Yale-New Haven Teachers Institute®

Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
2007 Volume III: The Physics, Astronomy and Mathematics of the Solar System

Voyage to the Planets

Curriculum Unit 07.03.03
by Nicholas R. Perrone

Objectives

Voyage to the Planets gives students an opportunity to research the planets and the Sun in our Solar System. The unit is an inquiry-based WebQuest requiring students to work in teams to research one celestial object. They use their research to create a PowerPoint presentation as well as a model of a planetary probe to further explore their object. The WebQuest may be found at the following Internet address: http://www.spomonie.com/mrp/voyage/title.htm.

Demographics

The students who will work on this project are predominately African-American urban youth living in the New Haven area. The students come from families of low socio-economic levels and have little interaction with computers. They are in fifth grade at the Barnard Environmental Studies Magnet School. Barnard is a school that currently services approximately 400 Pre-K through sixth grade students. The school's magnet focus is on environmental studies; therefore, it has a strong emphasis on science education.

Since many of the students have little computer experience, this lesson centers on the use of computers connected to the Internet. The computers will allow the students to access the most current information on the Solar System. The newest information enables the students to learn things that are not even published in text books. This unit reaches objectives from the New Haven Public School's fifth grade science curriculum on the Solar System.

Strategies

In the Voyage to the Planets WebQuest, student groups will take on real-life roles to research properties of celestial objects using computers connected to the Internet. They will use their research and create a PowerPoint presentation to give to the rest of the class at the end of the project. Each student will take on the role of astronomer in their research during the unit; in this role he will imagine what an astronomer would

need to know about his topic. Other individual roles include the planetary scientist, who will become an expert in the physical properties of the celestial object; the engineer, who will design and build the probe model that will investigate the celestial object; and the expert in celestial mechanics, who will research the movements and gravitational forces of the object.

In the unit, students will research basic properties of their celestial object including: average distance to Sun, minimum distance to Earth, length of orbit, length of rotation, obliquity (tilt of axis), diameter, mass, surface temperature, composition of atmosphere, composition of object, number of known satellites, surface gravity, and escape velocity. They will also research various probes that have been created and sent into space to further research celestial bodies. The students will learn about the engineering features on the probe and how these features help discover new facts about these space objects. They will research the history of sending out space probes as well as what information the probes gathered as a result. The ultimate goal of the WebQuest probe model is for it to be chosen by a fictional panel of judges (the teacher) from "NASA" to be sent into space for a mission to that celestial object.

As explained in *The WebQuest Page* , "A WebQuest is an inquiry-oriented activity in which most or all of the information used by learners is drawn from the Web. WebQuests are designed to use learners' time well, to focus on using information rather than looking for it, and to support learners' thinking at the levels of analysis, synthesis and evaluation." Bernie Dodge developed the idea of the WebQuest in 1995 at San Diego State University. It also centers on the Constructivist theory where students explore and problem solve on their own while the teacher guides and facilitates learning. [1]

The Voyage to the Planets WebQuest will take between three and four weeks in the current setting, allotting a minimum of 1 hour per day. Ample time must be given to the students to research their celestial object as well as work on the development of their PowerPoint and probe model. More days may be necessary if students must receive training on Internet searching as well as PowerPoint presentation making.

Background Information

The Sun - The Center of it All

(image available in print form)

Figure 1:Left: Plasma erupting in atmosphere; prominence; [2] Center: Extreme ultraviolet image showing solar corona (about 1 million K) - has two large active region systems of magnetic loops - 11 September 1997; [2] Right: Image shows huge eruptive prominence (over 350,000km across - 28 earths) - 60,000-80,000 K (Images courtesy of NASA/JPL-Caltech) [2]

The Sun is the most massive object in the Solar System; it contains more than 99.8% of the total mass of the Solar System. Its mass enables the planets to stay in orbit instead of rocketing off into space from their inertia. Although, in relation to the other stars in the universe, the Sun is midway between extremes in terms of size, mass, surface temperature, and chemical composition. But the most remarkable details about the Sun is how it sustains life by powering photosynthesis and being the fundamental the source of all food and fossil fuel. [3]

Even though its surface temperature is only approximately 5500°C, the temperature of the Sun increases greatly by depth. The core temperature is estimated to be 15,600,000°C. The energy source that powers the Sun occurs in its center where thermonuclear reactions convert hydrogen atoms into helium. This dynamic process also causes the Sun to shine. [4]

The Sun's atmosphere consists of three layers: the photosphere, chromosphere, and corona. The photosphere, or "sphere of light", produces the visible light seen from the Sun. It has a temperature in the range of 4500-6000 Kelvin. The chromosphere is made up of transparent gases and is about 2500 km thick. The temperature of the chromosphere increases as altitude increases; a difference between the Sun's atmosphere and those of the planets. In the chromosphere, the average temperatures increase from 4500 to 10,000 Kelvin from its lowest altitude to its highest. The final region of the Sun's atmosphere, the corona, extends far beyond the photosphere - millions of miles into space. It is not as bright as the photosphere; therefore, it cannot be seen unless an eclipse hides the photosphere's brightness. Although its density is extremely low, the corona is extremely hot, reaching millions of Kelvin. Due to the high temperature, the corona emits mostly ultraviolet and X-ray wavelengths. [3]

The Sun produces solar wind - a steady stream of charged particles that flow from the Sun at an average velocity of 400 km/sec. Solar wind has been known to cause major interruptions in satellite transmissions. [3]

Sunspots are cooler areas on the photosphere that appear darker than the rest of the Sun since they are approximately 1500 Kelvin cooler. Sunspots can last anywhere from a couple of hours to months. The number of Sunspots changes from time to time. The presence of these darker regions is directly linked to the Sun's magnetism. 3

Table A 5, 6, 7, 8 , 9

Average distance from Sun: 0 km

Maximum distance from Sun: n/a

Minimum distance from Sun: n/a

Orbital period - length of year: n/a

Rotation period - length of day: 25.38 earth days / 609.12 earth hours

Obliquity (tilt of rotation axis): n/a

Diameter (equatorial): 1.390 x 106 km

Mass: 2.00 x 1030 kg

Surface gravity: 274.00 m/s^2

Escape velocity: 617.7 km/s

Average surface temperatures: 5500°C

Minimum distance to earth: 1.496 x 108 km

Number of known satellites: 8 planets + others

Composition by Volume: 92.1% H, 7.8% He

Composition by Mass: 70% H, 28% He, 2% Other

Table A: Basic facts about the Sun

The Planets - "What is a planet?"

