Solar System 2010

Script for teachers
RMSC Strasenburgh Planetarium star show for grades 3-6

Rev. 10/21/09

Rochester day panorama fades to night

Here is Rochester, New York. The buildings all look as if they are standing still, on flat, level ground. Usually, Earth looks flat to us – except where there are hills. And when we stand still on Earth, we do not feel as if we are moving.

Up in the sky, the sun appears to move every day. Every afternoon, the sun goes down in the west and sets. After sunset we see twilight, then dusk, then night.

FIRST SKY SECTION

Live presenter points out current bright planets: Jupiter thru January 2010, Mars beginning in February, Venus and Saturn beginning in April.

ROCKET CAM SECTION

Rocket cam video

From our homes, we see only a small part of Earth. To see the whole planet we must send astronauts – or a camera – into space.

This was the launch of the Stardust probe, which flew by a comet in 2004….

Let's press fast forward.

When we started out, we could see roads and grass on the ground. Now we are up far enough to see the Earth's curved shape. We can see the *atmosphere*, the blanket of air that covers our planet. There's the coast of Florida.

Let's go back to normal "play" speed. The rocket's first stage has used up all its fuel, so it drops away. Then a new rocket engine starts on the second stage.

Rotating Earth effect

Our Earth, a ball rotating every 24 hours, making day and night. Earth is not flat, and we are not standing still. Surface of Earth: 70 percent covered by water. We do not know of any other planet with liquid water oceans on its surface. A thin layer of air, our atmosphere, makes life as we know it possible. White clouds of water droplets drift through our atmosphere. Other white features are snow and ice.

Things stay on the Earth because of Earth's gravity. *Every* planet and moon has gravity. NOT every planet or moon has an atmosphere.

Now let's travel much farther out.

Solar system projector ON.

If we could put time in fast forward, travel a billion miles from Earth, and turn around to look back, we might see something like this. At the center of our solar system: the star we call the Sun.

Planets revolve in their orbits around the sun. The Sun's gravity holds the planets in their orbits and keeps the planets from flying off into space. There is no air between the planets, but there is gravity.

Closest to the sun: Mercury; then Venus; then our planet Earth. The time Earth takes to revolve around the sun once is called a year.

Beyond Earth: Mars. Mars goes slower than Earth, so Earth catches up and comes near Mars about every 26 months.

Next, the biggest planet in our solar system…Jupiter.

Between the orbits of Mars and Jupiter: the main asteroid belt, over one hundred thousand small rocky fragments that never became part of any planet.

Beyond Jupiter, the planet famous for its rings, Saturn.

Planets far from the sun, like Saturn, revolve slower than planets near the sun. Saturn takes 29 1/2 years to revolve once around the sun. Mercury takes only about three months.

Beyond Saturn, the planets are too far out to show in this picture. Uranus revolves more than twice as far out as Saturn. Neptune is so far out that it would be inside the dome for only a small part of each orbit. And Pluto, revolving around the sun every 250 years, would be out in the lobby waiting to buy a ticket for the next show.

Solar system projector OFF

How do we learn about the planets and other features in our solar system?

European Southern Observatory Very Large Telescope

Telescopes here on Earth help us look out into space. This one is in South America. To see how big it is, look for the technician standing underneath.

Most astronomical telescopes are used only at night, but a few are made for looking at the sun in the daytime.

Hubble Space Telescope

The Hubble Space Telescope does not go visit other planets, but it's up above Earth's atmosphere, where it has a very clear view.

Cassini in shop

Here is a space probe. This one is Cassini, in the workshop being built. It is now in orbit around Saturn.

How do we make a space probe like Cassini and use it to find out about our solar system?

Meeting scene and drawings of Cassini with callouts

First, many people work together to decide where a new space probe should go and what features it should have. They have to be careful: if the space probe has too many different parts it might be too big and heavy to launch into space, or it might cost too much.

U.S. Capitol

If it's an American mission, the United States Congress must vote to provide money to build the space probe. If Congress gives the OK…

Techs at work

Technicians work together to build the space probe.

Cassini nose fairing

Then, they put the probe on top of a rocket and cover it with a protective shell called a nose fairing.

Cassini launch

The rocket takes off. Out in space, the nose fairing opens up and the space probe comes out.

Cassini trajectory

The probe travels through space.

Cassini near Saturn

When the probe reaches its planet, moon, asteroid, or comet, it may fire a rocket engine to slow down before it turns on its camera to take pictures and send them back to Earth.

