



All About The Solar System

By
David Roth MEd

This book is dedicated to the 2008/2009 fifth grade class of Michelle Anderson. Mrs. Anderson is the type of teacher every child should have. I am truly lucky that my son was taught by her as she has inspired him to reach for the stars.

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AUTHOR

DAVID ROTH

HAMILTON HIGH SCHOOL

DEPARTMENT OF SCIENCE

FOR PERMISSION TO USE MATERIAL FROM THIS PUBLICATION:

ROTHD@COX.NET



Figure 1. both pictures show different planetary nebulae where stars and solar systems form.

The Solar System

It all started billions of years ago when a gigantic star exploded sending dust and gas off in every direction. Some of this dust and gas formed a massive cloud called a solar nebula. A solar nebula is a cloud of dust and gas where stars and planets form. Within the solar nebula some of the dust and gas flattened out like a pancake because of gravity. This flat spinning cloud of dust and gas is called an accretion disk and it is in the center of this disk that the star forms. Planets begin to form, at the same time, around the new star. Our solar system formed in a solar nebula about 5 billion years ago.

In ancient times people believed that the earth was flat and was located at the center of the universe. They also believed that the sun and planets revolved or orbited around the earth. When they looked up at the night sky they saw stars as being fixed points of light attached to the inside of a dome or canopy. Today we know that the sun, not the earth, lies at the center of the solar system and that our solar system is located along a spiral arm of our Milkyway galaxy which is one of hundreds of millions of galaxies within our universe.

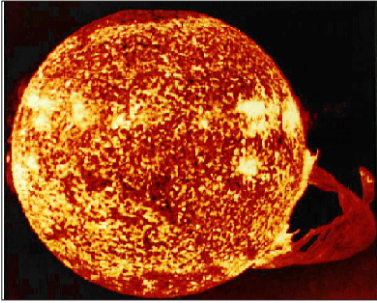


Figure 3 . Sun erupting a solar prominence. Picture by NASA

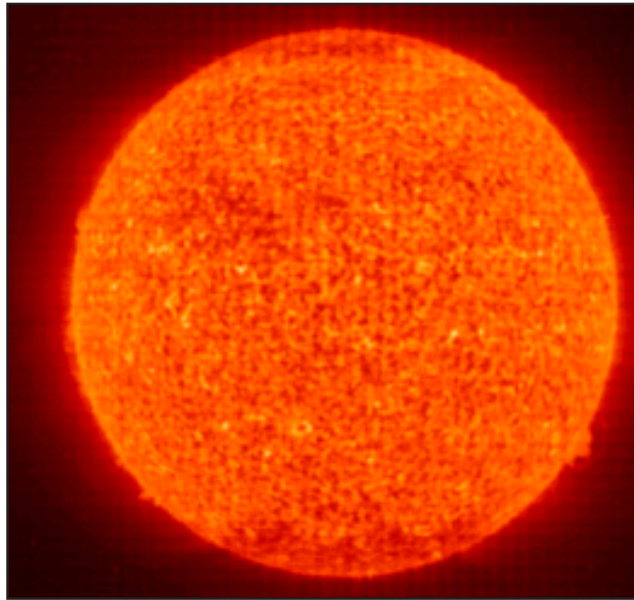


Figure 2. The Sun. Picture provided by NASA.

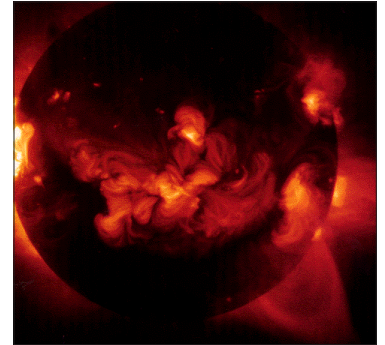


Figure 4. X ray image of the sun. Picture by NASA.

The Sun

Located in the center of our solar system the sun, a medium size star, is a giagantic ball of glowing gas with a diameter almost 110 times that of the earth. The diameter of the sun is 864,600 miles. It would take about 1,300,000 planets, each the size of earth, to equal the volume of the sun. So what makes the sun so important? First, all life on earth depends upon the sun, therefore, scientists need to learn what happens in side of the sun and how it affects life on earth. Second, by learning about the scientists are better able to understand how other stars work.

Deep within the sun lies the core which is a vast atomic furnace that produces the energy that makes it shine as well as the energy that allows life on earth to exist. Within the core energy is produced by the conversion of hydrogen into helium. During this conversion four hydrogen atoms collide, at the speed of light, creating one helium atom. When this happens



Figure 5. M116 Nebula.

there is a loss of mass which is converted the energy. Some of this energy travels to the surface making the sun shine while some more of this energy travels through space as different types of energy such as xrays ad ultra-violet light.

The Planets

The planets making up our solar system may be divided into two groups or categories. Planets within the first category are the terrestrial planets which means earth like. There are four terrestrial planets which all have solid rock surfaces and metal cores. The four terrestrial planets are Mercury, Venus, Earth, and Mars. The second group of planets are the outer planets. The outer planets are gigantic compared to the terrestrial planets and are located further away from the sun. Unlike the terrestrial planets outer planets are made mostly of gas with cores made of ice, rock, or metal. The outer planets are Jupiter, Saturn, Uranus, and Neptune.