The discoveries of large objects beyond the orbits of Neptune and Pluto have raised the question, "What is a planet?" In August 2006, the International Astronomical Union (IAU) passed a resolution that redefines the criteria for planetary status. The IAU defines a planet as having three properties: 1) it is a celestial body that orbits the Sun; 2) it is massive enough that its own gravity causes it to form in a spherical shape; and 3) it has cleared the neighborhood around its orbit. By this definition, our solar system has only eight planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune .[10] Pluto, along with numerous other celestial bodies, is now considered a dwarf planet since it did not clear the other objects in its orbit. Other dwarf planets include Ceres, the largest asteroid in the Asteroid Belt between the orbits of Mars and Jupiter, and Eris, an icy body that is farther away and larger than Pluto. All the other objects that directly orbit the Sun shall be referred to as "Small Solar-System Bodies".[11]

In this unit, Pluto will still remain an object that students may choose to learn about; however, the students must know its classification. Additionally, students who choose to research Pluto must research all known dwarf planets as well. This unit will present fewer facts about the dwarf planets compared to the other planets since less information is known at this time. In the future, another educator may want to include additional information about more dwarf planets when more data becomes available.

Mercury - The Closest Planet

(image available in print form)

Figure 2: Left: Mercury's south pole photographed by one of Mariner 10's TV cameras - 21 September 1974 (Courtesy NASA/JPL-Caltech);[2] Center: 98 km diameter crater on Mercury's surface - Mariner 10 - March 1974 (Courtesy NASA/JPL-Caltech);[2] Right: Updated color image from Mariner 10 to highlight the differences in opaque minerals, Iron content, and soil maturity (Images courtesy of NASA/JPL-Caltech)[2]

Mercury is the closest planet to the Sun, and the smallest of the eight planets. It is a rocky planet comprised of basaltic rock, "a dark and dense igneous rock", and anorthositic rocks, "a granular plutonic rock composed largely of labradorite or a more calcic feldspar".[12,13] In many ways, it is similar to our Moon in that it bears the scars of many impacts in the countless craters that appear on its surface.[13] The craters are due to meteors that collided with the planet in its youth while it was clearing its orbital path; the relatively thin atmosphere permitted the objects to reach the planet's surface. The thin atmosphere is due to the strong solar wind from the Sun as well as the fact that Mercury has a low escape velocity allowing for these molecules to easily leave its surface. Another surprising feature of this planet is its temperature variation between day and night. It is believed that it may have frozen water ice in its polar caps, while the equator remains hot enough to melt lead.

Mercury's orbit is highly elliptical; in fact, its orbit is the most elliptical of the eight planets. At aphelion,

farthest distance to the Sun, Mercury is approximately 69,800,000 km away; at perihelion, it is only 46,000,000 km, a variance of around 24 million km. [14]

Mercury's shape is slightly elongated - it is not a perfect sphere. Due to its shape, the Sun's gravity pulls with greater force on one side of the planet and a weaker force on the other. If Mercury's orbit were more circular in shape, the orbital time period and rotational time period would be identical, a 1-to-1 spin-orbiting coupling. Although, due to its highly elliptical path, Mercury exhibits a 3-to-2 spin-orbit coupling - meaning that for every two orbits, it rotates three times.

Mariner 10 was sent to observe Mercury in 1973. In the spring of 1974, the unmanned *Mariner 10* coasted above the planet's surface and took pictures of the side that was illuminated by the Sun. It did not land on the surface; therefore, no analysis of the rocks or soil content was conducted. The pictures did, however, reveal that the planet's surface was heavily cratered in a similar fashion to that of the Moon. Although, Mercury's surface is also vastly different from that of the Moon in that it has many additional tectonic features including extensive plains and meandering scarps. In the three passes Mariner 10 made while still having the power to function, it recorded over 3500 images of only 45 percent of the planet. Scientists have yet to take detailed images of the rest of the 55 percent of the planet. [15]

Table B [5, 6, 7, 8, 9, 16]

Average distance from Sun: 5.79 x 107 km

Maximum distance from Sun: 6.98 x 107 km

Minimum distance from Sun: 4.60 x 107 km

Orbital period - length of year: 0.241 earth years / 87.969 earth days

Rotation period - length of day: 58.646 earth days / 1407.5 earth hours

Obliquity (tilt of rotation axis): Less than 2°

Diameter (equatorial): 4879 km

Mass: 3.302 x 1023 kg

Surface gravity: 3.70 m/s^2

Escape velocity: 4.3 km/s

Average surface temperatures: Day: 350°C / Night: -170°C

Minimum distance to earth: 7.73 x 107 km

Number of known satellites: 0

Atmosphere composition: H & He - very thin (blasted off by solar wind)

Table B: Basic facts about Mercury

Venus - The Inferno

(image available in print form)

Figure 3: Left: Hemispheric view made from radar investigations covering over ten years - culminated by the Magellan mission (1990-1994); [2] Center: Ultraviolet-light image from the NASA Hubble Space Telescope - 24 January 1995; [2] Right: Global view surface taken by Magellan using a mosaic format (Pioneer-Venus Orbiter filled in data gaps) (Images courtesy of NASA/JPL-Caltech) [2]

Even though Venus is the second planet from the Sun, its average surface temperature is many times hotter than that of Mercury, the closest planet. The dense Carbon Dioxide atmosphere of the planet effectively traps in the Sun's heat energy in a dynamic greenhouse effect, resulting in a surface temperature of approximately 480°C. In addition to the Carbon Dioxide in its atmosphere, Venus also has droplets of concentrated sulfuric acid; most likely due to the planet's active volcanoes. [17] The planet's thick cloud cover completely blocks its surface from outside view.

