non-living organisms. Allow the students use of dictionaries, books, encyclopedias, and the Internet. Use the examples below to encourage the students, but not to limit them.

Examples: Consider a bear and a chair—they both have legs, but one can move on its own and the other would need a motor made by humans; therefore, independent movement might be one characteristic that indicates life. Not every living organism needs legs or roots, but they have a mode of locomotion or a way to get nutrients. Also, the bear breathes and the chair does not, another indication of life. Or consider a tree and a light pole. We know that a light pole cannot reproduce it is made by humans, and we know that the tree makes seeds that may produce more trees. The tree also absorb nutrients, gives off gasses, and grows. The light uses electricity and gives off light through a strict energy exchange; there is no growth and there are no metabolic processes.

4. Have students share their research in their cooperative groups, then have the class come to a consensus about how to identify living things.
5. Discuss the indications of life, ask students for examples from a diverse sampling of living things. Then paraphrase and write each groups' criteria on the board, overhead, or chart. This

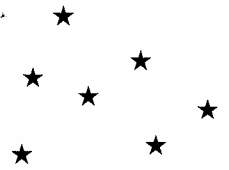
can be used to guide the students to summarize the groupings and to reflect the fundamental criteria for life.

6. If students have difficulty developing criteria, the following will be used for this activity:
 - Metabolic processes that show chemical exchanges that may be detected in some sort of respiration
 - Exchange of gases or solid materials
 - Reproduction, replication, or cell division
 - Continued reaction to stimuli

Part 2

(Information for teacher only—do not share all the information with students!)

1. Students will take three different soil samples and look for signs of life based on the criteria from Part 1.
2. Explain to the students that each team has a set of simulated Martian soil samples. No one knows if there is anything alive in them. The assignment is to make careful observations and check for indications of living material in them—based on their criteria.
3. Ask students to observe all three samples. They can smell and touch the samples but not taste them. Encourage students to put a few grains on a flat white surface and observe them with a hand lens.
4. Students should then record their data in the Data Log.
5. Give each group a cup of hot sugar water, which can be used by living organisms as nutrient solution. (Use warm tap water, approximately ~50 C so as not to kill the yeast.)
6. Have students "feed" (add stimulus to) each soil sample by pouring the sugar water so that each soil sample is covered.
7. Students should look for and record in the Data Log differences caused by adding sugar water.
8. After recording the first observations have students go back after 10 minutes and observe again. (After about ten minutes Sample B will show even more activity.)
9. Now have students "feed" (add stimulus to) each soil sample again after 10 minutes by adding 5 ml of sugar water to each soil sample.



10. Have students observe and record the reaction to the second feeding.
11. Discuss with students which samples showed activity after the first “feeding” (adding of stimulus) B and C.
12. Discuss with students which samples showed activity after the second “feeding” (adding of stimulus) C.
13. Does that activity mean there is life in both B and C and no life in A?
14. Did the reaction start again after the second feeding?
15. Are there other explanations for the activity in either B or C?
 - Sample A shows no reaction.
 - Both B and C are chemical reactions.
 - Sample C chemical reaction stops and does not react to the second “feeding” because the first “feeding” used up all reactants in the sample.
 - Sample B sustains long term activity and reacted again to the second “feeding” indicating life is present i.e. when life is present, more food means more biological activity.
16. Students should realize that there could be other tests that would detect life in Sample B.
17. Have students determine which sample(s) should be studied further by applying the fundamental criteria for indicating life developed in Part 1.

18. Tell students that Sample B contained yeast and Sample C contained Alka-seltzer®. Discuss how you might tell the difference between a non-living chemical change (Alka Seltzer®) and a life process (yeast).

Management

Students will observe all safety procedures and policies including, but not limited to, personal safety protection and safe materials handling. This activity should take two to three class periods to complete.

Reflection & Discussion

1. When adding water, what differences did you see in the grains?
2. How can geologists use this procedure to identify possible life on Mars?
3. What other tests could be run on the soil samples?