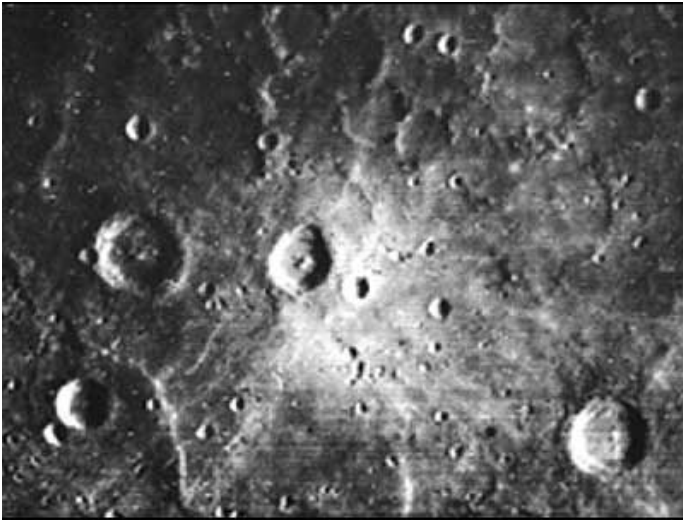


Figure 6. Mercury's surface is covered in craters.
Picture provided by NASA.

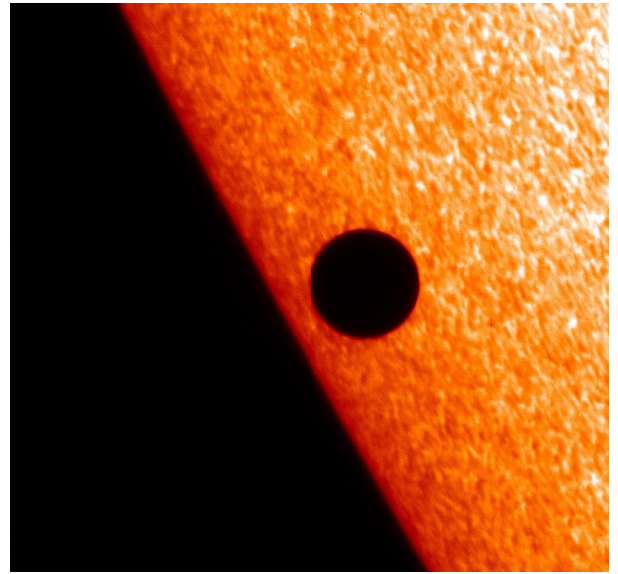


Figure 7 . mercury orbiting the sun.
Picture provided by NASA.

The Inner Planets

Mercury is the planet that sits closest to the sun and takes about 88 days to revolve around the sun. The spacecraft Mariner 10 was sent to Mercury in the 1970's and sent back pictures of Mercury's surface. These pictures showed that the surface is covered in craters of hardened lava which means that Mercury once had active volcanoes just like the ones on earth. Because mercury is so close to the sun, and is very small, it does not have an atmosphere. An atmosphere is a thin layer of gas that surrounds a planet. Because Mercury is so close to the sun, about 36 million miles, it's day time temperatures reach up to 800°F and at night temperatures drop to around -279.4°F. As you can tell temperatures here go from very cold to very hot every day. Is this a place that you would like to live?



Figure 8. Venus. Picture provided by NASA.

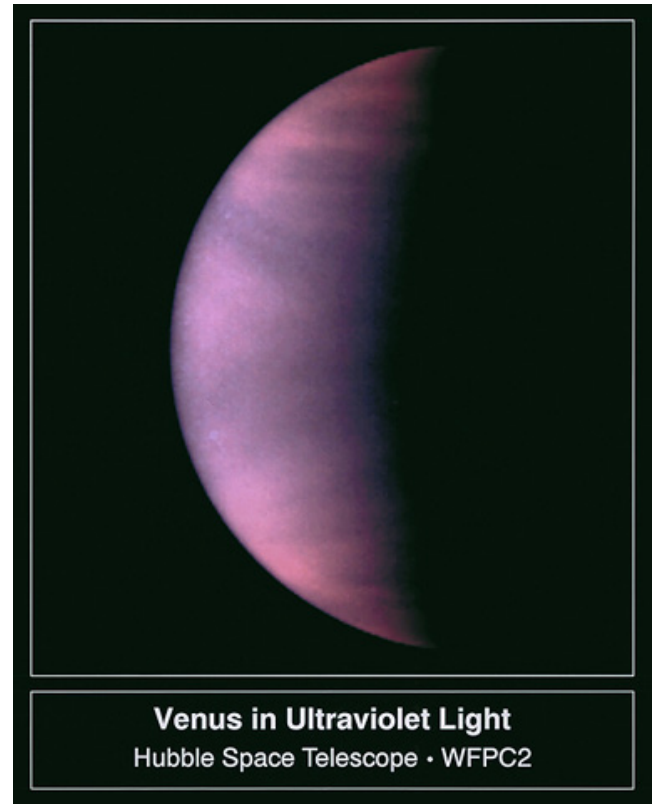


Figure 9. Picture of Venus through ultra violet light.

Venus is about 67 million miles away from the sun making it the second planet in the solar system. It takes Venus about 225 days to revolve around the sun and 243 days to make one complete rotation. Compared to Earth, Venus has very long days and even longer years. Because Venus rotates in the opposite direction from the rest of the planets the sun appears to rise in the West and set in the East as viewed from Venus. Venus and Earth are very much alike because they are about the same size, mass and density, except that Venus has a very thick atmosphere that keeps it's surface very warm. Because of Venus' thick atmosphere energy from the sun gets trapped inside causing temperatures to go as high as 848°F. Scientists believe that Venus once had oceans, just like the ones on Earth, but evaporated as temperatures got warmer.

