Experiment Bar

Brief Summary

- With no Museum Galaxy Guide to facilitate
  Located near the Mars diorama, the Experiment Bar gives visitors a chance for hands-on exploration of planetary geology at several experiment stations. Visitors can put together a Mars puzzle, view very thin slices of rock, explore how volcanos on Mars and Earth compare, and look at different views of Mars.

- When a Museum Galaxy Guide is present to facilitate
  Museum Galaxy Guides (MGGs) will facilitate deeper exploration at the Experiment Bar. The MGG will encourage visitors to make observations, develop questions, and find answers to these questions themselves whenever possible. Also, the MGG will bring out some special equipment and do demonstrations for the visitors, for example the properties of materials used to protect astronauts against ultraviolet radiation and a vacuum jar to make water boil without heating it.

Below are the Experiments and Demonstrations That Can be Found at the Experiment Bar:

Experiments that do not need to be facilitated:

- Mars Globes- There are two globes of Mars. One shows what Mars actually looks like in sunlight. The other uses false colors to represent the heights (elevations) of features on Mars. Visitors can compare the appearance of mountains, canyons, craters, and other features of Mars.
- Mars Puzzle- 3-D blocks fit together to form a model of a section of Mars's surface.
- Thin Sections- A circular lazy-susan containing a half dozen thin sections of rocks can be rotated by the visitor and a microscope. (These are NOT actual Mars rocks, but Earth rocks that may be similar to Mars rocks). An audio track provides interpretive comments about the significance of the different rock sections.
- Volcanos on Two Worlds- Explore the structural similarities and differences between the largest volcano on Mars (Olympus Mons) and Earth (the Hawaiian Islands).
- Valles Marineris Model- Explore a model of the largest canyon in the solar system, Valles Marineris. The Mars Diorama is located in Candor Chasma, on the northern side of Valles Marineris.
- Kasei Valles Model- Kasei Valles is one of the largest outflow channels on Mars. This model can be used to talk about the history of water on Mars.

MGG Experiments done only by facilitators (not visitors alone):

- Cubelets- Cubelets are simple robots. Robots do three things: sense, plan and act. So using just three cubes you can build a simple robot. Why build robots in Space Odyssey? Robots are the main explorers of space. Humans have only been on the moon but robots have been rovers and landers all over the solar system.

- Scale of the Solar System- With this model, visitors can explore the relative sizes of the Sun, planets, and major moons in the solar system.
- Planet Weight Bottles- Visitors explore how surface gravity is different on each of the planets by lifting bottles that simulate how much an object (that weighs one pound on earth) would weigh on each of the planets and the Moon.
- Planet Matching Game- Match pairs of cards with images and/or facts about things found in our solar system, within the framework of game playing.
- Rock Core Samples- These core samples are from Earth, but someday scientist may be able to gather samples from other planets, including Mars. Core samples capture layers of rock and dirt laid down over time, making them "time capsules" of past surface conditions.
- Mars Dirt Simulant- Two Plexiglas cubes at the Experiment Bar contain dusty, rust-colored soil. This soil actually came from the slopes of a Hawaiian volcano, but the color and texture are similar to Martian soil (called regolith). Visitors can shake the cubes and see how the dust clings to every surface and hangs in the air like smoke.
- Mars Rocks- These rocks from Earth represent both rocks known to be on Mars and rocks that we hope to find on Mars.
- Hematite Samples- Visitors can explore different types of hematite. Hematite is a form of iron-oxide. Fine grain hematite is what gives Mars its characteristic red hue. Grey hematite is generally formed in the presence of liquid water.
- Viking Battery- Batteries exactly like this one were used to power the Viking Landers, which were the first mission to successfully touch down on Mars. The Viking Landers
- Moon Globe- While humans haven't yet been to Mars, they have been to the Moon. Use the globe to explore different moon features with guests, talk about the formation of the Moon, and the history of lunar exploration.

MGG Demonstrations:

- Vacuum Chamber Experiments- The facilitator uses a vacuum pump and several props to illustrate the effects of low pressure on water and other materials.
- Fuel Cell- Fuel cells are another way to store energy, much like a battery. The Space Shuttle used fuel cells because they were lighter weight than batteries. This activity uses a functioning fuel cell to demonstrate how fuel cell works and discuss future uses of fuel cells in space exploration.
- Bowling Ball Density Demo- Demonstrate the concept of density using three balls. Two of the balls are the same mass but different sizes and two are the same size but different masses. Each planet has a different density. Saturn is the only planet that is less dense that water (It is about 70% as dense as water, and so would float in a giant tub of water with about 70% of Saturn below the water and 30% above).
- Protecting astronauts from ultra-violet light- A UV lamp, a UV detector, and several swatches of materials are made available for visitors to determine the UV protection value of each material.

Equipment Required

Though several experiments are located at permanent stations on the Experiment Bar (see Experiments that do not need to be facilitated), some stations and demos will need to be taken from storage and set out by the facilitator. Each demo will have the required equipment, below.

Below are the Experiment Bar Components:

Mars Globes

Main Teaching Points

- Different Mars globes can provide contrasting types of information about what Mars is like.
- Even though satellites orbit Mars at an elevation of a hundred or so kilometers, instruments such as radar altimeters, spectrometers and various kinds of cameras, on-board satellites can give us quite a good profile of what the surface of Mars is like.
- Though Mars has ice caps and seasons as Earth does, the scale of its surface landforms are much more extreme than Earth's. For example, Mars has several volcanoes at least twice as high as Mt. Everest, and a canyon 2,500 miles long.

