Maynard F. Jordan Planetarium

MARS INVASION:
New Views of the Red Planet

Edited by Leisa Preble

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Mission Statement:
The mission of the Maynard F. Jordan Planetarium of the University of Maine is to provide the University and the public with educational multi-media programs and observational activities in astronomy and related subjects.

Cosmic Classroom

Looking for fun and interesting space activities? The planetarium staff has prepared a collection of materials we call the Cosmic Classroom for you to use before and/or after your visit. These materials are entirely for use at your own discretion and are not intended to be required curricula or a prerequisite to any planetarium visit. The Cosmic Classroom is one more way that the Jordan Planetarium extends its resources to help the front line teacher and support the teaching of astronomy and space science in Maine schools.

The lessons in this Cosmic Classroom have been edited and selected for the range of ages/grades that might attend a showing of this program at the Jordan Planetarium. Those activities that are not focused at your students may be adapted up or down in level. Our staff has invested the time to key these materials to the State of Maine Learning Results in order to save you time.

The State of Maine Learning Results performance indicators have been identified and listed for the program, the Cosmic Classroom as a package, and each individual activity within the package. The guide also includes related vocabulary and a list of other available resources including links to the virtual universe. We intend to support educators, so if there are additions or changes that you think would improve, PLEASE let us know.

Thank you, and may the stars light your way.

The Maynard F. Jordan Planetarium Staff

The Program – *Mars Invasion*

The Mars invasion has begun. The red planet has attracted the attention of humans for decades, and this program will follow the history of some of the interest in our little red neighbor. Join us as our planetarium guide gives an introduction to the night sky, and explains how to find this planet in your own backyard this season. Then, follow the most intense assault of technology on this planet since the Viking project in the 1970's.

We are very glad that you have chosen to visit our planetarium with your group. We hope that this guide will help you prepare your group or help you review their experience at the University of Maine's sky theater.

State of Maine Learning Results Guiding Principles

The lessons in this guide, in combination with *Mars Invasion*, will help students to work towards some of the Guiding Principles set forth by the State of Maine Learning Results. By the simple act of visiting the planetarium, students of all ages open an avenue for self-directed lifelong learning. A field trip encourages students to think about learning from all environments including those beyond the schoolyard. A Jordan Planetarium visit also introduces visitors to the campus of the largest post-secondary school in Maine and encourages them to think of this as a place which holds opportunities for their future education, enjoyment and success.

Other sites on the University campus, including three museums, explore a variety of subjects, and the Visitors Center is always willing to arrange tours of the campus. A field trip can contribute to many different disciplines of the school curriculum and demonstrate that science is not separate from art, from mathematics, from history, etc. The world is not segregated into neat little boxes with labels such as social studies and science. A field trip is an opportunity for learning in an interdisciplinary setting, to bring it all together and to start the process of thinking. For a more complete discussion of field trips, please visit the Jordan Planetarium web site at http://umainesky.com.

If used in its entirety and accompanied by the Planetarium visit this guide will help students to:

Become **a clear and effective communicator** through

A. oral expression such as class discussions
B. listening to classmates while doing group work, cooperation, and record keeping.

Become **a self-directed and life long learner** by

A. introducing students to career and educational opportunities at the University of Maine and the Maynard F. Jordan Planetarium.
B. encouraging students to go further into the study of the subject at hand, and explore
C. giving students a chance to use a variety of resources for gathering information

Become **a creative and practical problem solver** by

A. asking students to observe phenomena and problems, and present solutions
B. urging students to ask extending questions and find answers to those questions
C. developing and applying problem solving techniques
D. encouraging alternative outcomes and solutions to presented problems

Become **a collaborative and quality worker** through

A. an understanding of the teamwork necessary to complete tasks
B. applying that understanding and working effectively in assigned groups
C. demonstrating a concern for the quality and accuracy needed to complete an activity

Become **an integrative and informed thinker** by

A. applying concepts learned in one subject area to solve problems and answer questions in another
B. participating in class discussion

State of Maine Learning Results Performance Indicators

In conjunction with the Maynard F. Jordan Planetarium show *Mars Invasion,* this guide will help you meet the following State of Maine Learning Results Performance Indicators in your classroom.

Grades 3-4

Science and Technology –

G. Universe

#4. Describe the relationship between the earth and its moon

J. Inquiry and Problem Solving

#1. Make accurate observations using appropriate tools and units of measure.

#2. Conduct scientific investigations: make observations, collect and analyze data, and do experiments.

K. Scientific Reasoning

#4. Use various types of evidence to support a claim.

L. Communication

#4. Make and/or use sketches, tables, graphs, physical representations, and manipulatives to explain procedures and ideas.

Grades 5-8

Science and Technology –

E. Structure of Matter

#4. Describe how a substance can combine with different substances in different ways, depending on the conditions and the properties of each substance.

G. Universe

- #3. Compare and contrast distances and the time required to travel those distances on earth, in the solar system, in the galaxy, and between galaxies.
- #4. Describe scientists' exploration of space and the objects they have found.

J. Inquiry and Problem Solving

- #1. Make accurate observations using appropriate tools and units of measure.
- #2. Design and conduct scientific investigations which include controlled experiments and systematic observations.

K. Scientific Reasoning

- #3. Identify basic informal fallacies in arguments.
- #6. Support reasoning by using a variety of evidence.

L. Communication

- #1. Discuss scientific and technological ideas and make conjectures and convincing arguments.
- #4. Make and use scale drawings, maps, and three-dimensional models to represent real objects, find locations, and describe relationships.
- #5. Access information at remote sites using telecommunications.
- #6. Identify and perform roles necessary to accomplish group tasks.

M. Implications of Science and Technology

- #1. Research and evaluate the social and environmental impacts of scientific and technological developments.

Secondary

Mathematics

C. Data Analysis and Statistics

- #1. Determine and evaluate the effect of variables on the results of data collection.

Science and Technology –

F. The Earth

- #5. Demonstrate how rocks and minerals are used to determine geologic history.

L. Communication

- #8. Engage in a debate, on a scientific issue, where both points of view are based on the same set of information.