Earth is the third planet from the sun at about 147 million kilometers or 93 million miles. It takes the Earth 365.24 days, one year, to revolve around the sun and 23 hours and 56 minutes to make one complete rota-

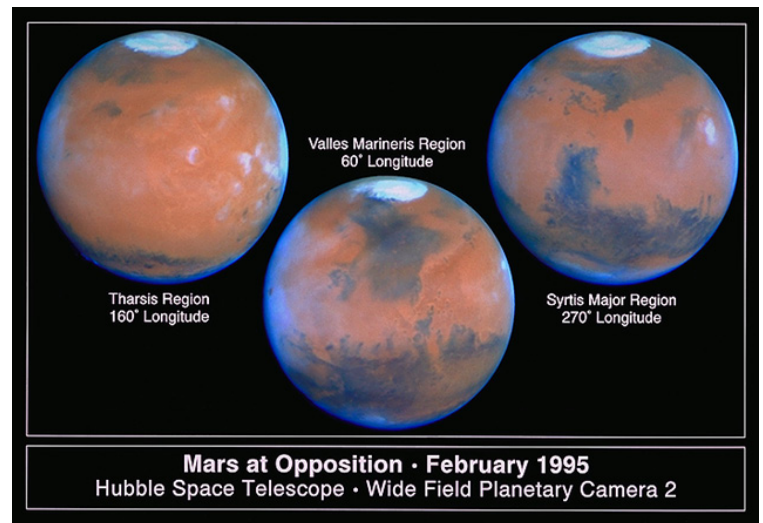
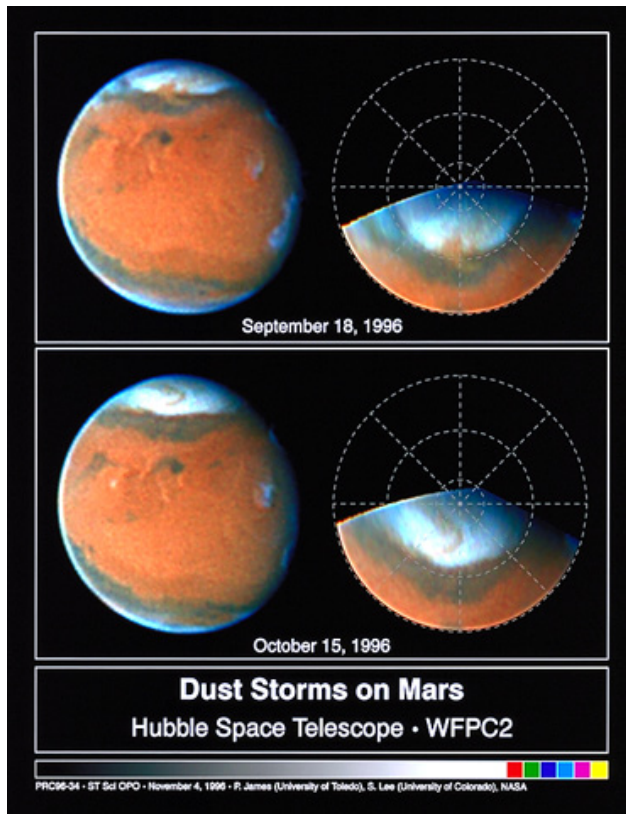


Figure 10. Image of Earth provided by NASA.

tion. Surface temperatures, on average, vary between -60°F and 120°F . Earth has a solid iron core surrounded by a semi-solid mantle which are both covered by a solid surface. The surface of Earth is constantly changing due to the flow of liquid water and wind across its surface.

The Earth's continents are separated by oceans of liquid water that contain millions of species of living organisms. The Earth is also far enough away from the sun to possess an atmosphere mainly of nitrogen and oxygen which are two elements, along with water, that sustain life on our planet. The Earth is orbited by one moon that orbits the planet once about every 28 days.

Mars is the fourth planet from the sun at about 142 million miles and is the last of the terrestrial planets. It takes Mars almost twice as long as the Earth to rotate around the sun at 687 days. One day on Mars, the amount of time to make one complete rotation, lasts 24 hours and 37 minutes.



Figures 11 and 12 show different views of Mars.

Temperatures on the Martian surface vary between -220°F and 68°F . Mars also has seasons similar to Earth and is orbited by two moons Phobos and Deimos.

Mars also has several volcanoes and is covered with large sheets of lava. The volcanoes on Mars are the largest in the solar system the largest of which is Olympus Mons which is three times higher than Mount Everest. Mars is also marked by a series of canyon systems the largest is Valles Marineris which is about 2,796 miles long, about the size of the United States.

Mars does not have enough of an atmosphere to allow liquid water to exist on the surface, however, scientists think that it may exist below the surface because canyons on the surface appear to change just like canyons on Earth change when water flows through them.

The Outer Planets

Jupiter is the fifth planet from the sun and is the first of the outer planets. Jupiter is about 483.3 million miles away from the sun and is the largest