Suggested ways of presenting demo

Try this:

1. Hold up the golf ball and soft ball and tell the visitors that these two balls represent the approximate ratio of Mars to Earth (Mars is actually 53% of Earth's diameter).
2. Ask visitors which ball represents which planet. Note that numbers here can be deceiving: The visual impression of the size of a ball is based in its volume more than its diameter. Though Mars is more than half the diameter of Earth, Mars appears to be only about 1/6 the volume of Earth.

3. Point out the volcano model that is striped with multicolored bands. This is a topographic model with the same color assignments to elevation as the globe, so that red on the globe indicates high elevation, blue represents low elevation.
4. Have the visitor look at both globes of Mars. Ask them to find the same geological features on both globes. (See below under Additional Science Content for geographic details.)

Or try this:

1. Explain that one shows Mars in natural light, the other shows elevation, and begin a discussion about the features they see.
2. Ask visitors to hypothesize what forces might be responsible for causing prominent surface features such as Hellas Basin and Tharsis Plateau, or why the northern and southern hemispheres look so different.

Additional Science Content

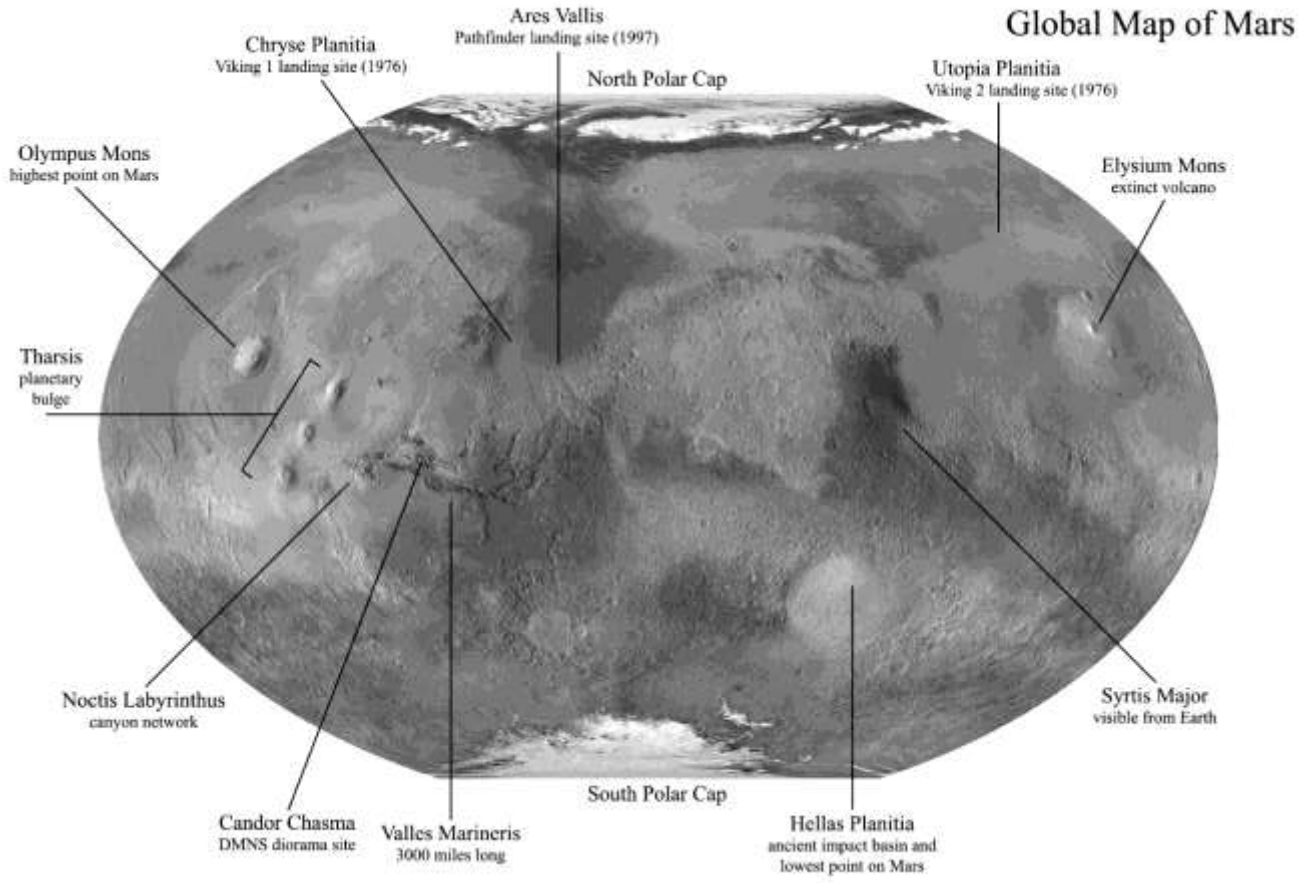
- Mars has an equatorial diameter of 6,693 km, which is about half that of Earth's.
- The highest mountain on Mars, Olympus Mons, is nearly 80,000 feet high.
- Valles Marineris is as long as the distance from New York to San Francisco and wide enough in places to insert Arizona's Grand Canyon sideways.
- The lowest point on Mars, Hellas Planitia, is on the opposite side of the globe from the highest point, Olympus Mons.
- The Martian year (687 Earth Days) is about twice as long as an Earth year (365 Earth Days). Like Earth, Mars has seasons, because its axis is tilted at a similar angle (25°) as Earth's (23.5°). Unlike on Earth, however, this tilt in not the only reason for the seasonal change in temperatures on Mars. The other important reason is the elliptical shape of its orbit, in contrast with the Earth's orbit, which is nearly round.
- Because Mars's orbit is significantly elongated, the seasons in the northern and southern hemispheres are not symmetrical. It is much colder in southern winter than northern winter.
- 1/3 of the Martian atmosphere freezes out to make the seasonal part of the polar caps.