Performance Indicators Snapshot

The Show

<u>Grades 3-4</u>

Science and Technology
G. #1, J. #2, L. #2, M. #2, #3
English Language Arts
B. #3

<u>Grades 5-8</u>

Science and Technology
B. #2, G. #3, #4, #5

<u>Secondary</u>

Science and Technology
F. #5, G. #1, M. #4

The Guide

<u>Grades 3-4</u>

Science and Technology
G. #4, J. #1, #2, K. #4, L. #4

<u>Grades 5-8</u>

Mathematics
J. #1
Science and Technology
E. #4, G #3, #4, J. #1, #2, K. #3, #6, L. #1, #4, #5, #6, M. #1

<u>Secondary</u>

Mathematics
C. #1
Science and Technology
F. #5, L. #8

Earth, Moon, Mars Balloons

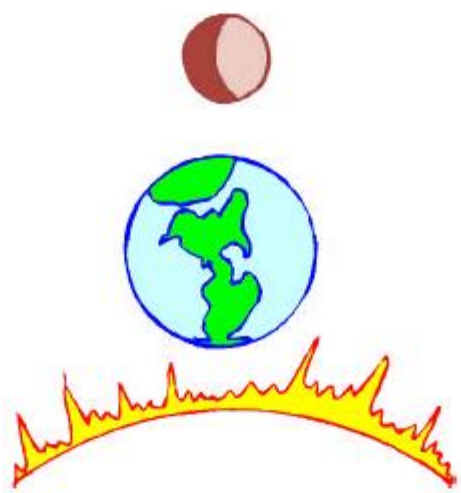
Mars Education Program
Jet Propulsion Laboratory, Arizona State University

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to explore the relationship between the earth and its moon. (3-4. Science and Technology. G. #4)
2. Learners will be able to make and use a three-dimensional model to represent the distance between Earth, its moon, and Mars. (3-4. Science & Technology. L. #4) (5-8. Science & Technology. L. #4.)
3. Learners will be able to show the relative distances between the Earth, the Moon and Mars. (5-8. Science & Technology. K. #3)

The General Idea:

How big is the Moon; how far is it relative to Earth? Earth science and astronomy books depict a moon that is much closer and much larger than in reality. The example pictured is typical of what is found in textbooks. The balloon activity will allow students the opportunity to construct a scale model of the Earth-Moon system, both in terms of planetary sizes and distances. In addition, students will make a scale model of Mars, and discover how far one might have to travel to visit the most Earth-like planet in our Solar System. It is also a good icebreaker at the beginning of a term, to get students to interact with each other.



Getting Ready:

Photocopy Planetary Data Handout

What You Need:

- 1 bag blue balloons (at least 9 per bag)
- 1 bag white balloons
- 1 bag red balloons
- copies of Planetary Data Handout
- Rulers/measuring devices in both inches and centimeters

What To Do:

1. Obtain balloons. The best are balloons with 2 1/2 inch diameter when deflated, but any round balloons will work. An easy way to do this activity is to purchase balloons that are colored. The red, white, and blue balloons can be used for Mars, Moon, and Earth. (using green for Earth and yellow for the Moon are also fine).
2. Discuss the question of size of the Earth relative to the Moon. Determine what misconceptions the students may have.
3. Distribute balloons, one per student. It is best to provide one third of the class with "Earth" (i.e. blue), one third with "Moon" (i.e. white), and one third with "Mars" (i.e. red).
4. Distribute Planetary Data Handout, one per student.

5. Tell students that the Earth balloon will have a diameter of 20 cm. Have them figure out the scale (divide the Earth's actual diameter by 20 cm. Earth is about 63,800,000 times larger than 20 cm). Ask students with

Earth balloons to inflate their model approximately 20 cm (obviously the balloon is not a perfect sphere, but neither is the Earth).

6. Ask students to look at the handout and calculate the size that the Moon and Mars should be, at the same scale as the Earth model. (Note the teacher's copy has the answers: the Moon should be about 5 cm, Mars about 11 cm).
7. Have students inflate the Mars and Moon balloons.
8. Ask students, at this scale, how far apart are the Earth and Moon? The diagrams seen in common textbooks might lead many of them to suggest that the Moon balloon should be held less than a meter from the Earth balloon.
9. Have students calculate the distance from Earth to the Moon at the same scale as the balloon models. The distance is about 6 meters. Have students holding the Earth models stand at one side of the room, and a partner holding a Moon model about 6 meters away.
10. Point out to students that they now have a scale model of the Earth-Moon system. Earth and its Moon are considered a double planet. The distance between the two is the distance traversed by the Apollo astronauts who went to the Moon in the 1960's and 70's. (Have students recall the film Apollo 13).
11. Compare the size of the Mars model with the Earth and Moon model. Look at the distance between Earth and the Moon.
12. Ask students how far away they think Mars will be at this scale. Have students attempt to demonstrate it in the classroom.
13. Have students calculate the distance to Mars at this scale. The answer is about 12,000 cm, which in more familiar terms is 3/4 of a mile! Have students identify a local landmark that is about 3/4 of a mile away.
14. Discuss the relative distance between Earth and Mars in the context of a human trip. How long did it take for Apollo astronauts to get to the Moon? (3 days) How long would it take for astronauts using similar technology to get to Mars? Mars Pathfinder, which launched in December 1996, arrived at Mars on July 4,1997 (7 months). Mars Global Surveyor, which launched in November 1996, arrived at Mars in September 1997 (11 months).