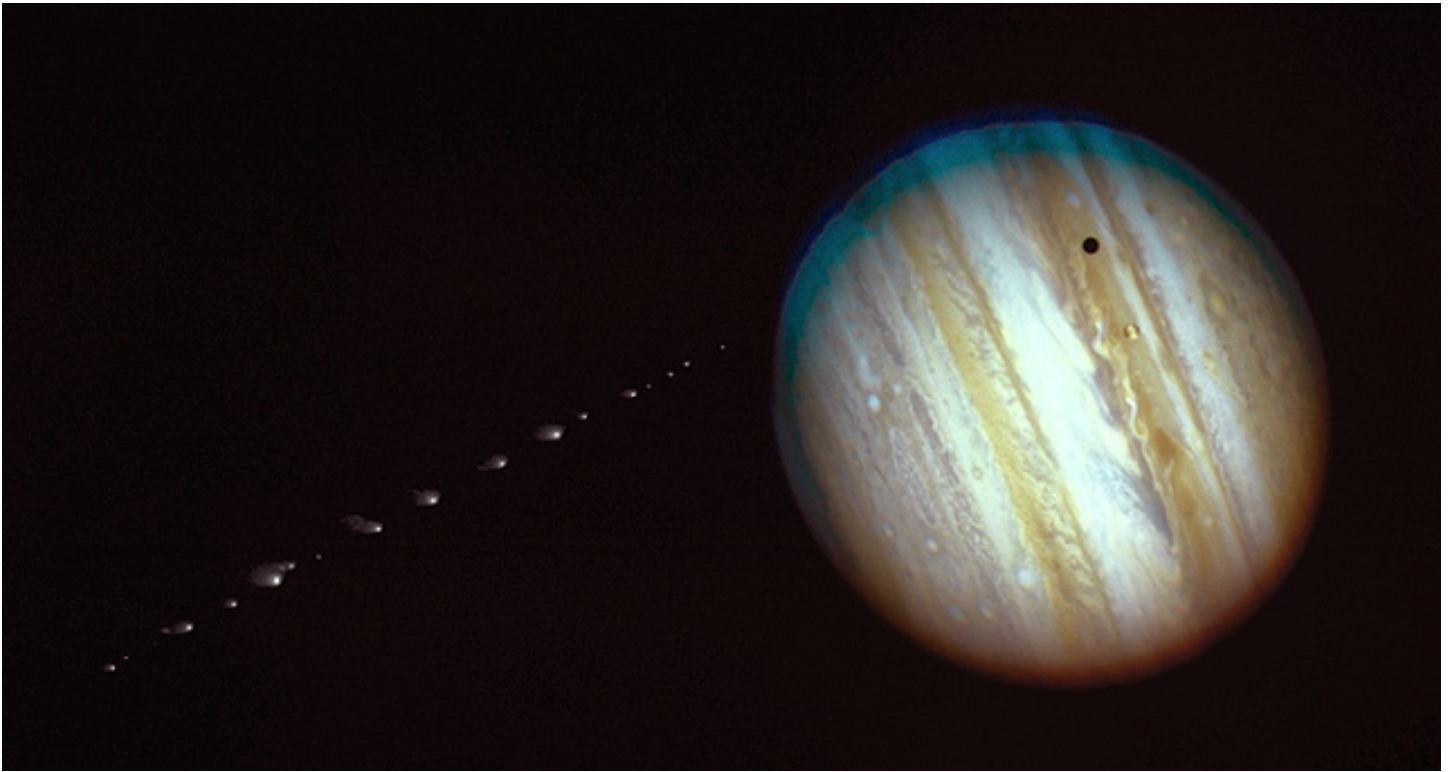
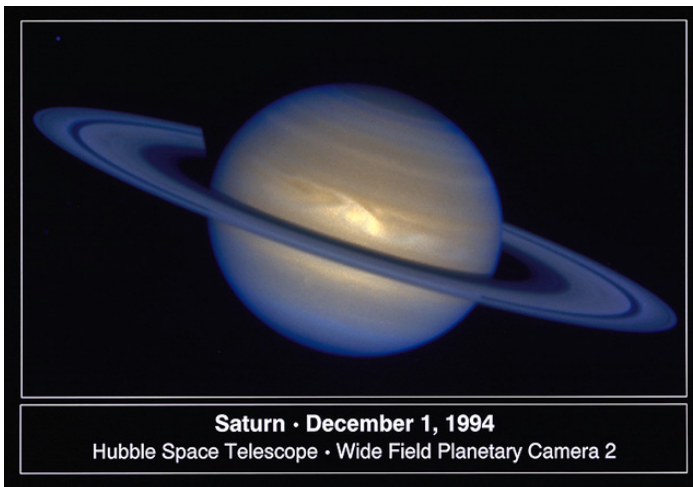


Figure 13. Comets approaching Jupiter July 1994. Hubble Space Telescope.

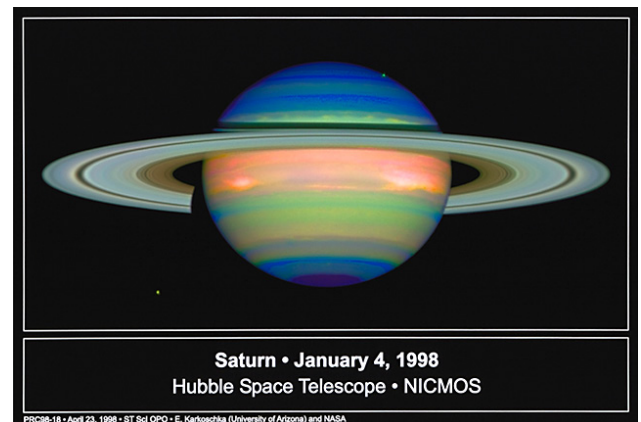
planet in the solar system having roughly twice the mass of the other seven planets combined. It takes twelve Earth years for Jupiter to make one complete revolution around the sun. Jupiter rotates so fast that one day lasts only 9 hours and 50 minutes. Jupiter also has one ring that is made of billions of tiny dust and ice particles.

Jupiter's core seems to be made of liquid metal that is surrounded by gas. Gravity is so strong on Jupiter that its interior is made of liquid hydrogen. The hydrogen and helium, together, make up about 92% of Jupiter's mass. Looking at a picture of Jupiter you will notice that it is covered with bands of different colors. These bands get their color from other gases such as methane, ammonia, and water vapor. The average temperature at the top of Jupiter's atmosphere is about -200°F

Jupiter is orbited by, at least, 16 moons. The four largest moons are called the Galilean moons and are named after Galileo who discovered them in the year 1610. The Galilean moons are Io, Europa, Ganymede, and Cal-



Figures 14 and 15 show different views of Saturn. The picture to the right was taken through ultra violet light.



listo.

Saturn is quite possibly the most spectacular of all the planets because of its brilliant yellow color and extensive ring system. Named after the Roman god of agriculture Saturn is 886.2 million miles away from the sun. The second largest planet in the solar system temperatures can reach up to -292°F at the top of its atmosphere and is orbited by at least 20 moons. Saturn makes one complete rotation every 10 hours and 40 minutes and revolves around the sun once every 29.5 years. Saturn is probably most famous for its extensive series of rings that make it stand out from any other planet in the solar system.