The planet's greenhouse effect keeps the surface at a consistent temperature. The greenhouse effect is where solar energy penetrates the planet's atmosphere and is trapped by it, making the planet hot. The equilibrium of its heat intake and output is surprising. "The rate of energy that enters the atmosphere (in the form of visible light from the Sun) equals the rate at which energy leaves the atmosphere (in the form of infrared radiation "leaking out" of the atmosphere)". [18]

One striking feature of Venus is how slow it rotates; it actually revolves around the Sun (224.70 earth days) faster than it completes one rotation around its axis (243.01 earth days). Therefore, a Venusian day is longer than its year. The direction in which it rotates is another interesting fact about this planet: contrary to almost all of the other planets and most solar system bodies, Venus' rotation is retrograde; in other words, the direction in which it spins on its axis is backward compared to the direction in which it orbits the Sun; the only other planet that experiences such a motion is Uranus. [19]

The surface of Venus is comprised mostly of basaltic rock and other altered materials. The numerous active volcanoes produce large amounts of sulfuric acid, accounting for the dense clouds of the acid in the sky. The sulfuric acid from these volcanoes also make the planet rich in chemical reactions that produce other acids such as hydrofluoric acid (HF), hydrochloric acid (HCl), and fluorosulfuric acid (HSO_3F). These acids are hostile to metals and other solid materials; making it exceedingly difficult for scientists to determine a material for space probes that is sufficient in preventing corrosion on the Venetian surface. At its surface, Venus has an atmospheric pressure of 90 atmospheres - the equivalent to being 1 kilometer underwater on Earth. This high pressure poses even more problems for space probes to successfully experiment on this planet. [20]

The first successful mission to Venus was that of *Mariner* 2 in 1962. This voyage helped prove the existence of solar wind; it also found that the planet does not have a magnetic field. Scientists connected the two observations and determined that without a magnetic field, and thus no magnetosphere, the solar wind from the Sun hits the planet's upper atmosphere directly. [20]

A Soviet probe called *Venera 7* was able to transmit a few seconds of data directly from the surface of Venus before the various planetary threats overtook it. American probes determined that Venus has three distinct cloud layers: an upper cloud layer, a denser and more opaque middle cloud layer, and an even denser still and more opaque lower cloud layer. [20]

Table C 5, 6, 7, 8 , 9

Average distance from Sun: 1.082 x 108 km

Maximum distance from Sun: 1.089 x 108 km

Minimum distance from Sun: 1.075 x 108 km

Orbital period - length of year: 0.615 earth years / 224.70 earth days

Rotation period - length of day: 243.01 earth days (retrograde) / 5832 earth hours

Obliquity (tilt of rotation axis): Less than 177.3°

Diameter (equatorial): 12,104 km

Mass: 4.869 x 1024 kg

Surface gravity: 8.87 m/s^2

Escape velocity: 10.4 km/s

Average surface temperatures: 480°C

Minimum distance to earth: 42 million km

Number of known satellites: 0

Atmosphere composition: 96% C02, 3% N, 0.1% Ar

Table C: Basic facts about Venus

Earth - The Living Planet

(image available in print form)

Figure 4: Left: Crescent Earth; [21] Center: Africa: lower continent; 21 Right: United States, Mexico, and some of Central America under heavy cloud cover - 16 April 1972 (Images courtesy of NASA) [21]

As seen from a far distance, Earth seems to glow with life. Planet Earth balances many complex systems that ultimately sustain life - elaborate weather systems, flowing bodies of water, floating continental plates, active volcanoes. Due to the fact that 71% of the Earth is covered with water, it appears blue from a distance.

The major system that separates Earth from the other rocky planets is its plate tectonics, the continuous motion of the plates on the Earth's crust. The moving plates create visible features like mountain ranges, canyons, rift valleys, volcanoes, and oceanic trenches. The two basic movements between the plates include the separation of plates and collision between plates. Both processes create dynamic geological features on the surface. [22]

The Earth's interior has an iron-rich core surrounded by a thick, partially molten rock mantle. The convection

currents in the mantle move the plates and constantly reshape the Earth's crust. The iron core produces Earth's magnetic field, which protects the planet by shielding it from solar wind. 2 1

The Earth's crust consists of basaltic and granitic rock as well as altered materials. These three basic types of rock are further broken down into different categories including minerals, crystals, igneous rocks, sedimentary rocks, and metamorphic rock. Earth constantly creates, breaks down, moves, and recycles its rock in an endless cycle.

Table D 5, 6, 7, 8, 9

Average distance from Sun: 1.496 x 108 km (1.000 A.U. - by definition)

Maximum distance from Sun: 1.521 x 10^8 km

Minimum distance from Sun: 1.471 x 108 km

Orbital period - length of year: 1 earth years / 365.24 earth days

Rotation period - length of day: 1 earth days / 23.93 earth hours

Obliquity (tilt of rotation axis): Less than 23.4°

Diameter (equatorial): 12,756 km

Mass: 5.98 x 1024 kg

Surface gravity: 9.77 m/s^2

Escape velocity: 11.18 km/s

Average surface temperatures: 15°C

Minimum distance to earth: 0

Number of known satellites: 1

Atmosphere composition: 78%N, 21% O, 1% Ar

Table D: Basic facts about Earth

Mars - The Red Planet

(image available in print form)

Figure 5: Global view in full color using four hemispheric views - Hubble Space Telescope (Images courtesy of NASA/JPL-Caltech) [2]

Mars has long been the preferred topic of science-fiction films and novels. Sightings of "canals" in the early 1900s prompted glorified reactions about intelligent civilizations that created elaborate water-ways. Even today, scientists debate the presence of microorganism fossils found in a peculiar Martian meteorite that landed on Earth. The "life on Mars" debate centers primarily on the existence of water. [23]

In many ways, Mars is similar to Earth. The two planets share orbits of similar length and almost identical rotation periods. Due to the tilt of their axis, both planets experience seasons. Even though Earth is nearly twice as large in diameter, the two planets remain more alike in mass and size compared to the other planets in the solar system. Both planets also share similar surface features including volcanoes, canyons, valleys, and signs of river channels. No similarity, however, more closely links Mars to Earth like that of the presence of water.

The surface of Mars suggests that water once flowed on it. Ancient river channels spreading out like veins hint that water may have created such signs of erosion. And the discovery of signs of ancient floods back up the same theory. The presence of liquid water on Mars would be impossible today; however, since the average temperature and pressure are both too low. Thus on Mars, water only exists as water vapor or ice. [2] [4]

Mars has two satellites: Phobos and Deimos. They appear to be captured asteroids, but may have been caused by gathering up small objects in their path as they orbited Mars. Since their shapes are potato or football-like in nature, only one side of both moons faces the planet (similar to that of Earth's Moon).