Major geographic features of Mars

- **Tharsis Planitia region** with its four huge volcanoes. Mars has no tectonic plates, no continental drift, so volcanic eruptions can build up in one location over a very extended period of time. This is also known as the Tharsis Bulge.
- Of the four volcanoes, one is **Olympus Mons**, the highest point on Mars at 80,000 ft. above the average surface level.
- **Valles Marineris** (Mariner Valley – named after the Mariner 9 mission) is a rift valley caused by internal stresses (not a water-carved valley like Earth's Grand Canyon of the Colorado). It is 2,500 miles long, up to several hundred miles wide, and more than five miles deep in places.
- **Noctis Labyrinthus** (the Labyrinth of Night) is on the west end of the Valles Marineris is a region of chaotic terrain. It looks like the situation when you bury your hand in wet sand at the beach, then lift it up slightly. The huge cracks that appear would look much like the Noctis Labyrinthus.
- **Candor Chasma** is the site of the diorama, -6° S, 76 °W, several hundred miles east of Noctis Labyrinthus, between the equator and Valles Marineris. Candor Chasma is a

side canyon of Valles Marineris with a lot of geology happening. Many layers of rock are visible. Landslides have occurred periodically, possibly because of sublimation of ice from the permafrost below the surface. Also, very thin fogs have been photographed in the low areas of Candor Chasma.

- **Hellas Planitia** is the largest impact basin on Mars. It boasts the lowest location on Mars at 26,000 feet (more than 5 miles) below the average surface level.
- Mars has **polar ice caps** at the northern and southern poles. These caps, made up of carbon dioxide and water ices, dramatically change in size with the seasons.
- **Syrtis Major** is a region covered in very dark sand in the form of a very distinct dark "shark fin" surrounded by brighter, dust-covered bedrock. This feature is visible with small telescopes (though the telescope inverts the image as compared to the now-standard maps and globes) and the size changes visibly as seasonal dust storms deposit bright dust on the dark sand, then at other times of year prevailing winds strip the dust away.
- **Utopia Planita** is the landing site of the Viking 2 Lander. In 2016, scientists using the Mars Reconnaissance Orbiter discovered a large deposit of water ice less than 30 feet below the surface in the southwestern portion of Utopia Planitia. The deposit is more extensive in area than the state of New Mexico and holds a little more than the volume of water in Lake Superior (which holds 3 quadrillion gallons of water). It represents approximately 1% of the total volume of water ice on Mars.



Background materials (websites, videos, articles, digital collections links)

- https://astropedia.astrogeology.usgs.gov/download/Docs/Globes/i2782_sh1.pdf - zoomable topographic map of Mars
- http://www.nasa.gov/mission_pages/MRO/multimedia/pia10134-caption121107.html -- 'Hilltop' View of the Terrain in Candor Chasma
- http://apod.nasa.gov/apod/ap030218.html -- Candor and Ophir Chasmata
- http://www.jpl.nasa.gov/spaceimages/details.php?id=PIA03838 - 2001 Mars Odyssey photo of Candor Chasma
- http://www.planetary.org/blogs/guest-blogs/2016/1122-subsurface-water-ice-in-utopia-planitia-mars.html - Utopia Planitia subsurface ice discovery

Mars Puzzle

Main Teaching Points

- Scientists have to piece together ("mosaic") many individual photos of Mars to make large maps.
- Just as visitors piece together the blocks of Mars surface, scientists create photo-mosaic images by matching up surface features such as canyons or craters.

Suggested ways of presenting demo

- With all pieces removed, this puzzle is difficult to visualize. Unless the visitor is particularly good with puzzles, try offering only 4 pieces for the visitor to assemble with the rest of the pieces pre-assembled.

Additional Science Content

- The first photo mosaics of Mars were made possible by fly-bys of four spacecraft: Mariner 4 (1964), Mariner 6 (1969), Mariner 7 (1969), and Mariner 9 (1971).
- Four Viking spacecraft (two Orbiters and two Landers) arrived at Mars in 1976
- Mars Global Surveyor reached Mars in 1997 and operated unitl 2006
- Six spacecraft are currently operating in Mars orbit: Mars Odyssey (NASA; reached Mars in 2001), Mars Express (European Space Agency; arrived in 2003), Mars Reconnaissance Orbiter (NASA; entered orbit in 2006), Mars Atmospheric and Volatile EvolutioN (MAVEN) (NASA; arrived in 2014), Mars Orbiter Mission (MOM) (Indian Space Research Organization; arrived in 2014), and the ExoMars Orbiter (ESA, operating since 2016).

Background materials (websites, videos, articles, digital collections links)

- http://nssdc.gsfc.nasa.gov/photo_gallery/photogallery-mars.html - Photo mosaic images of Mars

Thin Sections

Main Teaching Points

- Scientists look for evidence of mineral components and the environments in which a rock formed to determine the presence of past or present liquid water on Mars.
- By examining pieces of rock that have been cut into very thin slices (only 0.03mm = about one third as thick as a human hair!) scientists can determine the mineral composition of the rock as well as the environment (such as ocean floor or volcanic slope) that the rock formed in. Using this data, scientists can piece together the geologic history of a certain location.

Suggested ways of presenting demo

- After visitors have examined the thin section and listened to the commentary, show them the laminated photograph of the ALH 84001 meteorite that is thought to have originated on Mars, and shows sausage-like shapes that resemble Earth bacteria. Discuss the implications.
- Review with visitors what they saw in each of the thin sections. Using thin sections of rock examined in polarized light, it is possible to distinguish volcanic rocks such as granite and volcanic breccia, a rock composed of angular grains tightly cemented together. Some rocks typically formed in water are limestone and hematite. When a rock contains these minerals, especially in the form of rounded grains, it may indicate that the rock was formed in the presence of moving water.