How can YOU find out about the planets? You're invited to look through the telescope at the top of our observing tower on clear Saturday nights. Best times for viewing are fall and spring.

Strasenburgh Planetarium telescope

You can also get a lot of good information from the Internet. But be careful to get your information only from reliable, trustworthy web pages.

MAJOR PLANET TOUR SECTION

The Sun

Let’s take a tour of our solar system. Solar means having to do with…the Sun.

The Sun is a star. It is so big, you could put 109 Earths in a line in front of it. If the Sun were hollow – which it is NOT – it could hold about a million Earths inside.

The Sun is a giant ball of hot gases. On the bright outside of the sun, the temperature is about 10,000 degrees. Deep inside, at the center, where we cannot see, astronomers think the temperature is about 27 million degrees.

The Sun is hot because nuclear energy is being released deep inside, near the center.

On the outside of the Sun we sometimes find sunspots. They look like holes, but they’re not. Sunspots are places where the gases are not quite as hot as on most of the Sun.

Special telescopes can see other solar features that our eyes cannot: prominences, solar flares, and giant explosions called coronal mass ejections.

Mercury, Venus, Earth, Earth’s moon, Mars

The planets closest to the sun are Mercury, Venus, Earth with its Moon, and Mars. Let’s compare them.

Mercury is gray, covered with cup-shaped pits called craters, made when giant chunks of rock hit Mercury long ago. We can see the surface of Mercury because Mercury has no atmosphere.

We cannot see the surface of Venus because it is completely covered by clouds in its atmosphere. Venus is hotter than Mercury because the atmosphere of Venus traps heat from the Sun. The atmosphere of Venus is made of carbon dioxide gas. The clouds are sulfuric acid.

Special cameras can take pictures of the surface of Venus, as if we could see through the clouds. Those pictures show many volcanoes. A volcano is a hole or fracture in the surface of a planet where melted rock, called lava, comes up from inside the planet to the surface.

Earth… is the only planet where we are sure there is life. Many features of Earth are changing all the time:

The weather on Earth is different every day. Energy from the sun, acting on the air, water and land, causes Earth's weather to change.

When water falls from clouds as rain, it flows over the ground to make rivers and streams. Flowing water shapes Earth's surface by erosion.

The Earth's outermost solid part, the crust, is always moving very, very slowly. In the places where pieces of Earth's crust push against each other, we often find tall mountains, volcanoes and the locations of many earthquakes.

Many volcanoes on Earth are active. They erupt, or release lava and hot gases. Sarychev volcano, north of Japan, erupted in 2009, and astronauts took a picture of the eruption from the International Space Station.

Living things change our planet. The oxygen in Earth's atmosphere comes from green plants.

Human beings change Earth too. We change the surface wherever we build cities, or cut down trees. When we burn fuels we change Earth's atmosphere by adding more carbon dioxide.

Now, compare Earth to…Earth's Moon. What a difference! We see no clouds, no atmosphere, no water. We do see craters, everywhere, made by space rocks crashing into the surface. Long ago the moon must have been hit millions of times by chunks of rock from space. The Earth must have been hit as well, but most of Earth's craters were erased long ago by the movement of Earth's crust, by water erosion, and by wind. Earth has only a few craters, like Meteor Crater in Arizona.

On Earth's moon, the dark-colored areas are smoother than the light-colored areas. Astronomers call the moon's dark areas maria, which is the Latin word for seas. These are not seas of water – instead they used to be seas of melted rock that flowed up from inside the moon, filled in low places, and hardened.

From 1969 to 1972, twelve American astronauts walked on the moon as part of Project Apollo. On the moon the sky is black even in the daytime because there is no atmosphere. But the astronauts could not see stars in the sky because the sunshine is so bright. Astronauts wore space suits so they would have air to breathe. The moon has gravity, but less than on Earth. An astronaut in a moon suit weighed about 360 pounds on Earth, but only 60 pounds on the moon. That's light enough to get around by hopping.

On one Apollo mission, an astronaut showed what happens if you drop a hammer and a feather at the same time. On Earth, the feather would fall slowly because the air in Earth's atmosphere would slow it down. But, on the moon…

…the feather falls just as fast as the hammer.

No other humans have ever been to the moon. No humans have ever traveled farther from Earth than the moon.

Now let's compare Earth and Mars.