Saturn's rings probably consist of icy particles that range in size from specs of dust to large boulders. When Voyager I flew past Saturn in 1981 it sent images back to earth allowing scientists to measure the width and thickness of the rings. The largest of Saturn's rings are about 5 times wid-

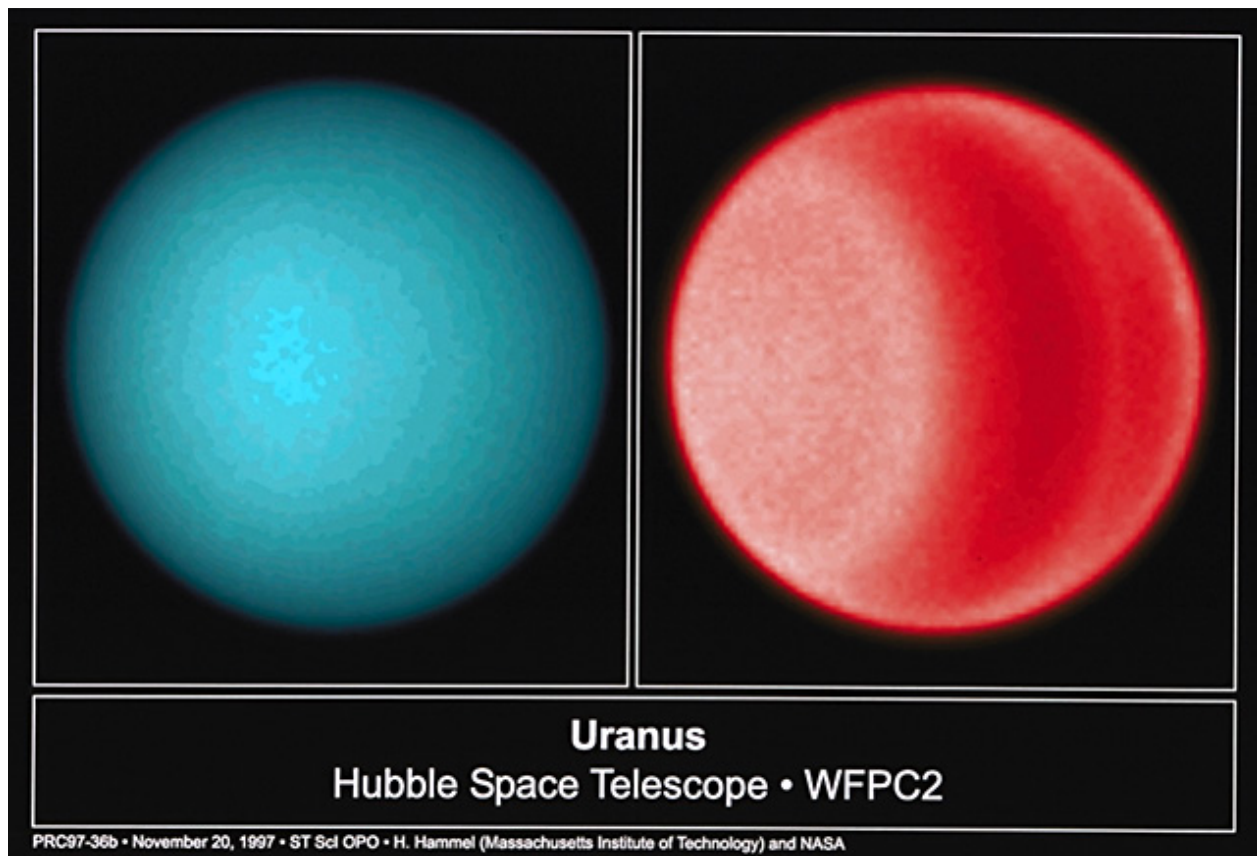


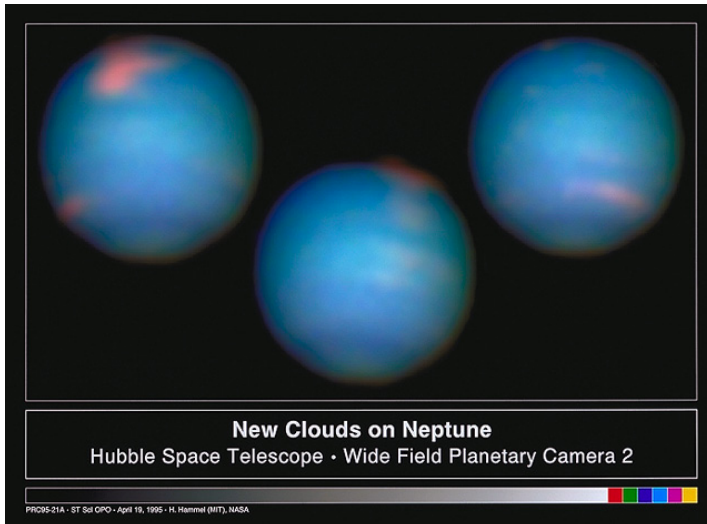
Figure 16. Notice the detail picked up by Hubble's infrared camera.

er than earth and only about 100 meters thick.

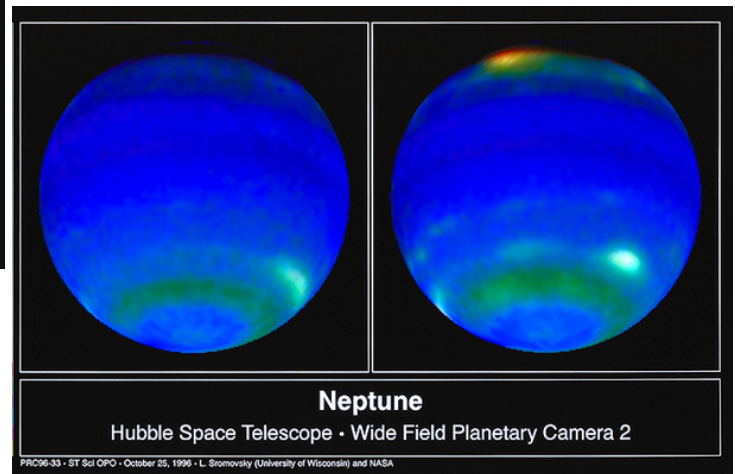
Uranus pronounced (yur-un-us) is the seventh planet from the sun at a distance of 1,783 million miles and was discovered in 1781 which makes it the first planet discovered in modern history. Uranus has at least 15 moons and is surrounded by a series of 11 rings. Four of the largest moons include Oberon, Titania, Umbriel, and Ariel.