Mars is called the red planet mainly due to its presence iron oxide, or rust; thus giving it an overall red hue. The composition of rocks collected by spacecraft determined them to be rich in iron, silicon, and sulfur. [25]

Mars is the most extensively studied planet from spacecraft and probes alike. The first space probe to observe Mars was *Mariner 4* ; since then, several others have been sent. The *Viking* missions were highly successful in collecting information about possible Martian life. Both *Viking Lander* spacecraft carried instruments that collect meteorological data. This data measured large variations in air temperature between dawn (-93°C) to the "heat" of the afternoon (-33°C) - a difference of 60°C in just one location. The spacecraft also found large changes in atmospheric pressure. Even with all of the sophisticated scientific instruments, the *Viking Landers* found no existence of living organisms. [26] Since then, other spacecraft have continued the exploration of the planet. Recent, notable steps in gathering information include the *Mars Global Surveyor* that mapped out the entire surface of the planet and the *Mars Pathfinder* that sent down a small, wheeled robot called *Sojourner* . *Sojourner* analyzed rock samples and sent back high-resolution images of the Martian surface. [26]

Table E 5, 6, 7, 8, 9

Average distance from Sun: 2.279 x 108 km

Maximum distance from Sun: 2.492 x 108 km

Minimum distance from Sun: 2.067 x 108 km

Orbital period - length of year: 1.88 earth years / 686.98 earth days

Rotation period - length of day: 1+ earth days / 24.62 earth hours

Obliquity (tilt of rotation axis): 25.19°

Diameter (equatorial): 6794 km

Mass: 6.419 x 1023 kg

Surface gravity: 3.69 m/s²

Escape velocity: 5.0 km/s

Surface temperature variations: Max: 20°C / Min: -140°C

Minimum distance to earth: 7.83 x 107 km

Number of known satellites: 2

Atmosphere composition: 95% CO2, 3% N, 0.1% water vapor

Table E: Basic facts about Mars

Jupiter - The Big One

(image available in print form)

Figure 6: Left: "Little Red Spot" (LRS) - New Horizons Long Range Reconnaissance Imager (LORRI) - 27 February 2007; [2] Center: true color mosaic constructed from 27 separate images taken by the narrow angle camera on NASA's Cassini spacecraft - 29 December 2000; [2] Right: Io, the Galiliean satellite, orbiting Jupiter above the planet's cloudtops - Cassini spacecraft - 1 January 2001 (Images courtesy of NASA/JPL-Caltech) [2]

If the planets were to hold an award ceremony, Jupiter would steal the night away. It is the largest and most massive planet in the solar system (more massive than all the other planets combined), and it has the most satellites. Jupiter also rotates faster than all the other planets, spinning once around in less than 10 hours. It is, however, comprised largely of hydrogen and helium; thus making it the first of the Gas Giants. [27]

Scientists discovered Jupiter's gaseous composition largely due to the fact that its equator rotates at a different rate than its poles. Comparably, a swirling pot of water demonstrates the idea that its center will rotate at a faster rate than its outer edge. [28] The most prominent feature of the "Lord of the Planets" is the Great Red Spot, an enormous storm in the Jovian atmosphere that is about twice the size of Earth. This storm has been raging for centuries, and represents only one example of the planet's massive weather systems.

In July 1994, astronomers around the world watched as 23 fragments of Comet Shoemaker-Levy 9 (named after its discoverers from the previous year) collided with the planet. The impacts of the relatively small objects were estimated to have had an "energy equivalent to 600,000,000 megatons of TNT, tens of thousands of times greater than the total destructive energy of all of the nuclear weapons on Earth". [29] In addition to the massive energy created, the impacts produced quite a show for onlookers to view through telescopes on Earth.

Jupiter has been observed by numerous spacecraft including *Pioneer 10* and *Pioneer 11* in the mid 1970s; *Voyager 1* and *Voyager 2* in the late 1970s, sending back close-up color pictures of the planet's dynamic atmosphere; *Ulysses* ; and *Galileo* , orbiting it for eight years to monitor changes in its atmosphere on timescales of weeks or months. [30] The extensive findings from the various spacecraft have shown a great deal of active weather patterns in its atmosphere.

Jupiter has 63 known satellites including the four famous Galilean moons. Some of these structures exhibit similarities close to that of Earth. This unit will not go into detail about these celestial bodies, but the author feels strongly that they represent fascinating features of an active and dynamic planet.

Table F 5, 6, 7, 8, 9

Average distance from Sun: 7.783 x 108 km

Maximum distance from Sun: 8.160 x 108 km

Minimum distance from Sun: 7.306 x 108 km

Orbital period - length of year: 11.86 earth years / 4328.9 earth days

Rotation period - length of day: 0.41 earth days / 9.8 earth hours

Obliquity (tilt of rotation axis): 3.12°

Diameter (equatorial): 142,984 km

Mass: 1.899 x 1027 kg

Surface gravity: 20.87 m/s²

Escape velocity: 59.5 km/s

Average surface temperatures: -110°C

Minimum distance to earth: 6.287 x 108 km

Number of known satellites: 63

Atmosphere composition: 90% H, 10% He, 0.07% methane

Table F: Basic facts about Jupiter

Saturn - The Ringed Planet

(image available in print form)

Figure 7: Left: Tilted ringplane toward Cassini; [2] Center: Largest and most detailed global image of Saturn and its rings in natural color ever made; the mosaic consists of 126 images - Cassini - 6 October 2004; [2] Right: Clouds of Saturn in the background of the planet's second largest moon, Rhea - Cassini - 4 February 2007 (Images courtesy of NASA/JPL-Caltech) [2]

Saturn's most prominent feature is its elaborate ring system. Although relatively thin, the rings stretch nearly 100,000 km in collective width. The rings are not solid as is evident by the fact that images show Saturn is visible through the rings. The rings are composed of icy fragments of matter ranging in size from pebbles to boulders. The rings reflect 80% of the Sunlight that falls on them, suggesting to scientists that they are made of ice and ice-coated rock. [3] [1] Although Jupiter would sweep most of the awards, it still does not beat the depth and wind speed of Saturn's atmosphere. Saturn takes first place in those two categories. In many ways, however, Saturn and Jupiter are alike. They both exhibit differential rotation; their compositions are similar; and Saturn also probably has three distinct cloud layers: "an upper layer of crystals of ammonium hydrosulfide (NH_4SH), and a lower layer of water ice crystals". [3] [2]

Saturn takes second place in its number of known satellites; however, 34 is by no means a shameful number. Its moons are rich in features and might also merit an additional section in this unit were it not for a limit in length.

Pioneer 11 , *Voyager 1* and *2* , as well as *Cassini-Huygens* each observed Saturn to gather more information about this massive planet. It is the opinion of this writer that no other mission has produced as spectacular a collection of data than that of the *Cassini-Huygens* mission to Saturn and Titan. Only half way through its entire mission, it has already delivered over 100,000 images of Saturn, its moons, and ring system. 3 3 This mission is sure to continue to produce even more relevant data about this distant planet.