Mars is about half the size of Earth. Mars rotates a little slower than Earth. A day on Mars is 24 hours 40 minutes long. Mars has an atmosphere, but only a little, and it's carbon dioxide, which our bodies cannot use. So if, someday, you walk around on Mars you will have to wear a space suit.

No humans have been to Mars, but many space probes have gone there and have sent pictures back to us.

Some parts of Mars are covered with craters, like Mercury or our Moon. In other places, Mars has giant volcanoes…a grand canyon as big as the entire United States…and something else very mysterious: valleys that look like river valleys made by water erosion.

But there is no liquid water on Mars, only ice, mostly underground. We do not know how the river-like valleys on Mars formed. How those valleys formed is one of the greatest unsolved mysteries in planetary science.

Mars has two small moons, and we'll talk about them a little later.

So we've seen Mercury, Venus, Earth, Earth's moon and Mars. They are different in many ways. But they are the same in one

way: they all have solid surfaces. That is not true for the next four planets.

Jupiter, Saturn, Uranus, Neptune

Jupiter, Saturn, Uranus and Neptune are giant planets. Jupiter is so big that you could line up 11 Earths in front of it. The globe of Saturn is a little smaller than Jupiter. Uranus and Neptune are smaller than Saturn, but still much larger than Earth.

On Jupiter we see bands of color – white, yellow, tan and brown – going around the planet like belts. Those are clouds in a deep atmosphere. We cannot see through the clouds, but astronomers are pretty sure that there is no solid surface underneath. If you tried to land on Jupiter you would sink through thicker and thicker gases until you were immersed in liquid hydrogen thousands of miles below. We think that is also true for Saturn, Uranus and Neptune.

On Jupiter, the best-known cloud feature is the Great Red Spot, a storm that has been there for over 300 years. You could fit two or three Earths in the Great Red Spot. The clouds in the Great Red Spot rotate about every six days.

Saturn has cloud belts, too, but there are not as many different colors as on Jupiter. On Saturn we have never seen anything like Jupiter's Great Red Spot, but we have seen storms that are as big as the entire Earth.

Many pictures of Saturn show dark stripes that are not clouds; instead, they are shadows of Saturn's most amazing feature, its rings.

The rings of Saturn are millions of pieces of ice and rock going around Saturn like tiny moons, held in their orbits by Saturn's gravity. The ring pieces also pull on each other with their gravity, sometimes changing their orbits and making waves or lumps in the rings.

The planet Jupiter has a ring, too. But, unlike Saturn's rings, the ring of Jupiter is very thin and made of dust.

But wait, there's more…much more. Jupiter and Saturn have many strange and interesting moons. We have time to look at a few.

Jupiter's four largest moons are like planets in a miniature solar system.

Jupiter's moon Io is yellow, orange, black and white. The colors come from melted sulfur coming out of volcanoes that are erupting all over Io all the time.

Jupiter's moon Europa has a white surface of ice. The ice is broken into pieces, like pieces of a jigsaw puzzle. The giant chunks of ice on Europa could be icebergs floating on an ocean.

Jupiter's moon Ganymede has a dark-colored surface with ridges and grooves. In some places there are bright white craters. It looks as if rocks from space smashed into the surface and threw fresh white ice out over the dark dust.

Jupiter's moon Callisto is covered with dark dust and craters.

Now, some moons of Saturn. The largest moon of Saturn is Titan. Titan is special because it is the only moon we know that has an atmosphere. Titan's atmosphere is mostly nitrogen gas, with orange haze that makes the surface hard to see.

Special cameras on the Cassini space probe can take pictures through the haze and show us features on Titan that look like rivers and lakes. But the liquid in those rivers and lakes cannot be water, because the temperature there is 300 degrees below zero. Instead, it's probably a strange chemical that is like the liquid propane people use to fire up their outdoor grills here on Earth.

Another very interesting moon of Saturn is Enceladus. It has a white icy surface with many different kinds of features including craters, grooves and ridges, and smooth places. The crust of Enceladus may be floating on an ocean of liquid water, like the ice on Jupiter's moon Europa. The Cassini space probe camera took pictures of ice crystals being sprayed out of cracks in the ice on Enceladus.

Saturn's moon Iapetus has some strange features. One side of this moon is almost completely black, the other side almost completely white. No other moon we know has that feature. Another strange feature of Iapetus is a ridge, about 6 miles high, that goes all the way around it. We do not know why the ridge is there.

Now, the next two giant planets, Uranus and Neptune.