Extensions:

1. Ask students to make models of the Martian moons, Phobos and Deimos, at the same scale as the balloon models. They can calculate their scale diameters from the enclosed chart. It turns out that they are about the same size of a small grain of sand!
2. Have students convert all metric measurements into the English system.
   1 inch = 2.54 cm, 1 mile = 1.6 km

Answers to balloon exercise:

Scale Distances		(km) / 638 =	(cm)
Earth	Moon	3.84×10^5	600 cm = 20 ft
Earth	Mars	7.80×10^7	1.2 x 105 cm = 3/4 mi

Planetary Data

	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
Distance from the Sun (AU)	0.387	0.723	1	1.524	5.203	9.537	19.191	30.069	39.481
Approximate Distance from the Sun (10^3 km)	57,910	108,200	149,600	227,940	778,400	1,429,725	2,870,980	4,498,250	5,906,370
Radius (km)	2,439.7	6,0541.8	6,378.14	3,397.2	71,492	60,268	25,559	24,764	1,195
Mass (Earth = 1)	0.054	0.88	1	0.149	1,136	755	52	44	0.005
Density (gm/cm^3)	5.43	5.24	5.515	3.94	1.33	0.70	1.30	1.76	1.1
Rotation Period (day length)	58.65	-243.02	0.99	1.03	0.41	0.44	-0.72	0.67	-6.39
Orbital Period (year in days)	88	225	365	687	4,333	10,760	30,685	60,190	90,800
Sideral Period (length of year in Earth years)	0.24	0.62	1	1.88	11.86	29.42	83.75	163.72	248.02
Orbital Tilt (degrees)	0	177.3	23.45	25.19	3.12	26.73	97.86	29.58	119.61
Satellites	0	0	1	2	63	46	27	13	3

Glossary

AU - astronomical unit, the distance between Earth and Sun ($\sim 1.495 * 10^8$).
Rotation Period - the length of the day.
Orbital Period - the length of the year in Earth days.
Retrograde - when a celestial body rotates in the opposite direction of the Earth or clockwise.
Satellite - another name for a moon.
Sideral Period - the length of a planet's yea r in Earth years.
Tilt - how a far a planet is tilted sideways on its axis, measured in degrees.

Balloon Exercise

Body Diameter (km) / 638 = Approximate Scale (cm)
Earth 12,756 ~20 cm
Moon 3,476 ~5 cm
Mars 6, 794 ~11 cm
Phobos 22 ~0.03 cm
Scale Distances (km) / 638 = (cm)
Earth Moon 3.84×10^5 600 cm = 20 ft
Earth Mars 7.80×10^7 1.2 x 105 cm = 3/4 mi

The Path to Mars

http://school.discovery.com/lessonplans/programs/thepathtomars/
credit: Ted Latham, physics teacher, Watchung Hills Regional High School, Warren, New Jersey.

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to identify and compare geological features of Earth and Mars. (Sec.Grades. Science & Technology. F. #5)
2. Learners will be able to compare and contrast the Earth and Mars and the distances and time required to travel those distances. (5-8. Science & Technology. G. #3)
3. Learners will be able to use various types of evidence (logical, quantitative) to support a claim. (3-4. Science & Technology. K. #4)(5-8. Science & Technology. K. #6)
4. Learners will be able to discuss scientific and technological ideas and make conjectures and convincing arguments. (5-8. Science & Technology. L. #1)
5. Learners will be able to access information at remote sites using telecommunications. (5-8. Science & Technology. L. #5)
6. Learners will be able to engage in a debate on a scientific issue, where both points of view are based on the same set of information. (Sec.Grades. Science & Technology. L. #8)
7. Learners will be able to research and evaluate the social and environmental impacts of life on Earth vs. life on Mars. (5-8. Science & Technology. M. #1.)

The General Idea:

Students will compare Earth and Mars to find similarities between the two planets, using computer technology and other research materials.

Getting Ready:

Download pictures from the internet for the students and guide them in finding geological similarities.

What You Need:

- Current Research Materials On Mars
- Books Containing Geological Photographs Of The Surface Of Mars And Earth
- Computer With Internet Access

What To Do:

1. Tell students that they are going to compare Earth and Mars to find similarities between the two planets. Have them begin by doing research to find information and collect pictures of geological features of both planets. They should start their research at the following Web sites:
   - Views of the Solar System: Mars Introduction
     http://www.hawastsoc.org/solar/eng/mars.htm
   - Views of the Solar System: Earth Introduction
     http://www.hawastsoc.org/solar/eng/earth.htm
2. Instruct students to download and print pictures of geological features and formations on Earth and Mars. They can also find pictures in text references and photocopy them.
3. Have students post pairs of pictures of Earth and Mars side-by-side on a bulletin board in order to compare similar geological features and formations shared by both planets.
4. For each pair of pictures, students should identify the planet in each picture and write short descriptions of the geological features being compared. Students should do further research to include in their descriptions explanations of how the feature was probably formed and of how the feature may be useful for supporting life on both planets.

What To Discuss:

1. What geological evidence have scientists found on Mars that suggests that this planet once had, and may still have, large quantities of water?
2. Although scientists no longer believe that a Martian civilization lives on Mars, a recent discovery suggests that some form of life may have once inhabited the Red Planet. Describe the consequences for Earth, if life once existed on Mars. Debate the presence of life in other parts of the universe.
3. How would human beings on Earth benefit if it were possible to create a space colony on Mars in which humans could live?
4. Discuss whether our government should spend money to fund further exploration of Mars, or use that money to improve conditions here on Earth? Or should funds be made available for both purposes?

Evaluation:

You can evaluate your students on their descriptions using the following three-point rubric:

- **Three points:** clearly and completely describes the geological feature being compared; includes plausible explanation of how the feature was probably formed; includes clear, accurate explanation of how the feature may be useful in supporting life; free of errors in grammar, usage, and mechanics
- **Two points:** adequately describes the geological feature being compared; includes acceptable explanation of how the feature was probably formed; includes acceptable explanation of how the feature may be useful in supporting life; includes some errors in grammar, usage, and mechanics
- **One point:** vague description of the geological feature being compared; implausible explanation of how the feature was probably formed; unclear explanation of how the feature may be useful in supporting life; many errors in grammar, usage, and mechanics

Continuations/Extensions:

Preparing a Meal for Space Flight

Let students know that in order to preserve food and reduce cargo weight on a space trip, food is dehydrated. This means that water is removed from the food. Mostly for reasons of preservation, some food is dehydrated for consumption here on Earth. Have students make a list of all the dehydrated foods (sometimes referred to as "freeze dried") that they can find in the supermarket and from that list prepare a meal that might be enjoyed by astronauts out in space. In some cases, students may want to rehydrate the food to make it tasty and more consumable. Here is a sample menu:

1. Dehydrated fruit such as bananas and strawberries: rehydrate in mouth by saliva
2. Dehydrated peanuts: rehydration not necessary
3. Dehydrated orange crystals: rehydrate with water in a sandwich bag, and use a straw to sip out the contents
4. Dehydrated instant pudding: rehydrate with water in a sandwich bag, snip off a corner of the bag with scissors, and slurp out the contents
5. Dehydrated beef jerky: rehydrate in mouth
6. Dehydrated ice cream: follow package instructions to rehydrate

After feasting on their space meal, students can rate their experience with each food and comment on whether they would look forward to the *cuisine* on a lengthy space flight.