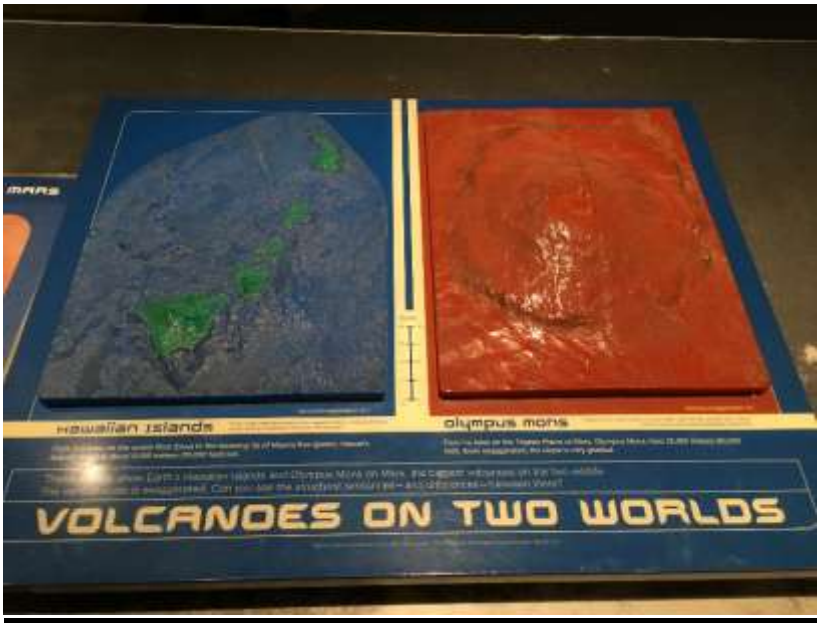
Additional Science Content

- Though certain meteorites believed to have come from Mars were found to contain crystals that closely resemble the crystals that form on Earth only by in the presence of blue green algae, there is no consensus among scientists that this evidence alone is strong enough to indicate life on Mars.
- Sausage-like structures found in a meteorite (designated ALH 84001) that originated from Mars led some scientists to believe they were remains of Martian bacteria, but the majority of scientists now believe these structures were formed by chemical not biological activity.

Background materials (websites, videos, articles, digital collections links)

- http://mars.jpl.nasa.gov/msl/mission/science/ - NASA Mars Science Laboratory (Curiosity) science site
- http://mars.jpl.nasa.gov/mer/science/ - NASA Mars Exploration Rover (Opportunity and Spirit) science site
- http://www.minsocam.org/# -- Mineral Society of America web site; check Education and Outreach tab.

Volcanos on Two Worlds



Main Teaching Points

- The largest volcano on Mars is Olympus Mons. It is a shield volcano that is approximately 375 miles in diameter (about the size of the state of Colorado) and 80,000 feet high.
- The largest volcano on Earth is Mauna Loa in Hawaii. It is also a shield volcano but is only 33,264 feet high (measured from the ocean floor) and 75 miles in diameter.
- Olympus Mons is located in the Tharis Volcanic Plateau (sometimes called the Tharsis region or the Tharsis Bulge). Volcanos in the Tharsis region are 10 to 100 times larger than any volcano on Earth.

Suggested ways of presenting demo

- This is a tactile model – encourage visitors to explore using touch. Have them feel the difference in size, slope. Ask them questions to help them describe their observations.

Additional Science Content

- The lava flows that have been observed on Mars appear to be much longer than lava flows on Earth. This is likely due to a higher eruption rate and lower surface gravity.
- One reason the Martian volcanoes are larger than terrestrial volcanoes is because the crust on Mars doesn't move like it does on Earth (no evidence for active plate tectonics). "On Earth, the hot spots remain stationary but crustal plates are moving above them. The Hawaiian islands result from the northwesterly movement of the Pacific plate over a stationary hotspot producing lava. As the plate moves over the hotspot, new volcanoes are formed and the existing ones become extinct. This distributes the total volume of lava among many volcanoes rather than one large volcano. On Mars, the crust remains stationary and the lava piles up in one, very large volcano." (From https://mars.jpl.nasa.gov/gallery/atlas/olympus-mons.html)

Background materials (websites, videos, articles, digital collections links)

- https://mars.jpl.nasa.gov/gallery/atlas/olympus-mons.html - Olympus Mons
- http://www.lpi.usra.edu/publications/slidesets/hawaiivolcanoes/slidespages/slide_01.html - Olymus Mons vs Hawaiian island volcanoes
- http://volcano.oregonstate.edu/giant-shield-volcanoes - Martian Volcanoes

Valles Marineris Model

Main Teaching Points

- Valles Marineris is the largest canyon in our solar system. It is up to 2,500 miles long and 4.5 miles deep.
- The Grand Canyon of the Colorado in Arizona, for comparison, is only 500 miles long and 1 mile deep. The Grand Canyon could fit sideways in some portions of Valles Marineris.
- Unlike the Grand Canyon, scientists do not think that Valles Marineris was primarily formed by flowing water. The leading theory is that it is a "tectonic crack" which formed as the planet cooled and the Tharsis region rose to the west. The canyon was then widened by erosional forces and sublimation of permafrost (a process known as "mass wasting"). These processes may be active to the present day.

Suggested ways of presenting demo

- Ask visitors if they have ever seen a canyon on Earth, such as the Grand Canyon and describe what they saw. Use their experiences to compare canyons on Earth to Valles Marineris
- Show visitors Candor Chasma on the model of Valles Marineris and then have them look at the diorama, which is based on an actual location in Candor Chasma. Explore features of the diorama, such as the canyon wall (painted in the background) and mesas.