Transfer/Extension

1. Research the Mars meteorite. Have students form teams and debate the presence of fossilized life.
2. Find out about the search for life under the ice in Antarctica that NASA is conducting. Write a news article about your findings.
3. Does life require sunlight and oxygen? Research the life in underground caves and on the bottom of the ocean at hydrothermal vents and design a bulletin board or poster.

Searching for Signs of Life

Student Data Log

	Record Observation No water added	Draw Observation No water added
Sample A		
Sample B		
Sample C		
	Record Observation Water added	Draw Observation Water added
Sample A		
Sample B		
Sample C		

Extending The Mission

Suggested Extensions

After completing the activities in this book, there are many directions in which to lead your students to learn more about Mars. Below are guidelines for two extension activities. The first is a discussion that can potentially lead to a debate. The second is a hands-on activity for individuals or small groups.

Suggestion #1: Debate

Today we conduct robotic space missions to Mars and someday we hope to send humans. Is one approach better than the other? This can lead to a lively debate. Here are some discussion points to consider:

- The advantages and disadvantages of sending robots.
- The advantages and disadvantages of sending humans.
- What it will take to send humans and reasons why we haven't sent humans yet.
- How will the information from robotic missions be used in preparation for human missions.
- If you had to pick one and only one form of exploration, which would it be?

Suggestion #2: Press Kit

Have each student imagine that he or she is a team member of a Mars Mission. This press kit will represent every aspect of the fictional mission from beginning to end. The way it is presented should be up to the student, but below are some guidelines to get started:

- A press release announcing the mission and its team members.
- A biography sheet of the student with title of job and how the job relates to the mission.
- A mission statement including a timeline, plan for research, and goals.
- Pictures of the spacecraft inside and out.
- Pictures of the Mars Outpost.
- A graph showing when Mars aligns properly with the Earth and how the spacecraft will properly launch to the Red Planet.
- Pictures or samples of plants that will be taken along.
- A dietary plan.



Glossary

Arc—Part of a circle, such as a line in the sky from horizon to horizon which extends 180° .

Atmosphere—An envelope of gases that surround a celestial body such as a planet, moon, or star. An atmosphere is held to the body by the body's gravity.

Atmospheric Pressure—A force over a given area that is caused by the weight of an atmosphere.

Axis—An imaginary line through the center of a planet (or a satellite) around which it rotates.

Crater—A basin resulting from the collision of an object with a planetary surface.

Density—The mass of a substance divided by its volume.

Diameter—The distance across a circle through its center. Also distance through a sphere, measured through the center of the sphere.

Erosion—The wearing away of a planetary surface by some process such as wind, water, or another mechanism.

Planetary Geology—The study of the processes and history associated with the solid, rocky objects of the solar system.

Latitude—The angular distance north or south from the Earth's equator, measured from the center of the Earth in degrees.

Longitude—The angular distance of a location east or west of the Prime Meridian (located in Greenwich, England), measured from the center of the Earth expressed in degrees or time.

Mass—The amount of material present in an object. In an Earth environment this quantity is often directly compared to weight. Mass is an intrinsic property of the object.

Meteorite—A small body from space that survives passage through the Earth's atmosphere and reaches the surface.

Orbit—The path followed by one object, such as the Moon, around another object, such as the Earth, due to their common gravity.

Space Debris—Debris from satellites and space vehicles, as well as natural objects like meteoroids and planetary particles that travel through the Solar System

Tectonics—The process that forms planetary features such as continents, mountains, and faults by the motion of sections (plates) of the Earth's crust driven by convection currents in the Earth's mantle.

Trajectory—The path of a projectile or other moving body.

Weight—The force with which the Earth's (or any astronomical body's) gravity pulls down on something.

Resources

This is a selected list of web sites, organizations, and magazines that are excellent sources for more information on space exploration or space education. We encourage you to visit them, and hope they will inspire you to keep exploring Mars.

Web Resources

Challenger Center OnLine <http://www.challenger.org>

In addition to links to the sites below, this web site has downloadable worksheet-quality classroom activities, called Lesson Launchers, as well as great links, space clipart, news, and information about our educational simulation programs.

Center for Mars Exploration <http://cmex-www.arc.nasa.gov/>

This site is constantly being updated, so keep checking it for many new features including historical references to Mars, previous Mars mission information, tools to analyze Mars, current Mars news, and much more.