Construct a Shuttle

Have students use tape, Velcro, glue, shoe boxes, paper towel tubes, plastic soda cans, and other household recyclables to construct a model of the space shuttle. Instruct students to glue or tape together the parts that never separate and to use Velcro to hold together parts that will be jettisoned after liftoff (e.g., the fuel tank and rocket boosters).

Strange New Planet

ASU Mars K-12 Education Program 6/99
Adapted from NASA Education Brief "EB-112: How to Explore a Planet" 5/93

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to describe scientists' exploration of space and the objects they have found. (5-8. Science & Technology. G. #4)
2. Learners will be able to make accurate observations using appropriate tools and units of measure. (5-8. Science & Technology. J. #1)
3. Learners will be able to design and conduct scientific investigations which include controlled experiments and systematic observations. (3-4. Science & Technology. J. #2) (5-8. Science & Technology. J. #2)
4. Learners will be able to identify and perform roles necessary to accomplish group tasks. (5-8. Science & Technology. L. #6)

The General Idea:

Strange New Planet brings insight into the processes involved in learning about planetary exploration. This activity demonstrates how planetary features are discovered by the use of remote sensing techniques. Students will be engaged in making multi-sensory observations, gathering data, and simulating spacecraft missions.

Getting Ready:

Photocopy enough "Strange New Planet" data sheets for each student.

What You Will Need: (Planets can be made from a combination of materials)

· Plastic bails, modeling clay, Playdoh©, styrofoam© balls, or rounded fruit (cantaloupe, pumpkin, oranges, etc.)
· Vinegar, perfume, or other scents
· Small stickers, sequins, candy, marbles, anything small and interesting!
· Cotton balls
· Toothpicks
· Objects that can be pierced with a toothpick to make a moon
· Glue (if needed)
· Towel (to drape over planets)
· Push-pins
· Viewer material (sheet of paper, paper towel roll, or toilet paper roll)
· 5" x 5" blue cellophane squares (one for each viewer) and other selected
· Colors to provide other filters for additional information
· Rubber bands (one for each viewer)
· Masking tape to mark the observation distances
· Student data sheet

What to Do

1. Selecting a Planet
   Choose an object such as a plastic ball or fruit (cantaloupe, etc) that allows for multi-sensory observations. Decorate the object with stickers, scents, etc. to make the object interesting to observe. Some of these materials should be placed discreetly so that they are not obvious upon brief or distant inspection. Some suggestions for features are:

   · Create clouds by using cotton and glue
   · Carve channels
   · Attach a grape using a toothpick (to make moons or orbiting satellites)
   · Affix small stickers or embed other objects into the planet
   · Apply scent sparingly to a small area

   For older students, teams can create their own planets for other teams to view. This allows the students to create their own set of planetary features and write up a key to these features for the team that explores that planet to compare to their own findings.

2. Set-up
   Place the object (planet) on a desk in the back of the room. Cover the object with a towel before students arrive. Brief students on their task: To explore a strange new planet. Students can construct viewers out of loose-leaf paper by rolling the shorter side into a tube (can also use toilet paper roll or paper towel roll.) These viewers should be used whenever observing the planet. Form mission teams of 4-5 students. Make sure students have a place to record their data (student data sheets.) Encourage use of all senses (except taste unless specifically called for).

3. Pre-Launch Reconnaissance
   This step simulates earth-bound observations. Arrange students against the sides of the room by teams. These areas will be referred to as Mission Control. To simulate Earth's atmosphere, a blue cellophane sheet could be placed on the end of the viewers, taped or held in place by a rubber band. This helps to simulate the variation that occurs when viewing objects through the Earth's atmosphere. Remove the towel. Teams observe the planet(s) using their viewers for 1 minute. Replace the towel. Teams can discuss and record their observations of the planet. At this point, most of the observations will be visual and will include color, shape, texture, and position. Teams should write questions to be explored in the future missions to the planet.

4. Mission 1: The Fly-by (Mariner 4,6,7 - 1965,1969,1969)
   Each team will have a turn at walking quickly past one side of the planet (the other side remains draped under towel). A distance of five feet from the planet needs to be maintained. Teams then reconvene at the sides of the room (Mission Control) with their backs to the planet while the other teams conduct their fly-by. Replace towel over planet once all the fly-bys have taken place. Teams record their observations and discuss what they will be looking for on their orbit mission.

5. Mission 2: The Orbiter (Mariner 9,1971-72; Viking 1 and 2 Orbiters, 1976-80; Mars Global Surveyor, 1996-present)
   Each team takes two minutes to orbit (circle) the planet at a distance of two feet. They observe distinguishing features and record their data back at Mission Control. Teams develop a plan for their landing expedition onto the planet's surface. Plans should include the landing spot and features to be examined.

6. Mission 3: The Lander (Viking 1 and 2,1976-1982; Mars Pathfinder, 1997)
   Each team approaches their landing site and marks it with a push pin (or masking tape if planet will pop using a pin.) Team members take turns observing the landing site with the viewers. Field of view is kept constant by team members aligning their viewers with the push pin located inside and at the top of their viewers. Within the field of view, students enact the mission plan. After five minutes, the team returns to "Mission Control" to discuss and record their findings.