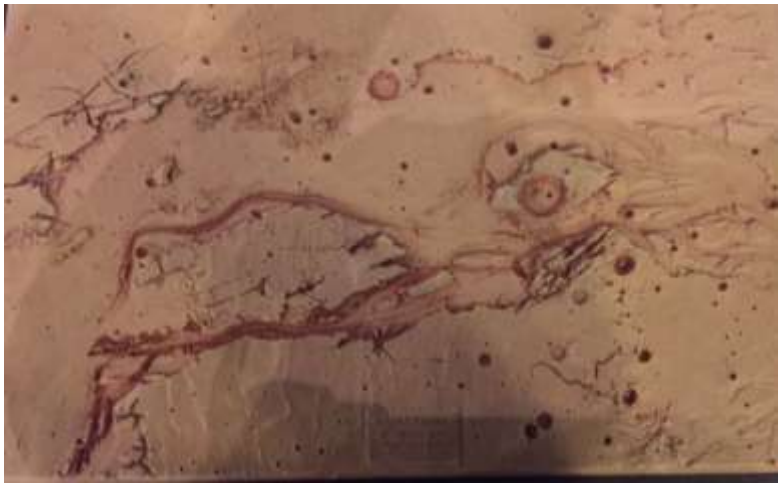
Additional Science Content

- Some of the regions to the east of Valles Marineris appear to be marked by channels formed by water.
- Numerous landslides have been observed to scar the steep canyon walls.
- Images from orbiters have shown that the canyon walls and mesas of Valles Marineris are highly layered and could have been caused by wind, water, or even episodic volcanic activity.
- No rover or lander has explored Valles Marieneris.

Background materials (websites, videos, articles, digital collections links)

- https://mars.jpl.nasa.gov/gallery/atlas/valles-marineris.html - Valles Marineris
- http://www.lpi.usra.edu/publications/slidesets/redplanet2/slide_7.html - Landslides in Valles Marieneris
- http://www.esa.int/Our_Activities/Space_Science/Mars_Express/Walls_of_Candor_Chasma - The walls of Candor Chasma
- https://themis.asu.edu/feature/36 - Geology of Candor Chasma

Kasei Valles Model



Main Teaching Points

- Kasei Valles is likely the largest outflow channel on Mars.
- This feature was caused by flowing liquid water. In this case, it was likely related to massive floods scouring the surface over an extended duration.
- This feature would span the state of Colorado.

Suggested ways of presenting demo

- Ask visitors if they have ever seen a similar feature on Earth and speculate as to what may have caused it.
- Use this as a jumping off point to talk about the history of water on Mars.
- Compare this feature to Valles Marines and explore the different formations of each of these features.

Additional Science Content

- This valley is still being modified by wind erosion today.

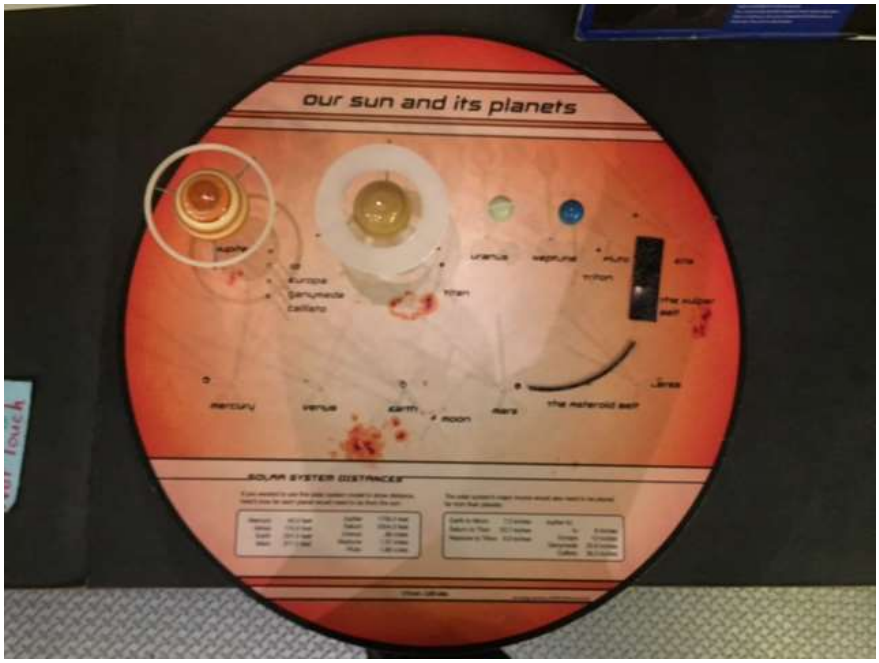
Background materials (websites, videos, articles, digital collections links)

- https://themis.asu.edu/feature/10 - Kasei Valles
- http://www.planetary.org/blogs/emily-lakdawalla/2013/06190805-kasei-vallis-mars-express.html - Kasei Valles

Cubelets

Please see separate Cubelets training manual

Scale of the Solar System



Main Teaching Points

- Explore the relative sizes of the Sun, planets, and major moons in the solar system

Suggested ways of presenting demo

- Let guests lead your conversation. Have them describe what they are noticing, or anything that surprises them. Ask probing questions to see where their interest lies and let that guide your conversation about the solar system.

Additional Science Content

- The Uniview Glossary and other Space Odyssey training manuals have great facts about the planets you can share with guests while facilitating this scale model.