Table G 5, 6, 7, 8, 9

Average distance from Sun: 1.429 x 109 km

Maximum distance from Sun: 1.509 x 109 km

Minimum distance from Sun: 1.350 x 109 km

Orbital period - length of year: 29.42 earth years / 10,755.7 earth days

Rotation period - length of day: 0.44 earth days / 10.2 earth hours

Obliquity (tilt of rotation axis): 26.73°

Diameter (equatorial): 120,536 km

Mass: 5.685 x 1026 kg

Surface gravity: 10.40 m/s^2

Escape velocity: 35.5 km/s

Average surface temperatures: -180°C (at cloudtops)

Minimum distance to earth: 1.278 x 109 km

Number of known satellites: 34 + rings

Atmosphere composition: 97%H, 3% He, 0.05% methane

Table G: Basic facts about Saturn

Uranus - The Titled Planet

(image available in print form)

Figure 8: Left: Two images -- one in true color (left) and another in false color (right) - Voyager 2 - 17 January 1986; [2] Right: False-color image of the four major rings surrounding the planet and 10 of its 17 known satellites - Hubble Space Telescope - 8 August 1998 (Images courtesy of NASA/JPL-Caltech) [2]

Uranus has a system of small moons and thin rings. It is also appears to have received an impact of massive

proportions to cause it to tip on its side so that its axis lies nearly in its orbital plane. Therefore, Uranus shares with Venus the only other retrograde rotation of all the major planets in the solar system. Its axis is tilted 98°. [3 4]

Since this radical tilt exists, the seasonal changes on Uranus are highly exaggerated. For instance, throughout the southern summer, Uranus's south-pole experiences light from the Sun; whereas, the north-pole experiences a frigid, continuous winter night. [3 3]

The atmosphere is comprised mostly of hydrogen (84%) and helium (14%), similar to that of Jupiter and Saturn. Although, 2% of Uranus' atmosphere is methane - more than ten times the percentage found on Jupiter and Saturn. The methane in its atmosphere absorbs the reds and yellows of visible light, thus giving the planet its greenish-blue appearance. [3 3]

Surrounding the planet is a series of thin, dark rings discovered by accident in 1977. While observing the planet, a distant star briefly blinked on and off several times. The astronomers concluded that the planet must have a narrow ring system, nine in all. During the *Voyager 2* mission, two more were discovered. [3 5]

The only spacecraft to observe Uranus was the *Voyager 2* in January 1986; although, it sent back close range images of the planet that were surprisingly featureless. Only after computers enhanced the images were cloud formations visible. The magnetic pole line stretching from its north to south magnetic axis is inclined at a surprising 59°. [3 6]

Table H 5, 6, 7, 8, 9

Average distance from Sun: 2.875 x 109 km

Maximum distance from Sun: 3.008 x 109 km

Minimum distance from Sun: 2.742 x 109 km

Orbital period - length of year: 83.75 earth years / 30,685 earth days

Rotation period - length of day: 0.72 earth days / 17.24 earth hours

Obliquity (tilt of rotation axis): 97.86°

Diameter (equatorial): 51,118 km

Mass: 8.663 x 1025 kg

Surface gravity: 8.43 m/s^2

Escape velocity: 21.3 km/s

Average surface temperatures: -218°C

Minimum distance to earth: 2.721 x 109 km

Number of known satellites: 27 + rings

Atmosphere composition: 83% H, 15% He, 2% methane

Table H: Basic facts about Uranus

Neptune

(image available in print form)

Figure 9: Left: Crescents of both the planet and Triton - Voyager 2; [2] Center: Global image showing the Great Dark Spot and its bright smudge, the fast moving Scooter, and the little dark spot - Voyager 2; [2] Right: The planet's rings - Voyager 2 - August 1989 (Images courtesy of NASA/JPL-Caltech) [2]

Neptune appears to be the twin to Uranus; however, by closer observation, Neptune is distinctly different. It is nearly the same size as Uranus, but is 18% more massive. It has a more normal 30° tilt. Neptune also has a more dynamic atmosphere compared to Uranus, suggesting a powerful internal energy source. The two planets do share an almost identical atmospheric composition, as well as, the fact that both planets have dark ring systems comprised of methane-converted dark carbon compounds. [3] [7]

Neptune has clearly visible cloud patterns in its atmosphere. The largest feature was a giant storm called the Great Dark Spot; it shared a number of similarities to the Great Red Spot of Jupiter including size, approximate latitude in the southern hemisphere, and winds circulating in a counterclockwise direction. One distinct difference to that of the Great Red Spot, however, is that it did not last for nearly as long. [3] [6]

Neptune receives nearly half as much energy from the Sun as does its neighbor, Uranus, due to its greater distance from the Sun. The presence of thermal energy heating the planet's core from converted gravitational energy explains how the planet seems to have such atmospheric conditions as high-altitude clouds and huge storms. [3] [6]

Just like Uranus, Neptune too has a series of thin, dark rings that were discovered by occultations, where the background of the planets briefly blinked on and off just before and just after the planet passed through sight. The rings are composed mostly of frozen methane.

Voyager 2 was the only spacecraft to observe Neptune. Nearly all of the current data on this planet is due to this vessel. In addition to the numerous images, *Voyager 2* also measured the planet's magnetic fields. Similarly to Uranus, the data showed that Neptune's magnetic field is oriented at an unusual angle; the north and south magnetic pole line is inclined by 47°. [3] [6]

Table I 5, 6, 7, 8, 9

Average distance from Sun: 4.504 x 109 km

Maximum distance from Sun: 4.545 x 109 km

Minimum distance from Sun: 4.464 x 109 km

Orbital period - length of year: 163.73 earth years / 60,190 earth days

Rotation period - length of day: 0.67 earth days / 16.11 earth hours

Obliquity (tilt of rotation axis): 29.56°

Diameter (equatorial): 49,528 km

Mass: 1.028 x 1026 kg

Surface gravity: 10.71 m/s²

Escape velocity: 23.5 km/s

Average surface temperatures: -218°

Minimum distance to earth: 4.359 x 109 km

Number of known satellites: 8 + rings

Atmosphere composition: 74% H, 25% He, 1% methane

Table I: Basic facts about Neptune

Pluto, Ceres, and Eris - The Dwarf Planets

Pluto

(image available in print form)

Figure 10: Left: Double image of Pluto and its moon, Charon; photo taken when the planet was 4.4 billion kilometers from Earth - Hubble Space Telescope - 21 February 1994; [2] Center: Surface of the distant planet; image captured using the European Space Agency's (ESA) Faint Object Camera (FOC) - Hubble Space Telescope; [2] Right: Surface map assembled by computer image processing software from four separate images of Pluto - Hubble Space Telescope - late June and early July 1994 (Images courtesy of NASA/JPL-Caltech) [2]

The planet formerly known as "Number Nine" was recently demoted to what is now defined by the IAU as a dwarf planet. The reason for this change in rank is due to a few discrepancies between Pluto and the other planets. Pluto does orbit the Sun, it has retained a nearly spherical shape; however, it has not cleared its orbit of other objects plus it follows a highly elliptical and steeply inclined orbit compared to that of the other planets. Pluto's orbit is so elliptical that it sometimes crosses Neptune's orbital path making it closer to the Sun than that planet for a period of time.