It takes 84 years for Uranus to make one complete revolution around the sun. Uranus rotates different than the other seven planets. To get a better idea of the difference between Uranus' rotation compared to the other planets imagine a spinning top. When the Earth rotates it spins just like a top. The rotation of Uranus is more like a ball rolling across the floor and it takes about 17 hours for Uranus to make one complete rotation (role).

Looking at Uranus it appears to have a greenish color. This is because the two main gases in its atmosphere are hydrogen and helium. The tem-



Figures 17 and 18. Views of Neptune taken with Hubble's wide Field Planetary Camera 2.



perature at the top of Uranus' atmosphere is around $-3,902^{\circ}\text{F}$. Beneath the green hydrogen/helium atmosphere may lie an ocean of liquid water and methane and a core of solid rock and metal. Temperatures within the core of Uranus may get as hot as $12,632^{\circ}\text{F}$ while at the top of the atmosphere they may only reach as high as -364°F .

The eighth planet in the solar system is **Neptune** which sits about 2,794 million miles from the sun. Neptune is similar to Uranus in its size and mass. It takes about 165 years for Neptune to revolve once around the sun. It also takes 16 hours for Neptune to make one complete revolution. Neptune's blue color comes from the hydrogen, helium, and methane gases that make up its atmosphere.

Neptune has very violent weather with winds that blow around 621.3 miles per hour. Looking at pictures of Neptune you will also notice a gigantic dark spot about the same size as the Earth. This dark spot is actually a storm that seems to rage on forever. Temperatures within the core of Neptune may be as high as $-4,082^{\circ}\text{F}$ while at the top of the atmosphere they may only be as high as -357°F .

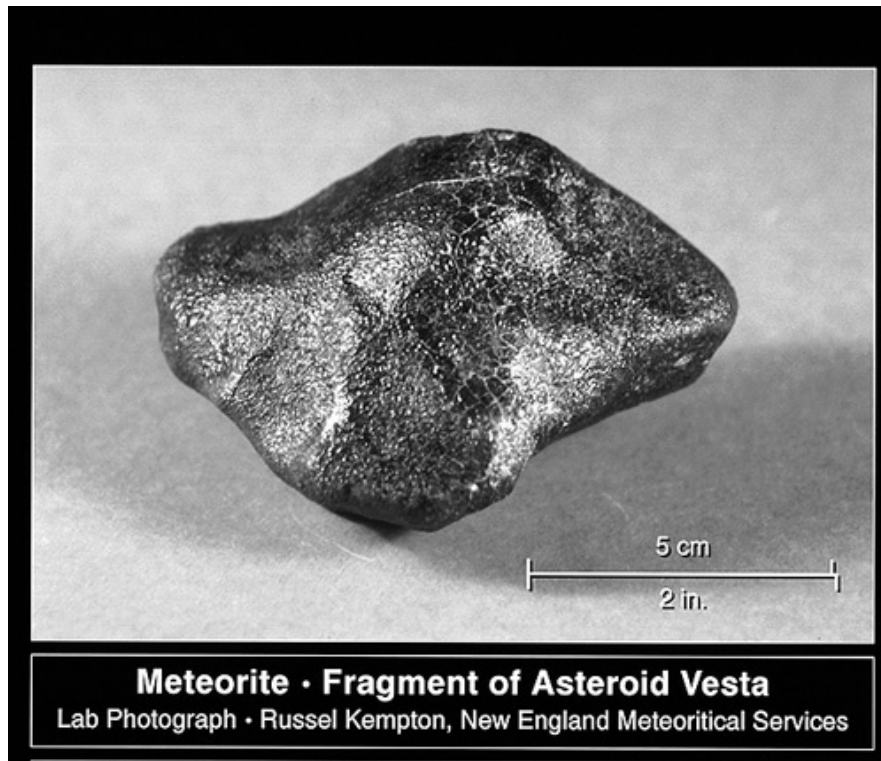


Figure 19. This meteorite is believed to have originated from the core, center, of asteroid Vesta. It is made mostly of the mineral pyroxene which is commonly found in lava flows here on Earth.

Meteors

Have you ever looked up at the night sky and made a wish upon a shooting star? Shooting stars are not really stars at all. In fact these brilliant flashes of light are actually meteors. As meteors burn up in our atmosphere they turn to dust which eventually falls to earth's surface adding about 40,000 tons of mass to the earth each year. As the meteors fall through earth's atmosphere, at about 50 miles per second, they burn up from friction creating a bright streak of light across the night sky.

The word meteor refers to shining objects falling from the sky. As the object is flying through space, before it falls to earth and burns up, it is called a meteoroid. Most of the meteors we see come from meteoroids that are as small as a grain of sand. Meteoroids that fall all the way to earth are called meteorites. Most meteorites fall into the oceans, however, thousands have been discovered in Antarctica and give us clues as to the age of