The Daily Martian Weather Report <http://nova.stanford.edu/projects/mgs/dmwr.html>

From the Mars Global Surveyor Radio Science Team, you will find a detailed study of the Martian atmosphere presented as daily weather reports.

International Space Station <http://station.nasa.gov/core.html>

A WOW! site ... be sure to check out the Reference section for great resources!

Mars Academy <http://www.marsacademy.com/>

An online collaborative project where students from all over the world are designing a manned mission to the Red Planet.

Mars ... Mars ... and Mars <http://mpf.jpl.nasa.gov>

There is a lot on Pathfinder & Sojourner, but don't miss Mars Global Surveyor, Mars Surveyor 98, and Mars Surveyor 2001

NASA Spacelink <http://spacelink.msfc.nasa.gov>

The primary NASA education web site offers educational materials, software, and images on aerospace topics. Special features for teachers who sign up for accounts. Check for upcoming educator events.

Reaching for the Red Planet <http://lyra.colorado.edu/sbo/mars/redplanet.html>

This gives you a taste of a multi-purpose curriculum geared for grades 4-6, focusing on planning a Mars colony.



Shuttle/Mir Operations <http://spaceflight.nasa.gov>

Get the latest from the Mir Space Station.

Space Day <http://www.spaceday.com>

On the official Embrace Space web site, you will find snazzy graphics, fun space facts, and electronic postcards to send friends.

Non-Web Resources

Challenger Center for Space Science Education: Mixing a little adventure with education has proven to be a recipe for success, resulting in a vibrant, growing portfolio of Learning EdVentures programs. Classroom programs include:

Cosmic EdVentures: Exploring Earth's Neighborhood (grades 3-6): Cosmic EdVentures creates a simulation for upper elementary and middle school students in which they apply for and are accepted to work for Cosmic EdVentures, Challenger Center's travel agency on board the futuristic Millennium Station.

When students are accepted to Cosmic EdVentures Academy, they become Planetary Excursion Planners, or PEPs for short. PEPs become space savvy as they complete three levels of coursework: Solar System Basics, Planetary Features, and Planetary Excursions. These courses contain hands-on activities about the Solar System, the features of planets and moons, and Solar System travel. PEPs are tested on content, build portfolios, and make team presentations.

Mars City Alpha (grades 5-8): This exciting classroom simulation transforms students into scientists and engineers launching an international effort to design a settlement on Mars. Students work in teams to prepare for the culminating event, the building of a tabletop model of a futuristic human settlement on Mars. Mars City Alpha meets science education standards and benchmarks while providing many memorable crosscurricular learning opportunities. Mars City Alpha™ received Learning Magazine's coveted Teacher's Choice Award in 1994.

Marsville: A Cosmic Village (grades 5-8): Marsville is a classroom-based project that allows students to create a prototype habitat for Mars. Students create their own living environment using a multitude of interdisciplinary skills. The program culminates with a link-up day when all the classes rendezvous at one site to construct their cosmic village and share the experience of creating a settlement on Mars.

Vista Station (grades 3-4): Vista Station is an innovative mix of the arts and sciences that creates a dynamic setting from which students launch a series of seven themed educational adventures called "Mini-EdVentures." Self-contained and ready to use, each of the seven Mini-EdVentures provide both the tools for transformation and some of the biggest WOW's of space learning. Vista Station will engage your learners in learning about living and working in space. All seven modules function independently of one another and are designed for maximum ease of use as well as grade-level flexibility.

EdVentures in Simulation: A Great START to the 21st Century: EdVentures in Simulation is a professional development workshop sharing the secrets behind Challenger Center's simulations based on more than 10 years of experience conducting successful simulation programs. The Challenger Learning Center network reaches more than a quarter of a million students and teachers each year with full immersion simulations at sites across North America, Canada, and the United Kingdom.

For more information, please visit www.challenger.org or call 888-683-9740.

Astronomical Society of the Pacific: ASP has a free quarterly educational newsletter, a catalog full of great educational items, and Project ASTRO's Universe at Your Fingertips (see below). For more information, contact ASP, 390 Ashton Ave., San Francisco, CA 94112. Call (415) 337-1100.