Background materials (websites, videos, articles, digital collections links)

- https://solarsystem.nasa.gov/planets/ - Planet, Dwarf Planet, and Moon Facts from NASA
- https://solarsystem.nasa.gov/planets/compare - Planet Comparison Tool
- https://www.universetoday.com/33415/interesting-facts-about-the-planets/ - Quick Planet Facts

Planet Weight Bottles

Pre-weighted water bottles

If you weigh 100 pounds on Earth, how much would you weigh on other worlds?

The Sun	2,707 lbs
Mercury	37.8 lbs
Venus	90.5 lbs
Earth	**100 lbs**
The Moon	16.5 lbs
Mars	37.9 lbs
Jupiter	253 lbs
Saturn	106.5 lbs
Uranus	90.5 lbs
Neptune	114 lbs

What would the Earth bottle weigh on other worlds?

The Sun	60.28 lbs
Mercury	0.83 lbs
Venus	1.99 lbs
Earth	**2.20 lbs**
The Moon	0.36 lbs
Mars	0.84 lbs
Jupiter	5.57 lbs
Saturn	2.34 lbs
Uranus	1.99 lbs
Neptune	2.51 lbs

Weight info sheet

Brief Summary

The nine pre-weighted water bottles allow guests to compare the strength of gravity on the 8 planets and our moon. The laminated information sheet shows the actual weight of the bottles and also the weight of a 100 pound object (on Earth) complete to the other planets, our moon, and the Sun

Main Teaching Points

- Your weight is different on different planets
- The mass of the object remains the same even though the weight changes.
- The diameter and mass together determine the surface gravity.

Suggested Ways of Presenting this Demo

- Hand a visitor the bottle labeled “Earth.” Ask them how much the same object would weigh on a different planet. Hand the visitor the bottle labeled “Jupiter.” Explain that your weight on that planet would change because of the different gravity of that planet. Repeat with the other bottles.

Additional Science Content

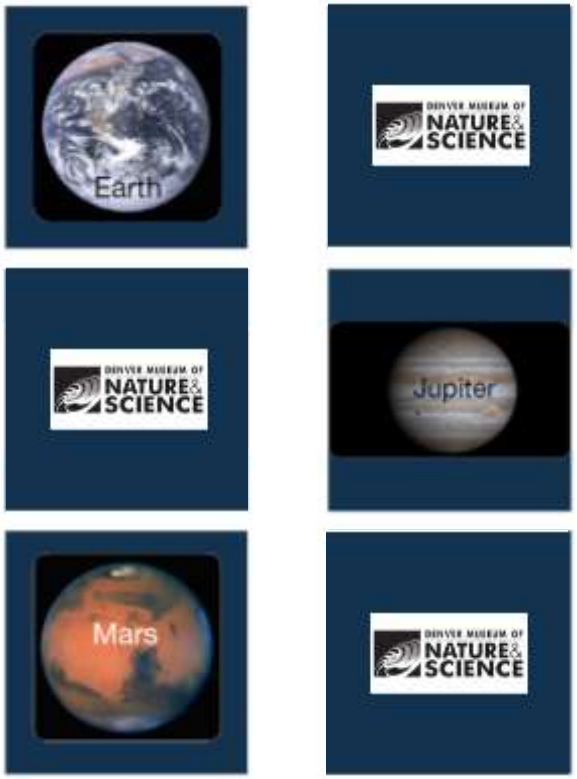
- ***Surface Gravity -*** The diameter and mass of a planet combine in a very important way. They determine its surface gravity. You are very familiar with gravity. It is the force that keeps you from flying off into space when you leap off the ground. It is the force that pulls you down on the scale when you weigh yourself. Since different

planets have different diameters and different masses, the amount of gravity at each planet's surface is different. The actual relationship is pretty interesting. Greater mass means greater surface gravity. But, greater diameter means lesser surface gravity.

Background materials (websites, videos, articles, digital collections links)

- See Scale of the Solar System background materials

Planet Matching Game



Main Teaching Points

- Gain a familiarity with objects in our solar system
- Learn new and interesting things about known objects in our solar system
- Discover unknown objects in our solar system

Suggested Ways of Presenting this Demo

- Ask visitors if they want to play a space card game. This game can be played with as many as 3 people comfortably. Pick one of the decks, either the “Easy” or “Challenge” deck based on what ages of visitor you are playing with. Shuffle the deck and lay all the cards face down in rows. The first player turns over two cards. If the two cards are a match the player keeps the match and goes again, turning over two more cards. If the cards are not a match, the cards are turned back face down and the next player

takes a turn. Players take turns turning 2 cards at a time until all the matches are made. The player with the most matches wins.
- Try a multiple choice game to test your space knowledge. Lay several image cards face up, pick a FACT card and read it out loud. Ask the visitor to select the image card that is the right answer to the Fact Card.
- As you reveal objects you know about, share other interesting facts.

Background materials (websites, videos, articles, digital collections links)

- See Scale of the Solar System background materials

Rock Core Samples

Main Teaching Points

- Rock core samples are one way to study the geologic history and past surface conditions of the planet. By taking a core sample, scientists can capture and study layers of rock from beneath a planet's surface.
- These core samples are from Earth, but represent rock that is similar to what may be found on Mars.

Suggested ways of presenting demo

- Ask visitors how we might study the history of the planet since we are unable to directly observe what happened millions of years ago.
- Explore with visitors the layers of rocks in the Mars Diorama, and connect that to the layers seen in the core samples.
- Ask visitors if they can find similar looking rocks in the diorama (there are sandstone and vesicular basalt samples in the diorama).
- Bring these samples, on a cart, over to the Mars diorama during the Astronaut on the Surface of Mars Show is happening if they are doing the Core Drilling Experiment to show visitors what a core sample looks like.