For its tiny size, astronomers have collected a considerable amount of information on this dwarf planet. Its rotation axis is tipped by more than 90°, thus causing it to have retrograde rotation. [3] [8] Pluto's surface is perhaps methane ice with a thin atmosphere of methane and nitrogen. It has three known satellites.

Pluto has not been directly observed by a fly-by spacecraft; however, the New Horizons spacecraft was sent on January 19, 2006 to do a fly-by in an effort to collect more information. It will encounter Pluto in 2015. In February of 2007, the spacecraft successfully performed a gravity-assist with Jupiter cutting off additional years of travel before it would get to Pluto. New Horizons has already sent back numerous images of Jupiter

the likes of which we have never seen. [39] July 2015 will certainly be an exciting time for anyone interested in learning more about this little-known dwarf planet.

Table J 5, 6, 7, 8, 9

Average distance from Sun: 5.916 x 109 km

Maximum distance from Sun: 7.389 x 109 km

Minimum distance from Sun: 4.442 x 109 km

Orbital period - length of year: 248.0 earth years / 90,520 earth days

Rotation period - length of day: 6.387 earth days / 153.3 earth hours

Obliquity (tilt of rotation axis): 118°

Diameter (equatorial): 2300 km

Mass: 1.3 x1022 kg

Surface gravity: 0.81 m/s^2

Escape velocity: 1.2 km/s

Average surface temperatures: -223°C

Minimum distance to earth: 5.75 x 109 km

Number of known satellites: 3

Atmosphere composition: Methane & Nitrogen (perhaps)

Table J: Basic facts about Pluto

Ceres

(image available in print form)

Figure 11: Ceres: Left: Vectors in image show the direction of the Sun - Hubble Space Telescope; [40] Center: mid-ultraviolet image from the Hubble Space Telescope; [39] Right: "model image" with the darkness of the Piazzi feature exaggerated [39] (Images courtesy of Southwest Research Institute and NASA)

Ceres is the smallest identified dwarf planet in the Solar System; discovered on January 1, 1801 by Giuseppe Piazzi. It is located in the main asteroid belt between the orbits of Mars and Jupiter where 98.5% of asteroid orbits can be found. Ceres is the most massive object in the asteroid belt, accounting for approximately a third of the total mass of all the other asteroids in the Solar System. Most of the asteroids in the main belt have irregular shapes; however, Ceres has a spherical shape.

Ceres seems to be the reason why the IAU decided to include the third aspect of its planet definition.

Numerous debris exist in Ceres' neighborhood meaning that it did not clear this area sufficiently enough for it to be considered a planet. [41, 42, 43]

Table K 40, 41, 42

Average distance from Sun: 4.146 x108 km

Maximum distance from Sun: 4.478 x 108 km

Minimum distance from Sun: 3.814 x 108 km

Orbital period - length of year: 4.6 earth years / 1679.8 earth days

Rotation period - length of day: 0.38 earth days / 9.1 earth hours

Obliquity (tilt of rotation axis): "Yet to be discovered"

Diameter (equatorial): 950 km

Mass: 9.46 x 1020 kg

Surface gravity: 0.27 m/s^2

Escape velocity: 0.51 km/s

Average surface temperatures: -106.15 °C

Minimum distance to earth: 2.29 x 108 km

Number of known satellites: 0

Atmosphere composition: n/a

Table K: Basic facts about Ceres (those that have been discovered)

Eris - 2003 UB $_{313}$

(image available in print form)

Figure 12: Eris: Slightly larger than Pluto; Dysnomia is visible above just to the right of the dwarf planet - Keck Telescope, Hawaii - 18 September 2006 (Image courtesy of W. M. Keck Observatory & NASA) [44]

Originally known as UB $_{313}$, Eris was discovered in July 2005 by Astronomer Mike Brown of CalTech and his team. It is the known largest dwarf planet in the solar system. It is the most distant object seen orbiting around the Sun. It lies beyond the Kuiper belt, which extends from the orbit of Neptune to 50 AU from the Sun.

Eris has a highly eccentric orbit that brings it to within 37.8 AU of the Sun. It has an inclined orbit that tilts at an angle of about 44 degrees as compared to much the rest of the solar system planets, whose orbits lie in somewhat the same plane as Earth's.

Although Eris is larger than Pluto, it is believed that they are both composed of methane. The methane is in the form of ice since it is so far away from the warmth of the Sun. Eris has one known satellite, Dysnomia; it was discovered on September 10, 2006 using a laser guided star adaptive optics system. [45, 46 , 47]

Table L 42, 43, 44

Average distance from Sun: 1.01 x 1010 km

Maximum distance from Sun: 1.46 x 1010 km

Minimum distance from Sun: 5.65 x 109 km

Orbital period - length of year: 557 earth years / 203,500 earth days

Rotation period - length of day: earth days / ~8 earth hours

Obliquity (tilt of rotation axis): "Yet to be discovered"

Diameter (equatorial): 2400 km ± 100 km

Mass: 1.6 x 1022 kg

Surface gravity: "Yet to be discovered"

Escape velocity: "Yet to be discovered"

Average surface temperatures: -230.65°C

Minimum distance to earth: 5.498 x 109 km

Number of known satellites: 1

Atmosphere composition: n/a

Table L: Basic facts about Eris (those that have been discovered)

Brief Overview of Planetary Probes and Fly-by Spacecraft

Fly-by spacecraft offer limited data collection as compared to a probe that may collect much more information. In both cases, the device must be equipped with the proper instruments to collect the desired data. As technology has improved, these devices have been able to collect more data, faster, and with more precision than ever before.