Uranus and Neptune are about the same size. They are smaller than Jupiter or Saturn, but still about as wide as four Earths.

Uranus has a bluish-green atmosphere with a few lighter-colored clouds. Unlike any other planet we know, Uranus spins on its side. That is Uranus's most unusual feature. Uranus has a few thin dust rings, a few large moons and many small moons.

Neptune is bluish in color. Actually Neptune is bluer than Uranus. We do not know why. Our best pictures of Neptune were taken by a space probe called Voyager 2, which flew close to the planet in 1989. Neptune is so far from the Sun that it gets very

little solar energy. But it has interesting weather anyway, with clouds and storms that appear and disappear in a few years. Neptune has a few rings that are so thin that special cameras are needed to take pictures of them.

Neptune's most interesting moon is Triton, which goes around the planet backward compared to the direction the planet rotates. Maybe Triton used to go around the Sun as an independent planet and was later captured by Neptune's gravity. We do not know of any other large moon that goes around its planet backward.

CLASSIFICATION SECTION

Let's compare the eight planets we've seen. We can summarize their main features in a table.

Compile a table of planet features

Jupiter, Saturn, Uranus and Neptune are all much larger than Earth. All have very deep atmospheres and no solid surface. All have rings. All have many moons, and they are all far from the Sun and far from each other. Astronomers sometimes classify Jupiter, Saturn, Uranus and Neptune as the gas giant planets.

Mercury, Venus, Earth and Mars are much smaller than the giant planets. They have solid surfaces, so they can have features such as mountains, volcanoes and craters. They have no rings. They have few moons, or none. They all have orbits close to the Sun. Astronomers classify Mercury, Venus, Earth and Mars as Earthlike, or terrestrial planets.

But wait, there's more. We should not forget the moons. Most moons are smaller than any planet. But some moons are bigger than some planets. For example, Saturn's moon Titan is bigger than the planet Mercury. We classify Titan as a moon because it goes around a planet.

SMALL OBJECTS SECTION

But wait, there's still more.

Pluto was discovered in 1930, far beyond Neptune. At that time, astronomers called Pluto the ninth planet. But they knew it was very different from the other planets. The orbit of Pluto is odd: it is tilted compared to the orbits of the other eight planets. And Pluto is tiny, unlike Jupiter, Saturn, Uranus or Neptune. Pluto is actually smaller than Earth's moon.

Pluto has three moons of its own that we know so far: Charon, Nix and Hydra.

After Pluto was discovered, astronomers kept making their telescopes better and better so they could see more and more. In the 1990's, using newer and better telescopes and cameras, astronomers began to find many other small worlds besides Pluto in orbits beyond Neptune. This swarm of little worlds was named the Kuiper Belt, after an astronomer, Dr. Gerard Kuiper, who said way back in the 1950's that Pluto might not be alone out there.

Then, in 2003, astronomers discovered the Kuiper Belt object we now call Eris. As far as we can tell, Eris is bigger than Pluto. Astronomers had to decide: should Eris be called the tenth planet?

In 2006, a committee of astronomers called the International Astronomical Union decided to classify Plutoand Eris as dwarf planets, not planets.

A dwarf planet is a world that is big enough for its gravity to pull it into a round shape, but which is not alone or nearly alone in its orbit.

So far, astronomers have named some other dwarf planets: Eris, Makemake and Haumea. The name Makemake comes from the native people on Easter Island in the Pacific Ocean. The name Haumea comes from the native people of Hawaii.

Not all dwarf planets are are out beyond Neptune. Here is Ceres, which goes around the sun between the orbits of Mars and Jupter. It is about as big as the state of Texas. Ceres is big enough to be round, but it is classified as a dwarf planet because it is not alone in its orbit. Ceres is in the main asteroid belt.

So let's look at the asteroids, chunks of rock and metal too small to be round. There are thousands of asteroids in the main asteroid belt. Space probes have sent us pictures of a few asteroids, including Eros, Itokawa, and Ida with its little moon Dactyl. Sometimes asteroids collide with each other and small pieces break off. A few of those small pieces may hit the Earth, fall through our atmosphere without burning up completely, and end up on the ground, where we might find them and call them meteorites. Most meteorites are found on bare ground in deserts or on the ice in Antarctica.

Getting back to space: the two small moons of Mars, Phobos and Deimos, look just like asteroids. Astronomers wonder if the moons of Mars used to be asteroids, but then they were captured by the gravity of Mars. But we classify Phobos and Deimos as moons because they go around a planet.