Additional Science Content

- The Law of Superposition: Older rock layers are found underneath younger rock layers
- Sandstone is a sedimentary rock, which is a type of rock that is formed by sediment being deposited over time. Sandstone is formed from sand that has been deposited and compacted. Sandstone has been observed in several locations on Mars, including observations by the Curiosity Rover Mount Sharp in Gale Crater. Studying the grains that make up the sandstone, including their grain size, can help scientists determine the origins of the sediment and also what caused them to be deposited (wind, standing water, flowing water, etc.).
- Basalt is a dark colored igneous (volcanic) rock. Vesicular basalt is a type of basalt that has “vesicles” which are voids once occupied by gas bubbles when the material was still molten. Mars has many, now dormant, volcanos. The largest of these, Olympus Mons, is located in the Tharsis volcanic plateau to the northwest of Valles Marineris.

Background materials (websites, videos, articles, digital collections links)

- https://www.sciencelearn.org.nz/resources/643-reading-rock-core-samples - Core Sampling

Mars Dirt Simulant

Main Teaching Points

- This soil actually came from the slopes of a Hawaiian volcano, but the color and texture are similar to Martian soil.
- The difference is that Martian soil is much more powdery and lacks the medium-sized sand particles which form by water erosion on Earth.

Suggested ways of presenting demo

The Mars soil is contained inside Plexiglas cubes. Have a visitor shake the cube, then hold it up with backlight to see how the dust hangs in the air and doesn't settle out. Also point out how the dust clings to the Plexiglas. Dusting of solar panels and other equipment will be a major chore on the surface of Mars. This has already happened to NASA's Mars Exploration Rovers (Spirit and Opportunity).
(http://www.nasa.gov/multimedia/imagegallery/image_feature_2203.html and http://www.nasa.gov/mission_pages/mer/news/mer-20090212.html).

Additional Science Content

- Martian regolith, being volcanic, is rich in minerals needed for plant growth, but it makes a poor growing medium due to the lack of organic material that retains moisture and prevents hard packing that cramps root growth.
- The reddish color is due to the soil's content of iron oxide (rust) which is produced when iron containing minerals in the surface rock, which is of volcanic origin, react with traces of oxygen in the Martian air.
- Mars soil particles are finer than face powder, and hang in the air like particles of cigarette smoke.
- Mars regolith is highly toxic to humans. It contains a high concentration of silicas, which are known carcinogens. It also contains perchlorates. Perchlorates are a salt derived from perchloric acid that can be dangerous to humans at high levels, since it disrupts thyroid function. This is a groundwater contaminate at Earth, but the concentration of perchlorates on Mars is 10,000x higher than any levels seen on Earth.

Operating Tips & Potential Problems

- Be sure to put the Plexiglas cubes of soil back into their storage drawer before you leave the Experiment Bar. These are collection items and cannot be left unsupervised.

Background materials (websites, videos, articles, digital collections links)

- http://quest.arc.nasa.gov/mars/ask/soil/ - A dozen Q & A's about Mars soil
- See previous reference links.

Mars Rocks and Hematite Samples

Note: These nine simulated Mars rock specimens are found in a tray in the Experiment Bar cabinets

Hematite Samples

Main Teaching Points

- These sets of specimens allow facilitators to discuss the geology of Mars and present to visitors one of the scientific research areas of missions to Mars - finding out the past geologic history of Mars.
- Visitors will compare and contrast rocks from Earth and Mars to learn about the similarities and differences between the two planets.
- Note: These rocks are NOT from Mars. They are Earth rocks that represent rocks that have been observed on Mars or, in some cases, which we hope to find on the Red Planet (but might not actually exist there).

Suggested ways of presenting demo

- Ask the visitor to choose rocks that would look out of placed on Earth.
- Ask the visitor to hypothesize, based on previous knowledge, how these rocks were formed. Water? Volcanoes? Etc.
- Have visitors point to similar rocks outside the Candor Chasma Station.

Additional Science Content

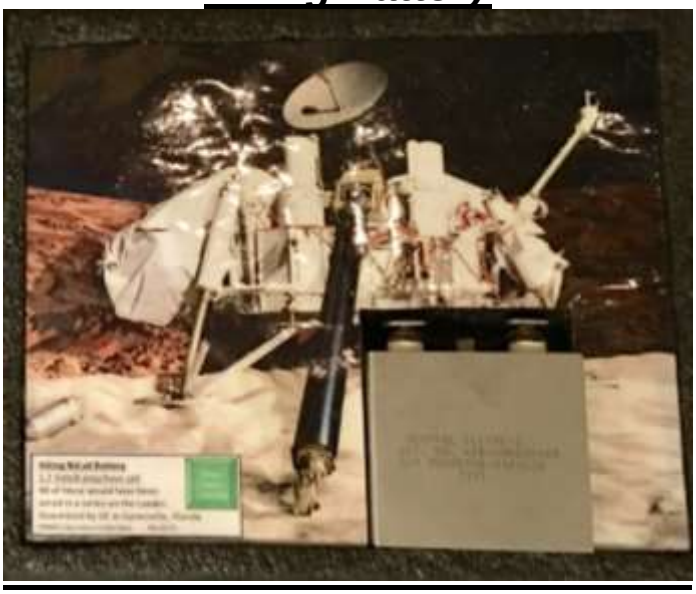
- The types of rocks we find on Mars are the same type of rocks we find on Earth. So far, we have not found any rocks which are completely unique to Mars. However, Earth rocks are much more diverse: very few sedimentary or metamorphic rocks are found on Mars.
- The provenance, (i.e. the exact setting and context where we find the rock) can also us about the history and geologic development of Mars. Rocks can get to their present location by a variety of processes, including secondary ejecta from impactors, landslides, erosional deposition, or in situ lithification.