Luna 3 was the first spacecraft to view the other side of the moon. It collected photographs of this region that had been previously impossible to observe. Since the 1960s, advancements in scientific data-collection have produced a new species of spacecraft. [4 8]

Mariner 10 was sent to study Mercury. It was equipped with a pair of long solar panels for energy, television cameras for taking pictures, an infrared radiometer for measuring surface temperature, an ultraviolet spectrometer for searching for atmospheres, a magnetometer for measuring magnetic fields, and a charged-

particle detector for measuring solar wind. [49]

The *Viking Lander 1* is a probe that was sent to study Mars from a first-hand perspective. In order to prevent the planet's atmosphere from destroying the spacecraft in its entry, the *Viking Lander 1* was equipped with a heat shield to protect the craft from the intense heat, retro-rockets to counter act the gravitational pull, and a parachute to slow the craft for landing. On the ground, the probe used additional instruments for experimentation: two television cameras for pictures, a dish antenna to relay data back to Earth, an extendable arm to retrieve samples of soil, and an X-ray fluorescence spectrometer to measure the chemical composition of rocks. [50]

Pioneer 10 and *11* and the *Voyager 1* and *2* spacecraft were sent to study the outer gas giants (Jupiter, Saturn, Uranus, and Neptune). Traveling to these extreme distances presented a problem to the scientists who designed these spacecraft since the Sun's light grows dim the farther away an object travels. Therefore, the most common power option, solar panels, could not be used. A long-term energy source was required, namely the energy created by the radioactive decay of plutonium - a nuclear reactor. The name of the *Voyagers*' power source is called a radioisotope thermoelectric generator (RTG) and it has powered the spacecraft for nearly three decades. [51] *Voyager 2* captured the only close-up images of Neptune and Uranus available to date. *Pioneer 10* became the first spacecraft to travel beyond our solar system. [45]

The *Voyager* spacecraft are identical, and are equipped with instruments to conduct 10 different experiments. The instruments include television cameras, a radio, infrared and ultraviolet sensors, magnetometers, plasma detectors, and cosmic-ray and charged-particle sensors. As of February 17, 1998, *Voyager 1* became the most distant human-made object in space. Although many of the instruments have been turned off due to limited power supply, scientists expect the spacecraft to continue to transmit data at least until the year 2020. [52]

Classroom Activities

The teacher of a WebQuest facilitates learning in a *Constructivist* way; meaning he/she guides learning instead of directly instructing it. The WebQuest site is designed so that each student has the ability to complete the project on his/her own; however, the teacher is a crucial element in making sure that each student is challenged along the way through various higher-level questioning strategies. The WebQuest represents approximately three weeks of daily lessons. Since students are meant to explore the WebQuest on their own, no traditional lesson plans are a part of this unit. Instead, a brief outline will showcase the WebQuest (Figure 13). The WebQuest can be found at the following address: http://www.spomonie.com/mrp/voyage/title.htm>.

(image available in print form)

Figure 13: Flow chart of WebQuest showing basic outline of the Web Site

Notes

1. Dodge, Bernie. "What's a WebQuest?." The WebQuest Page. San Diego State University. 13 Jun 2007 http://webquest.sdsu.edu/overview.htm>.

2. "Planetary Photojournal." Jet Propulsion Laboratory: California Institute of Technology. NASA. 19 Jun 2007 http://photojournal.jpl.nasa.gov/index.html>.

3. Newman, Phil. "The Sun - Introduction." Goddard Space Flight Center. 06 September 2006. NASA. 12 Jun 2007 http://imagine.gsfc.nasa.gov/docs/science/know_l1/sun.html>.

4. Kaufmann, William, and Roger Freedman. Universe. 5th ed. New York: W. H. Freeman and Company, 1999, 422.

5. Arnett, William. "The Nine Planets: A Multimedia Tour of the Solar System: one star, eight planets, and more...." The Nine Planets Solar System Tour. 25-08-2006. 28 Mar 2007 http://www.nineplanets.org/>.

6. Critchton, Dan. "Welcome to the Planets." Jet Propulsion Laboratory. 10-05-2005. Jet Propulsion Laboratory of the California Institute of Technology. 28 Mar 2007 http://pds.jpl.nasa.gov/planets/welcome.htm>.

7. "Exploring the Planets." Smithsonian National Air and Space Museum. National Air and Space Museum. 28 Mar 2007 http://www.nasm.si.edu/etp/>.

8. Munsell, Kirk. "NASA's Solar System Exploration." NASA. 23-03-2007. NASA. 28 Mar 2007 http://solarsystem.nasa.gov/planets/index.cfm>.

9. "Solar System Information #14: Planets." Welcome to the Perth Observatory. 27-09-2006. Perth Observatory. 28 Mar 2007 http://www.perthobservatory.wa.gov.au/information/planet_defn.html>.

10. "What is a Planet?." Exploring The Planets. National Air and Space Museum. 14 Jun 2007 http://www.nasm.si.edu/research/ceps/etp/pluto/pluto_planet.html>.

11. Martin, David. "What Defines a Planet?." NASA's Solar System Exploration: Planets: Dwarf Planets. 14 September 2006. NASA. 14 Jun 2007 http://solarsystem.nasa.gov/planets/profile.cfm?Object=Dwarf&Display=Facts>.

12. "Definitions from Dictionary.com." Dictionary.com. 2007. Lexico Publishing Group, LLC. 12 Jun 2007 http://dictionary.reference.com/browse/basaltic>.

13. Ibid. http://dictionary.reference.com/browse/anorthositic>.

14. Kaufmann, William, and Roger Freedman. Universe. 5th ed. New York: W. H. Freeman and Company, 1999, 244.

15. Ibid. 250-252.

16. "Mercury Statistics." Windows to the Universe. 05 March 2003. University Corporation for Atmospheric Research (UCAR). 14 Jun 2007 http://www.windows.ucar.edu/tour/link=/mercury/statistics.html>.

17. Kaufmann, William, and Roger Freedman. Universe. 5th ed. New York: W. H. Freeman and Company, 1999, 259.

18. Ibid. 265.

19. Ibid. 262.

20. Ibid. 265-267.

21. "The Gateway to Astronaut Photography of Earth." Image Science and Analysis Laboratory. 19 June 1997. NASA-Johnson Space Center. 19 Jun 2007 http://earth.jsc.nasa.gov/scripts/sseop/PhotoIdSets/PhotoIdSets.pl?set=EarthDisc>.