Assessment:

Each individual student should complete a Student Data Sheet. Each team shares their data with the class in a team presentation. As a class, compile a list of all information gathered by the teams to answer the question "What is the planet like?" (or each planet if multiple planets are used). Have the class vote on a name of the newly discovered planet or the geologic features discovered using the rules for naming a planet (planetary nomenclature) which is located at the USGS website: (http://wwwflag.wr.usgs.gov/USGSFlag/Space/nomen). Teams critique their depth of observations and ability to work together.

Variations:

Create a solar system of planets, hang them from the ceiling and have students make observations of all the planets.

Name:___________________________________

Strange New Planet Student Data Sheet

A. Pre-Launch Reconnaissance - Earth-bound observations

1) Estimate your distance from the planet: (feet or meters).

2) Using your viewer (with blue cellophane attached to simulate Earth's atmosphere) observe the planet. What types of things do you observe? Record any observations (shape of planet, color, size, etc.)

3) Discuss all of the observations with your team members while at Mission Control. Record any team observations that differ from yours.

4) As a team, write questions to be explored in the future missions to the planet. What else do you wish to know and how will you find that information out (special features of the planet, life of any kind, etc.)

a.

b.

c.

d.

B. Mission 1: The Fly-by (Mariner 4, 6, 7 - 1965,1969,1969)

Using their viewers (with the cellophane removed), each team will have a turn at walking quickly past one side of the planet. A distance of five feet needs be maintained from the planet. Teams will then meet back at Mission Control with their backs to the planet until all teams have completed their fly-by of the planet.

1) Record your observations of the planet. What did you see that was the same as your Earth observations? What did you see that was different? Can you hypothesize (make a science guess) as to why there were any differences?

2) Record any similarities or differences that your team observed.

3) List the team ideas as to what you want to observe on your next orbiting mission.

a.

b.

c.

d.

C. Mission 2: The Orbiter (Mariner 9, 1971-72; Viking I and 2 Orbiters, 1976-80; Mars Global Surveyor, 1996-present)

Using a viewer, each team takes a total of two minutes to orbit (circle) the planet at a distance of two feet. Divide the two minutes by the number of team members to get the time each person gets to orbit the planet. After your observation, return to Mission Control.

1) Record your observations of the planet. What did you see that was the same as your Earth or fly-by observations? What did you see that was different? Can you hypothesize (make a science guess) as to why there were any differences?

2) Record any similarities or differences that your team observed.

3) As a team, develop a plan for your landing expedition onto the planet's surface.

a. Where will you go and why? How did your team decide where to land?

b. What are the risks or benefits of landing there?

c. What specifically do you want to explore at this site?

d. What type of special equipment or instruments would you need to accomplish your exploration goals? (Remember, anything you bring has be small and light enough to bring on a spacecraft!)

D. Mission 3: The Lander (Viking 1 and 2, 1976-1982; Mars Pathfinder 1 1997)

Each team will approach their landing site and mark it with a push pin or masking tape. Each team member will take a turn observing the landing site through their viewer. Field of view (the area that you can see through your viewer) is kept constant by aligning the viewer with the push pin located inside and at the top of their viewers. Each team has a total of five minutes to view the landing site. After each member views the landing site, return to Mission Control.

1) Now that you have landed, what do you think you can accomplish at this landing site?

2) How long (in days) will it take you to get the job accomplished?

3) Was your mission successful? Why or why not?

4) What were the greatest challenges of this mission (Personally and as a team)? What would you change for the next mission?

5) List the members of your team.

a.

b.

c.

d.

e.

f.

Probing Below the Surface of Mars

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to make accurate observations using appropriate tools and units of measure. (3-4. Science & Technology. J. #1) (5-8. Science & Technology. J. #1)
2. Learners will be able to describe how a substance can combine with different substances in different ways, depending on the conditions and the properties of each substance. (5-8. Science & Technology. E. #4)
3. Learners will be able to support reasoning by using models, known facts, properties and relationships. (5-8. Mathematics. J. #1)
4. Learners will be able to determine and evaluate the effect of variables on the results of data collection. (Secondary. Mathematics. C. #1)
5. Learners will be able to design and conduct scientific investigations which include controlled experiments and systematic observations. (5-8. Science & Technology. J. #2)

The General Idea:

In this activity, students will record and graph temperature data to learn about the search for water on Mars. Students will use a model of an ice-rich and ice-free near-surface on Mars to examine how the ice content of the martian soil will affect the rate at which a warm probe will cool. This activity is matched to both NAS National Science Education Standards and NCTM Principles and Standards for School Mathematics.

Getting Ready:

photocopy the student information sheet about Mars and the table for each student.

Introduce the Activity:

Before the students begin the activity, spend a few minutes talking about how this activity is relevant to the ongoing search for water on Mars. Have students read the student information sheet.

Today's activity will focus on how ice in the soil would affect the temperature of the probe after impact. Initially, each probe would have been much warmer than the cold martian soil. Gradually, however, the probe would have lost its heat to its surroundings, and would cool down. For this experiment, thermometers will take the place of the Mars Microprobes.

A question to ask the students before the activity:

Do you think the temperature will cool down faster with ice in the soil, or without it?

Ask the students why they answered a particular way. They might say the icy soil will cool faster for the wrong reason; they think of ice as cold. But, both icy soil and dry soil can be at the same temperature. If the soil is as cold as the ice, how will the ice change how fast the probes can cool?