Harvard-Smithsonian Center for Astrophysics: CFA offers broadcast and instructional television programs, in-service and preservice workshops, and a physical science curriculum for elementary students called Project ARIES, among other programs. CFA can be contacted at 60 Garden Street, Cambridge, MA 02138.

Lawrence Hall of Science GEMS: Great Explorations in Math and Science (GEMS) is a growing resource for activity-based science and mathematics developed by the University of California at Berkeley's Lawrence Hall of Science. For a free GEMS catalog (another must), write LHS GEMS, University of California, Berkeley, CA 94720. Call (510) 642-7771.

Lunar & Planetary Institute: This branch of the Center for Advanced Space Studies is part of the Universities Space Research Association (USRA) that offers specialized slide sets for educators on a variety of Solar System topics. Contact LPI, Order Dept., 3600 Bay Area Blvd., Houston, TX 77058. Call (281) 486-2172.

NASA CORE: The Central Operation of Resources for Educators for NASA generated materials. CORE, Lorain County JVS, 15181 Rt. 58 South, Oberlin, OH 44074. Call (216) 774-1051, ext. 293 or 294.

National Space Society: With membership comes a subscription to NSS' *Ad Astra* magazine, a great way to stay in touch with the current events and issues surrounding space exploration. NSS, 600 Pennsylvania Avenue, SE, Suite 201, Washington, DC 20003. Call (202) 543-1900.

The Universe at Your Fingertips: An Astronomy Activity and Resource Notebook: Published by the Astronomical Society of the Pacific and its Project ASTRO, this comprehensive and ready-to-use collection of classroom activities, teaching ideas, and annotated resource lists is a must-have resource for every school in the country! For around \$30, it is a bargain that cannot be passed up. Call (800) 335-2624, or write to the Astronomical Society of the Pacific, 390 Ashton Avenue, San Francisco, CA 94112.





Challenger Center For Space Science Education

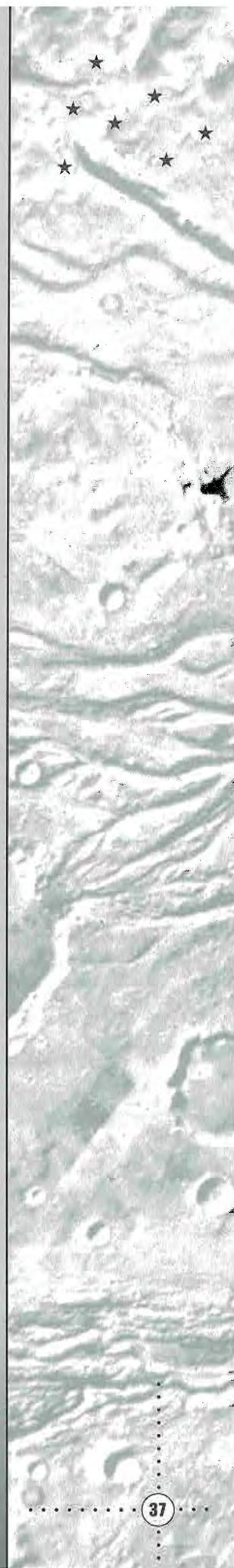
Challenger Center for Space Science Education is a global not-for-profit education organization created in 1986 by the families of the astronauts tragically lost during the last flight of the Challenger Space Shuttle. Dedicated to the educational spirit of that mission, Challenger Center develops Learning Centers and other educational programs worldwide to continue the mission to engage students in science and math education. Challenger Center's network of Learning Centers throughout the United States, Canada, and the United Kingdom have been recognized leaders in educational simulation, with a strong standards-based emphasis. Challenger Learning Centers and Challenger Center's award-winning classroom and teacher training programs all use the excitement of space exploration to create positive learning experiences that:

- Raise students' expectations of success;
- Foster in them a long-term interest in math, science, and technology; and
- Helps them develop critical communication, decision-making, team-building, and collaborative skills.

For a Challenger Learning Center in your area, please visit us at www.challenger.org.



Notes

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Acknowledgments

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