22. Kaufmann, William, and Roger Freedman. Universe. 5th ed. New York: W. H. Freeman and Company, 1999, 192 & 204.

23. Ibid. 281.

24. Ibid. 286-287.

25. Ibid. 293.

26. Ibid. 291-298.

27. Ibid. 303.

28. Ibid. 307.

29. Ibid. 313.

30. Ibid. 307-308.

31. Ibid. 347-349.

32. Ibid. 355.

33. "Cassini-Huygens Home." Jet Propulsion Laboratory: California Institute of Technology. 13 June 2007. NASA. 14 Jun 2007 http://saturn.jpl.nasa.gov/home/index.cfm>.

34. Kaufmann, William, and Roger Freedman. Universe. 5th ed. New York: W. H. Freeman and Company, 1999, 368-371.

35. Ibid. 376.

36. Ibid. 370 & 375.

37. Ibid. 373-377.

38. Ibid. 383.

39. "New Horizons Web Site." New Horizons: NASA's Pluto-Kuiper Belt Mission. 14 June 2007. NASA. 14 Jun 2007 http://pluto.jhuapl.edu/>.

40. "Observations reveal curiosities on the surface of asteroid Ceres." Solar System Exploration. NASA. 21 Jun 2007 http://www.swri.org/press/ceres.htm>.

41. "Ceres (dwarf planet)." Wikipedia: The Free Encyclopedia. 13 June 2007. Wikipedia. 14 Jun 2007

http://en.wikipedia.org/wiki/Ceres_(dwarf_planet)>.

42. "Ceres." Answer.com. 2007. Answers Corporation. 14 Jun 2007 http://www.answers.com/topic/ceres>.

43. "Dwarf Planets: What Defines a Planet?." Solar System Exploration. 14 September 2006. NASA. 14 Jun 2007 http://solarsystem.nasa.gov/planets/profile.cfm?Object=Dwarf&Display=OverviewLong>.

44. Nemiroff, Robert. "Astronomy Picture of the Day." Astronomy Picture of the Day Archive. 18 September 2006. NASA. 22 Jun 2007 http://apod.gsfc.nasa.gov/apod/ap060918.html>.

45. "Eris (dwarf planet)." Wikipedia: The Free Encyclopedia. 14 June 2007. Wikipedia. 14 Jun 2007 http://en.wikipedia.org/wiki/Eris_(dwarf_planet)>.

46. Watanabe, Susan. "Hotly-Debated Solar System Object Gets a Name." National Aeronautics and Space Administration. 14 September 2006. NASA. 14 Jun 2007 http://www.nasa.gov/vision/universe/solarsystem/erisf-20060914.html>.

47. "Eris." Answer.com. 2007. Answers Corporation. 14 Jun 2007 http://www.answers.com/topic/eris-dwarf-planet>.

48. "Tools of Exploration." Exploring The Planets. 2002. National Air and Space Museum. 15 Jun 2007 http://www.nasm.si.edu/research/ceps/etp/tools/etptools.html>.

49. Kaufmann, William, and Roger Freedman. Universe. 5th ed. New York: W. H. Freeman and Company, 1999, 252.

50. Ibid. 291.

51. "Voyager 1: Beyond Our Solar System." Solar System Exploration. 25 September 2003. NASA. 15 Jun 2007 http://solarsystem.nasa.gov/missions/profile.cfm?Sort=Alpha&Letter=V&Alias=Voyager%201>.

52. "Voyager Mission to the Outer Planets." NASA Facts. NASA: Jet Propulsion Laboratory: California Institute of Technology. 16 Jun 2007 http://www.jpl.nasa.gov/news/fact_sheets/voyager.pdf>.

Appendix - Embedded Science Standards

National Science Education Standards : Earth and Space Science: Content Standard D: Earth in the solar system - The earth is the third planet from the sun (an average star & largest body in the solar system) in a system that includes the moon, the sun, eight other planets and their moons, and smaller objects, such as asteroids and comets; Science and Technology: Content Standard E - Abilities of technological design; understandings about science and technology http://www.nap.edu/readingroom/books/nses >

Connecticut State Framework : Earth in the Solar System: Earth, Moon and Sun (5.3) - Most *objects in the solar system are in a regular and predictable motion* ; The Solar System (8.3) - *The solar system is composed of planets and other objects that orbit the sun* http://www.sde.ct.gov/sde/cwp/view.asp?a=2618&q=320890 >

New Haven Science Standards : Earth in the Solar System: Earth, Moon and Sun (5.3) - Most objects in the solar system are in a regular and predictable motion; The Solar System (8.3) - The solar system is composed of planets and other objects that orbit the sun http://www.newhavenscience.org >

Accessibility links. Skip to content. Accessibility Help. BBC Account.Â See all episodes from Space Odyssey: Voyage to the Planets. Broadcasts. Tue 9 Nov 2004 21:00. Voyage to the Planets visits the planets from two very personal perspectives: the direct experience of the people who have sent probes hurtling to all our cosmic neighbours, and the viewpoint of any one of us who might dream of making a trip ourselves. Take a ringside seat to the splendours of the Solar System with Voyage to the Planets: an astronaut's guide to whole new worlds of possibility. Written by Richard Smith. Plot Summary | Add Synopsis. Source: BBC. DVD Review: Voyage to the Planets and Beyond. By Tariq Malik, Staff Writer for Space.com. posted: 7 June 2005. Most television science fiction shows fling humans out to the vast reaches of the galaxy, but a new DVD is content with exploring our own planetary backyard. Originally entitled "Space Odyssey" during its airing on the British Broadcasting Co. (BBC), "Voyage to the Planets and Beyond" follows five astronauts on a mission to explore the Solar System aboard their vast spaceship Pegasus. A DVD version of the two-hour program is available from BBC Video. Space Odyssey: Voyage To The Planets (released as Voyage To The Planets And Beyond in the United States) is a British two-part science fiction miniseries telling the story of a manned voyage through the solar system, presented in the style of a documentary. It was made for The BBC by Impossible Pictures, written and directed by Joe Ahearne and produced by Christopher Riley, and first broadcast in November 2004.Â Their mission takes them to Venus, Mars, through a close fly-by of the Sun, Jupiter and its moons Io and Europa, Saturn and its rings and moon Titan, Pluto, and a fictional comet. Manned landings are made on Venus, Mars, Io, Pluto and the comet, while robot probes are dropped on Europa and Titan. According to the "heart-beat theory", for want a better name, Humans already live approximately three times longer than they should. This is based on the observation that small mammals like mice have an extremely high heart rate and short life whi...Â Given part of the effects are environmental on some planets we would age better than others. For the most part though, I would expect the average would fall within the variations we see on Earth. I know an 85 year old man I would have sworn was 65, and I've known a 58 year old man I would have sworn was 90.