What You Need:

- scientific classroom thermometers (Partial immersion thermometers are best. The thermometers should cover a range of at least 0 to 50 degrees C, or 32 to over 100 degrees F.)*
- identical deep salad bar containers or disposable food storage containers (Inexpensive disposable food containers such as the deep Ziploc brand 32 ounce containers work well.)*
- straws with a slightly larger diameter than the thermometers*(8 cm works best)

- tray or plastic shoe box to hold the two food containers, cold water, and ice. (The walls of the tray should be at least a few inches high.)
- cup to hold hot water*
- ice cold tap water
- hot tap water
- sand to fill each food container (50 lb. bags of playground or construction sand can be found in at most hardware stores, or smaller bags of sand can be found at many plant nurseries)
- access to a freezer the night before the activity
- wax paper
- transparent tape
- watch, clock, or stop watch
- data table for each student
- spoon (optional)
- masking tape (optional)
- permanent markers (optional)
- a cooler to transport the frozen materials (optional)
- graph paper (optional)
- two colors of colored pencils or pens (optional)
- petroleum jelly (optional)

  * you will need these supplies for each group of students doing the activity

What To Do:

The day before (with or without the students):

1. Wet half of the sand, either in a tray or another container.
2. Hold a straw upright in the center of each of the two identical food containers. Trim the straw so that it is slightly shorter than the top of the container. This will allow the students to more easily read the thermometers and will allow you to stack the lidded containers later.
3. Wrap the end of each straw in wax paper, and cover the seams with transparent tape, this will help prevent any excess water in the wet sand from filling the straw. Be careful not to wrap the entire straw in several layers or wax paper. This will make the contact between the straw and the sand very poor. *Note: coating the straw and wax paper with petroleum jelly may improve contact between the straw and the sand, it may also prevent the wax paper from absorbing moisture in repeated uses of the containers. Do not apply petroleum jelly before using the transparent tape.*
4. While holding the straw, fill one container with dry sand. Be careful to make sure the sand level is below the top of the straw. One person can do this, but it will be easier if one person holds the straw and another fills the container with sand.
5. Once again, while holding the straw, fill the second container with wet sand (using a spoon may help). The sand will compress under the added weight of the water, so you will need more sand to fill the same volume. Filling the container with dry sand and then adding water may increase the likelihood of the straw filling with water as well.
6. Let go of the straws. They should remain upright on their own after the containers have been filled.
7. If the students made their own sand-filled containers, label each container with the masking tape and markers. This is especially necessary if more than one group of students filled containers.
8. Place each container in a freezer for a few hours or overnight. Be careful not to tip the containers, which may cause the straws to shift.

The day of the activity:

1. Remove the containers from the freezer as soon to starting the activity as possible. The water in the sand should be frozen. If you need to remove them more than several minutes before the activity will begin, consider keeping them in a cooler. If you do use a cooler and ice, make sure that any water from melting ice doesn't enter the containers.
2. Just prior to beginning the activity, place the containers in the tray and put ice and cold water around them, being careful not to wet the sand, or displace the straw in the "dry" container.

The activity begins:

1. For a hands-on activity, divide the class into groups of 4 to 5 students. If this activity will be done as a demonstration, select 5 students to do this activity for the class.
2. Distribute the pre-made table, or make a 3-column table with time in the first column and two blank columns for the temperatures of the two probes. Make a place to record the starting temperature for each thermometer, the temperature every 15 seconds for the first minute, every 30 seconds for the next two minutes, and once every minute up to 6 minutes or so. If this activity will be done as a demonstration, have two of the student volunteers make separate tables on the board for the dry sand and the icy sand.
3. If you prepared the trays prior to the students' arrival, give the students the tray with the containers and the ice water.
4. Fill the cup with hot tap water. Place the two thermometers into the hot water. Wait a few minutes until the thermometers have adjusted to the temperature of the water. Tell the students that heating the thermometers in hot water simulates the heating the probes will experience as they pass through the atmosphere and impact Mars's surface.
5. Record the temperatures of the thermometers as the starting temperatures.
6. Place one thermometer into each straw.
7. Record the temperature of each thermometer at the recommended intervals over a period of 6 minutes. In groups of 5 students, have one student keep track of time for the group, two students read the temperatures off of the thermometers (with one thermometer each), and two students record the temperatures in the table(s). For groups of 4, announce the time intervals to the class. A clock the entire class can see may help in both cases. If a group has an extra student, he or she can be responsible for making sure the data is recorded on schedule. Groups of 2 to 3 students will also work if the temperatures of the dry sand or the icy sand are measured one at a time. If you choose this option, obtain new hot water to heat the thermometer, preferably close to the previous starting temperature.
8. Have all of the students in each group complete their individual tables from the recordeddata for the entire group.
9. Before putting away the trays, have each student test the hardness of the two samples with his or her fingers. This will simulate another way in which the probes will look for water ice. The icy sand will be much harder than the dry sand, making it more difficult for a finger to penetrate below the surface. On Mars, if ground ice is present, the probes will slow down more quickly, and will not go as deep as they will in ice-free soil. For younger students who have not been introduced to graphing, or if time is very limited, you can end here with a qualitative discussion of the data. Which "probe" cooled faster? Was the result a surprise to the students, or was it expected?

Graphing the data:

1. Have the students plot the data for each of the probes on the same piece of paper, preferably using a different color for each probe. Time should be plotted on the horizontal axis, and temperature on the vertical axis. For students new to making graphs, this can be done in groups. For students who have been previously introduced to graphing, this should be done individually.
2. Compare the results from the class. Did one sample consistently cool the thermometer faster than the other?

What To Discuss:

Discuss the results of the experiment with the class.

Why did the sample with the ice make the thermometer cool down faster?

The icy-sand conducts (moves) heat away from the thermometer better than the dry soil. The dry sand has pockets of air around each of the tiny grains. These pockets of air, called pore space, act as insulation, and make it harder for the heat to be passed from one part of the container to another. Air spaces are often used as insulation in buildings. Double paned windows have a sheet of glass on either side of a pocket of air. Air space is also used in walls, and insulation usually has a high fraction of pore space. When water is added and is frozen into the soil, ice fills the pore spaces. The combined material is less insulating and can conduct heat away from the thermometer and into the sand more efficiently. On Mars, dry soil will be more insulating than dry soil here on Earth. The air in the pores still transports heat in the soil, even if not very efficiently. The denser the air is, the better it is at moving heat. On Mars, the air is much thinner than here on Earth, and therefore will be even more inefficient in conducting heat.

Note: *Poor contact between the straw/thermometer and the icy sand can cause the thermometer to cool off more slowly in the icy sand sample. You should be able to identify this problem by a visual inspection of the sample. The thermometer is then better insulated by the air pocket around the straw than it is in the dry sand sample. Also, if the samples are not kept frozen, the experiment will not work properly. If either problem happens, all is not lost. Discuss with the students that result was not as expected (by you), and use this as an opportunity to discuss experimental design. How might the students improve the design of the experiment?*

If the Mars Microprobe Mission had succeeded, but *didn't* find ice in the soil of Mars, would that mean that permafrost doesn't exist on Mars?