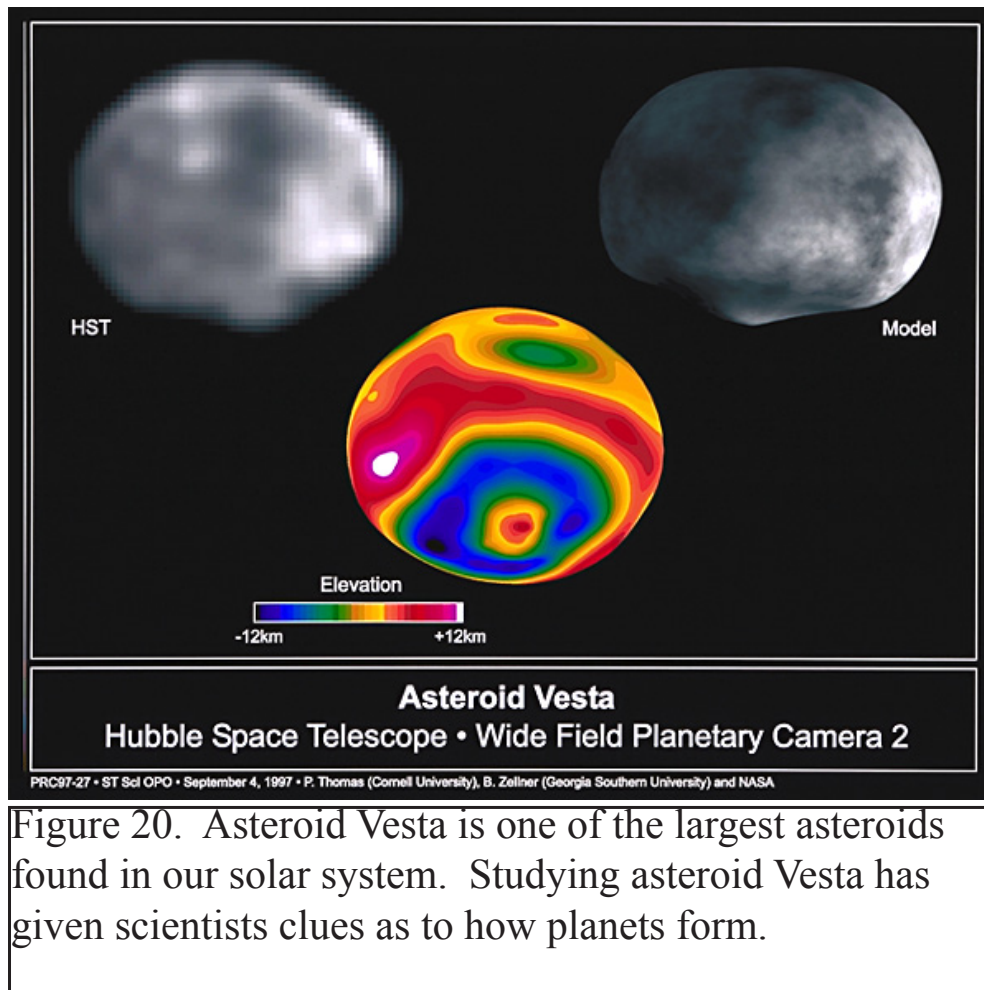


Figure 20. Asteroid Vesta is one of the largest asteroids found in our solar system. Studying asteroid Vesta has given scientists clues as to how planets form.

the solar system.

Asteroids

Asteroids are more difficult to study than meteorites because most of them are located far away from us in the asteroid belt between Mars and Jupiter. The largest asteroid discovered is Ceres and has a diameter that is roughly 30% of our moon. To give you an idea of how large Ceres is, our moon has a diameter of about 2,160 miles which means that the diameter of asteroid Ceres is 648 miles. Unlike meteors, asteroids are not made of solid rock. Asteroids have very low densities meaning that they are made of loosely packed dust, rock, and ice.

Asteroids have irregular shapes and are marked with craters from impacts with meteoroids and other asteroids. Scientists once thought that asteroids formed from the remains of planets that had long ago exploded. Since it would take more energy than that produced within the sun to make a

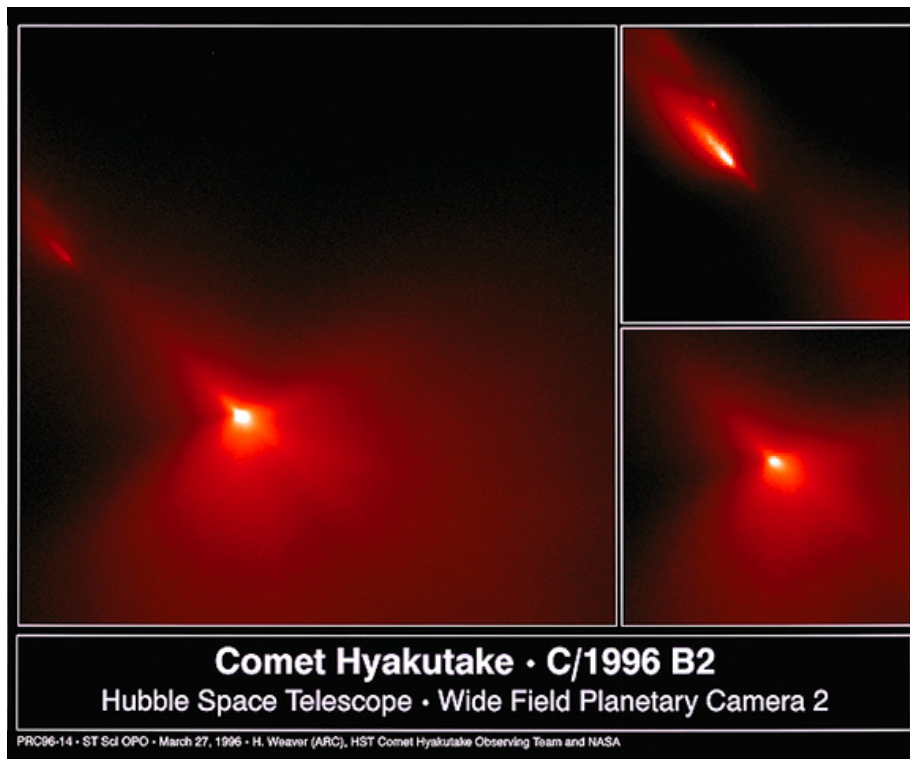


Figure 21. Notice the coma surrounding the bright core. As the comet enters the inner solar system it begins to evaporate, from the sun's heat, leaving a brilliant tail flowing behind the core.

planet explode scientists had to look else where for an explanation. Today scientists believe that asteroids formed from rocky particles that were left over after the planets in our solar system formed.