- Igneous rocks are the most common type of rock on Mars. In fact much of Mars is covered by primordial lava flows. One of the most common type of igneous rock we have found on Mars is basalt.
- Hematite is a form of iron-oxide. Fine grain hematite is what gives Mars its characteristic red hue. Grey hematite is generally formed in the presence of liquid water.
- Grey hematite was first detected on Mars in 1998 by the Mars Global Surveyor. In the early 2000's, the Opportunity Rover observed small rounded balls of hematite, which were affectionately referred to as "blueberries." This provided some of the best evidence found that liquid water once existed on the surface of Mars.
- Without a molten core and continental drift as on Earth, Mars lacks folded and faulted mountains. To see the deep rocks from the interior, scientist look for ejecta from craters. Impactors excavate deeper, older rocks on Mars, and help fill in the historical sequence on Mars.
- Without continental drift, landscapes on Mars last longer as compared to earth landscapes. In the case of Colorado, just in the last 350 million years, a dozen different landscape occurred, ranging from high mountains to a sea floor 500 feet under the surface. (See Ancient Denvers exhibition on the third floor on DMNS.)
- If there were an "Ancient Candor Chasma" exhibition the artist could convey what Mars looked like over the last billion years in only a few panels. Water on the surface apparently disappeared millions (if not billions) of years ago. It's been cold, dry and windy ever since.

Background materials (websites, videos, articles, digital collections links)

- http://mars.nasa.gov/ - NASA's Mars Website
- http://solarsystem.nasa.gov/planets/mars - Mars Quick Fact from NASA
- http://www.universetoday.com/14701/mars/

Viking Battery



Main Teaching Points

- Batteries exactly like this one provided storage of electrical power for the Viking Landers – the first missions to successfully touch down on Mars. Viking Lander 1 operated from July 20, 1976 through November 11, 1982. Viking Lander 2 operated from September 3, 1976 until April 11, 1980.

Additional Science Content

- General Electric in Gainesville, Florida built the batteries in 1971.
- Date stamp on battery denotes the date of manufacture: 7127= the 27th week of 1971
- Voltage: 1.2 v
- Amperage: 8 amp/hours
- Composition: NiCad (nickel-cadmium accumulator (a rechargeable battery with a nickel cathode and a cadmium anode; often used in emergency systems because of its low discharge rate when not in use)
- Shelf life: 30 years+
- On the Viking Landers, the batteries were arranged 40 in a series, for a total of 48 volts @ 8 amp/hours and were charged by an RTG (Radioisotope thermoelectric generator). The batteries in turn powered the landers.
    - A radioisotope thermoelectric generator (RTG) is an electrical generator that obtains its power from radioactive decay. In such a device, the heat released by the decay of a suitable radioactive material is converted into electricity by the Seebeck effect using an array of thermocouples. RTGs can be considered as a type of battery and have been used as power sources in satellites, space probes and unmanned remote facilities.

- A battery similar to this one is on display at the Smithsonian Air & Space Museum in Washington, D.C.

Background materials (websites, videos, articles, digital collections links)

- https://solarsystem.nasa.gov/rps/rtg.cfm - Radioactive Thermoelectric Generators used in spacecraft
- https://ntrs.nasa.gov/search.jsp?R=19770013613 – NASA Technical Report on the Viking batteries

Moon Globe

Main Teaching Points

- The Moon is the fifth largest natural satellite in our solar system
- There are two main features we see on the Moon – maria (plural for mare which is Latin for sea) and craters. Craters are formed when an asteroid, comet, or meteoroid hits the surface. Mare are large plains of basalt and we formed by volcanic eruptions.
- The Moon rotates at the same rate it orbits the Earth, so we only ever see on side of the Moon. Some people refer to the far side as the “dark side” but that is a misnomer since it is lit up by the Sun during some phases of the Moon.
- The Moon is the furthest that humans have ever traveled from Earth. Twelve people walked on the Moon during the Apollo missions of the 1960’s and 1970’s.

Suggested Ways of Presenting this Demo

- Ask visitors if they have ever seen the Moon in the sky before and if they have what it looked like to them and if they noticed any features. Use the globe to explore the features they have seen on the Moon, and some they might not have.
- Use as a tool when talking about human space exploration both past (Apollo and Mercury Missions), present (International Space Station), and future (Mars).

Additional Science Content

- The leading theory about the formation of the Moon is that a Mars sized object hit the Earth about 4.5 billion years ago. That impact created a debris field around the Earth which eventually accumulated to form the Moon.
- The moon is about a third of the diameter of Earth and about 30 Earth diameters away from Earth (239,000 miles)
- The temperatures on the moon reach about 260°F in the sunlight, but plummet to as low as -280°F in darkness.

Background materials (websites, videos, articles, digital collections links)

- https://solarsystem.nasa.gov/planets/moon - Moon facts
- https://www.youtube.com/watch?v=mCzchPx3yF8&list=PL8dPuuaLjXtPAJr1ysd5yGIyiSFuh0mIL&index=12 – Crash Course Astronomy, The Moon
- https://www.nasa.gov/mission_pages/apollo/missions/ - The Apollo Missions
- https://www.universetoday.com/55512/how-many-people-have-walked-on-the-moon/ - Human exploration of the Moon
- http://www.skyandtelescope.com/observing/celestial-objects-to-watch/take-a-moon-walk-tonight/ - Observing the Moon
- See the Moon Phases Cart for further resources

Museum Galaxy Guide Demonstrations

Please see the separate manuals for each demonstration located on the Experiment Bar Page on the Galaxy Guide Portal.