No. The probes from the Mars Microprobe Mission would have only sampled one area on Mars, and would have told us about the ground very near the surface.

What other methods could be used to search for ground ice on Mars?

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Student Information Sheet

Probing Below the Surface of Mars
Mars and the Search for Water

Mars is a cold desert. Long ago, liquid water flowed on the surface of Mars. Ancient water carved valleys were imaged by the Viking spacecraft, and more recently, by Mars Global Surveyor. The valleys are billions of years old, and look much like river valleys here on the Earth. Mars Pathfinder landed at a place on Mars that is the site giant flood, but no liquid water from that ancient flood remains on the surface.

Today, water still exists on the Red Planet, but what we can see is ice. Like the Earth, Mars has polar caps in both the north and the south. These ice caps are at least partly made of water ice. Telescopes and spacecraft can see a type of clouds made of tiny crystals of ice, called cirrus clouds, drifting in the atmosphere of Mars. Frost can even cover the surface of rocks and soil in the morning, much like it does on cold mornings in many places here on Earth. Scientists who study Mars see evidence that Mars had much more water in its past, at least on the surface. What happened to that water?

Some of the water is believed to be frozen in the martian soil. Many regions on our own world have water frozen in the ground, either during the winter or, in very cold places, all year long. Water frozen in soil is simply called ground ice. If the ground ice remains throughout the year without melting, it is called **permafrost.** Permafrost is common in places like Siberia, northern Canada, and near the peaks of high mountains. Mars is as cold, or colder, than the coldest places here on Earth. Ground ice on
Mars should stay frozen all year, and will be permafrost. However, finding the ground ice on Mars isn't easy. A dry layer of soil is believed to be on top of the icy soil, making it difficult to detect at the surface. Mars scientists have thought of several ways to search for permafrost on Mars. Some look at images of the surface of Mars taken by orbiting spacecraft like Mars Global Surveyor, which is currently in orbit around Mars. In these images, the scientists hope to find features similar to those made by permafrost here on the Earth, including wedge-shaped cracks in the ground that meet to form multisided shapes and look a lot like giant mud cracks. In 2001, NASA plans to send another orbiter to Mars. The Mars Surveyor 2001 orbiter has a special instrument called a Gamma Ray Spectrometer that will search for ground ice on Mars over the entire planet. This instrument is designed to "see" ice below the dry soil at the surface.

Another way to find the ice is to send a probe below the surface of Mars. Close to the poles, many Mars scientists think the dry layer of soil will be very thin, and the icy ground will be close to the surface. The Mars Microprobes, two grapefruit-sized spacecraft, were supposed to impact the surface of Mars near the south pole in December 1999. Part of each tiny probe was designed to penetrate up to about 1 meter (or 3 feet) into the soil. Unfortunately, the probes were never heard from. If they had survived, scientists might have been able to find ground ice on Mars. The dusty or sandy soil near the south pole may be dry, or it may be contain ice. If the soil in the top meter is ice-rich, the probes were designed to detect the ice in three ways:

- by measuring how fast the probes slow down after impacting the surface. Ice will make soil harder, causing the probes to slow down more quickly than they would in ice-free soil.
- by collecting a soil sample and testing it for the presence of water using a heater and a tiny laser.
- by measuring how quickly the probes cool off after impact.

The Mars Polar Lander, also lost in December 1999, was also designed to search for ice. Instead of sending tiny probes into the soil, it would have used a robotic arm to dig a trench down into the surface to look for water ice and collect samples. In what other ways do you think scientists could search for ground ice on Mars?

Answering the question of what happened to the water on Mars is important to Mars scientists for many reasons. Water is related to the climate of Mars and finding ground ice could help scientists understand how the climate of Mars has changed over time. Did bacteria ever live on Mars? Does anything live underground on Mars today? Knowing how much water Mars had in the past and what has happened to that water will help us answer these questions. Someday, people may even go to Mars, and those people will need water.

Even though the Mars Microprobes and Mars Polar Lander were lost in December 1999, the search for ground ice on Mars goes on. Maybe someday new missions to Mars will probe the subsurface for water, just like the tiny Mars Microprobes were designed to. How might you design a mission to look for water on Mars?

Time	Dry Sand	Icy sand
Starting Temperature		
15 seconds		
30 seconds		
45 seconds		
1 minute		
1 minute 30 seconds		
2 minutes		
2 minutes 30 seconds		
3 minutes		
4 minutes		
5 minutes		
6 minutes		

Vocabulary List

Astronomer	A person who studies and contributes to the science of astronomy.
Atmosphere	A layer of gases that surround a body such as a planet.
AU	astronomical unit, the distance between Earth and Sun (~1.495 * 108).
Axis	An imaginary straight line around which an object rotates.
Ecosystem	A group of living organisms, their physical environment, and all the interrelationships in a particular unit of space.
Exobiology	a branch of biology that deals with the search for extraterrestrial life.
Field of view	the area that you can see through your viewer
Gravity	The force of attraction between two objects which is influenced by the mass of two objects and the distance between the two objects.
Microgravity	A condition of real or apparent reduced gravity experienced on orbiting space vehicles.
Orbital Period	The length of the year in Earth days
Permafrost	If ground ice remains throughout the year without melting
Planet	An object revolving around a star.
Retrograde	When a celestial body rotates in the opposite direction of the Earth or clockwise.
Rotation Period	The length of the day
Satellite	Another name for a moon.
Sideral Period	The length of a planet's year in Earth years.
Solar System	All the objects, and the star they orbit around, in one system.
Spacecraft	vehicle designed to operate in Earth orbit or in outer space, with or without a crew.
Sun	The star at the center of our solar system.
Star	a massive, self-luminous celestial body of gas that shines by radiation derived from its internal energy sources.
Telescope	device used to form magnified images of distant objects, such as stars, galaxies and planets.
Terraforming	To use the greenhouse effect to increase the density of a planet's atmosphere by releasing carbon dioxide (and other gases) trapped in the planet's rocks.
Tilt	How far a planet is tilted sideways on its axis, measured in degrees.
Universe	The vast expanse of space which contains all of the matter and energy in existence.