Comets

Of all of the remnants left over from the formation of our solar system comets are by far the most spectacular. Meteors are tiny specs of dust that burn up when they hit our atmosphere and asteroids are irregular shaped darkly colored clumps of dust, rock, and ice. Comets on the other hand have a nucleus made up of frozen water and other compounds, groups of elements, that form magnificent tails when they get too close to the sun.

The **coma** of a comet is the cloud of dust and gas that surrounds the nucleus. A coma may be as large as 62,137 miles in diameter which is larger than the diameter of the sun. Comets have two types of **tails**. The first type is called an ion tail that is produced elements within the nucleus become super heated and then vaporize. An ion is an atom that has an elec-

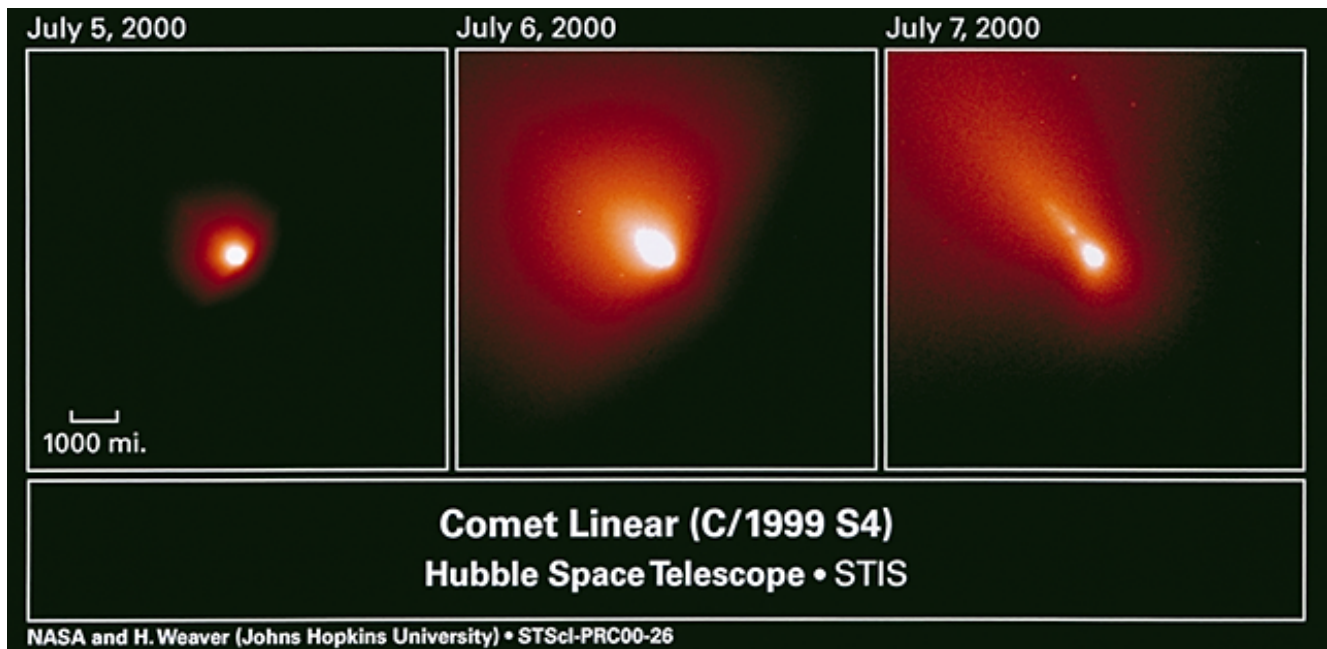


Figure 22. Comet Linear taken from the STIS, Space Telescope Imaging Spectrograph.

trical charge because it either gained or lost electrons. The second type is the dust tail which are produced as ice on the nucleus vaporize and turn into gas.

The nucleus of a comet may be very large. The nucleus of comet Hale-Bopp may be around 50 miles in diameter. Comets originate from a large section in the solar system called the Oort cloud named after a Dutch astronomer named Jan Oort. In 1950 Jan Oort proposed that comets came from a spherical icy cloud lying at the far reaches of the solar system beyond the minor planet Pluto. It is thought that collisions with other large comets and/or the gravitational effect of stars passing too close to our solar system pull comets out of the Oort cloud and send them hurtling toward the inner solar system. Some comets orbit the sun regularly. Comet Halley orbits the sun once every 76 years.

So how did the comets form. Astronomers think that comets formed in the outer solar system among the orbits of the gas giants. As the giant planets formed some comets were swept up by their tremendous gravity while others were propelled outward away from the solar system to their present location in the Oort cloud.

Glossary

Asteroid: Small, rocky world. Most asteroids lie between Mars and Jupiter in the asteroid belt.

Coma: Cloud of dust and gas surrounding the nucleus of a comet.

Comet: Small icy body that orbits the sun producing tails of dust and gas.

Galaxy: A large system of stars, star clusters, gas, dust, and nebulae orbiting a center of mass.

Meteor: Small piece of matter that vaporizes as it falls to earth.

Meteorite: A meteor that falls to earth without burning up in the atmosphere.

Meteoroid: A meteor in space before it enters the earth's atmosphere.

Nebulae: A vast cloud of dust and gas.

Orbit: The path an object takes as it revolves around another.

Planet: Small nonluminous body which formed in the solar system at the same time as the sun that follows its own orbit around the sun.

Planetesimal: A small body of dust and gas that formed into planets by collisions with other planetesimals.

Rotation: Spinning of a planet, on its axis, causing day and night.

Revolution: Movement of a planet around the sun.

Glossary

Solar nebula: A very large, swirling, cloud of dust and gas where stars and planets form.

Solar system: A system containing a star, planets, meteoroids, asteroids, and comets.

Terrestrial planet: Earthlike planet that is small, dense, rocky, and has a solid metal core.