Next: comets. A comet is a chunk of ice particles and dust, like a dirty snowball a few miles across, going around the sun. Most comets spend most of their time far from the sun, where it's cold and dark. When a comet comes near the Sun, the Sun's heat changes some of the ice to gases. The gases stream away from the comet, carrying dust with them, making tails of gas and dust. If a comet with a big tail passes near Earth, everyone can see it in the sky. Some famous comets of the past are Comet Hale-Bopp, Comet Hyakutake, and Comet Halley, which will come near Earth again in the year 2061.

In 2005 a space probe called Deep Impact launched a smaller probe to crash, on purpose, into Comet Tempel I, to find out more about what this comet is made of. The crash threw a lot of dust into space, and that tells astronomers that Comet Tempel I has more dust in it than they used to think.

Many comets leave tiny pieces of dust and dirt behind them as they go around their orbits. When Earth passes through a lot of dirt particles from a comet, we see more meteors in our sky than usual, and we say we are having a meteor shower.

We think most comets come from very far beyond Pluto, beyond the Kuiper Belt, from the Oort Cloud, named after the astronomer Jan Oort, who was an expert on comets. Our telescopes cannot see the Oort Cloud, but if it is really out there, the Oort Cloud is the farthest part of our solar system.

FUTURE DISCOVERIES SECTION

We have learned a lot so far in the exploration of our solar system, but there's more to come in the future. Let's look at some UNSOLVED MYSTERIES.

Mars panorama

On Mars, Eagle crater, landing site of rover Opportunity. You can see the air bags the rover used to make a soft landing, and the tracks the rover made as it drove around this crater.

Along the crater wall: rock layers, telling about the history of Mars. That's where rover Opportunity found curved layers that look as if they formed in a salty sea long ago. But we still don't know when Mars had seas, or what happened to them. If Mars had liquid water, we would really like to know if it ever had life. At this time, we do not know.

Europa ice ceiling

Under the ice on Jupiter's moon Europa. Actually, we don't know what's under the ice, so we are using our imagination combined with the best clues we have so far.

Sound effect for probe punching through

And there's a possible future probe from Earth, punching through the ice and launching a little R.O.V., like the one you can see next door at the museum, to explore the water—if there IS water—under the ice on Jupiter's moon Europa.

Please remember Jupiter's moon Europa. If there is a liquid water ocean there, we would like to know what, if anything, is in the water. We will need a very advanced space probe in the future to find out.

Also remember another "E" moon, Saturn's moon Enceladus. Enceladus also may have a liquid water ocean under its ice crust. We would really like to know. Maybe, when you get older, you will become a scientist, an engineer or a technician working on the exploration of the solar system, and you will help us find out.

Pluto-Charon scene with distant sun

Welcome to high noon on Pluto. That's the sun, four billion miles away. It is cold out here, about 390 degrees below zero. Pluto's moon Charon looks huge in the sky, because we know Charon is close to Pluto compared to its size.

No space probe has been to Pluto -- yet. A probe called New Horizons was launched toward Pluto in 2006. It will reach Pluto in the year 2015. You can think about how old you will be in 2015. At that time, if all goes well, the New Horizons probe will turn on its cameras, take pictures of Pluto and send the pictures back to Earth. Finally we will know what Pluto really looks like.

Finally, remember that OUR solar system is just one of many. Every star in the night sky is another sun. Sometimes a star gets just a little bit dimmer for a few minutes, then brightens again. That could be from a planet getting in the way of the star's light as it goes around the star. Some stars move back and forth very slightly. That could be caused by the gravity of a planet pulling on the star as the planet goes around its orbit. Using the world's largest telescopes, astronomers are watching several hundred stars near us in space to get more clues about any planets they might have.

HOME SKY SECTION

Now, let's go home, to the beautiful skies of western New York, and find out how YOU can see the planets in your REAL sky.

Live tour of current sky, pointing out stars, constellations, planets

SUNRISE SECTION

Sunrise music and effects

Twilight. The end of night. A new day is beginning. We'll get busy with our world, but we'll remember the mysteries waiting out in space. What happened to the water on Mars? What's under the ice on Europa and Enceladus? What is Pluto really like? These are some of the greatest unsolved mysteries of the solar system, our home in space. Maybe some of these mysteries will be solved in your lifetime. Maybe one of these mysteries will be solved by you.

Exit doors open