The Universe At Your Fingertips

In addition to the lesson plans included in this teacher guide, we recommend the following activities from The Universe at your Fingertips: An Astronomy Activity and Resource Notebook published by the Astronomical Society of the Pacific. This very comprehensive compendium of astronomy activities is an excellent resource that is available from the Maynard F. Jordan Planetarium. State of Maine Learning Results performance indicators are listed for each activity.

State of Maine Learning Results Performance Indicators	
"Fingertips" Activity Title	**Science and Technology Learning Results**
The Sun (B-1)	Gr.3-4. G. #2, H. #1 & Gr.5-8. G. #1
The Reasons for Seasons (B-5)	Gr.3-4. G. #2., G. #3. & Gr.5-8. F. #1.
Observing a Planet (C-4)	Gr.3-4. G. #1. & Gr.5-8. G. #3., G. #5.
Martian Canals (C-8)	Gr.3-4. K. #2. & #3. & Gr.5-8. G. #4., K. #4.
Can You Planet? (C-11)	Gr.3-4. G. #1. & Gr.5-8. G. #5.
How High Can you Jump on Another Planet? (C-12)	Gr.5-8. I. #2
Solar System Scale Model Sized to Your room (D-5)	Gr.3-4. G. #1. & Gr.5-8. G. #5.
Toilet Paper Solar System Scale Model (D-6)	Gr.3-4. G. #1 & Gr.5-8. G. #5.
The Thousand Yard Model (D-7)	Gr.3-4. G. #1. & Gr.5-8. G. #5.
Designing a Planetary Probe (I-1)	Gr.3-4. J. #4. & Gr.5-8. J. #6. & Secondary. G. #1., J. #4.
Making Measurements of Objects in the Sky (J-1)	Gr.5-8. G. #5.

Some good books to use with Mars Invasion

The Adventures of Sojourner: The Mission to Mars That Thrilled the World
Wunsch, Susi Trautmann. 1998, Mikaya Press.
Tells the story of the mission that placed the Sojourner remote control rover on Mars on July 4, 1997.

Living on Mars: Mission to the Red Planet
Cole, Michael D. 1999, Enslow Publishers.
Describes the landing of Sojourner and summarizes the history of information gathering missions.

Mars At Last
Washburn, M. 1977, Putnam's.

On Mars: Exploration of the Red Planet
Ezell, E. & L. 1958-1978. 1984, NASA SP-4212.
Mainly a history of the Viking project.

To Utopia and Back
Horowitz, N. 1986, Freeman.
On the search for life on Mars with the Viking instruments.

The Search for Life on Mars
Cooper,H. 1980, Holt, Rinehart & Winston.

To the Red Planet
Burgess,E. 1978, Columbia University Press.

Life on Mars
Getz, David. 1997, H. Holt.
Presents information about Mars as the reader joins a hypothetical three year space exploration.

Some good web sites to use with *Mars Invasion*

tes.asu.edu
ASU Mars Education / Thermal Emission' Spectrometer Homepage:

marsweb.jpl.nasa.gov
JPL Mars Mission Homepage

mars.jpl.nasa.gov
The Mars Exploration Program's Home Page

nova.stanford.edu/projects/mgs/dmwr.html
The daily Martian weather report brought to you by the Mars Global Surveyor Radio Science Team

www.jpl.nasa.gov/solar_system/planets/mars_index.html
The Jet Propulsion Laboratory's Mars site

www-mgcm.arc.nasa.gov
Created by Howard Houben of the Mars Global Circulation Model Group, is produced daily by the Center for Mars Exploration at NASA's Ames Research Center

Lessons From The World Wide Web

Also, a wide variety of lesson plans and activities can be found on the World Wide Web. These sites are dedicated to lesson planning in a variety of subjects.

athena.cornell.edu
Athena Rover Homepage

cse.ssl.berkeley.edu
The Center for Science Education at U. C. Berkeley Space Science Laboratory home page with a link to the Science Education Gateway (SEGWay), Lesson Plans

http://www.nasm.si.edu/help/links/edulinks.cfm
Smithsonian National Air and Space Museum Educational Links

http://www.seti.org/site/pp.asp?c=ktJ2J9MMIsE&b=178025
SETI Homepage

btc.montana.edu/ceres
Maintained by the Burns Telecommunications Center, this page links to educational activities and classroom resources.

spaceplace.jpl.nasa.gov/spacepl.htm
This California Institute of Technology and NASA Jet Propulsion Laboratory site for kids offers information and activities .

discoveryschool.com
This Discovery Channel education site allows teachers to search for lesson plans by grade and subjects.

http://www.eduref.org/
Lesson plans based of the popular PBS series, Newton's Apple

www.thegateway.org
Sponsored by The U.S. Department of Education's National Library of Education and ERIC Clearinghouse on Information & Technology, this site offers lesson plans for all subjects and all grades.

Astronomy Web Sites Worth a Visit

www.galaxymaine.com
The Maynard F. Jordan Planetarium and Observatory home page.

www.galaxymaine.com/SA/
The teacher resources and bibliography page on the Maynard F. Jordan Planetarium web site

space.jpl.nasa.gov
NASA's Jet Propulsion Laboratory web site

ssd.jpl.nasa.gov
A site about our solar system maintained by the Solar System Dynamics Group of the Jet Propulsion Laboratory.

seds.lpl.arizona.edu/nineplanets/nineplanets/nineplanets.html
A Multimedia Tour of the Solar System from the Students for the Exploration and Development of Space

www.dustbunny.com/afk
A web site about astronomy, designed for kids, with tons of information

hawastsoc.org
The Hawaiian Astronomical Society's home page

www.calacademy.org/planetarium
Alexander F. Morrison Planetarium home page

www.nss.org/
The official National Space Society webpage.

The Maynard F. Jordan Planetarium does not guarantee that the information given on the above web sites to be accurate, accessible, or appropriate for students.