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"Other Worlds Other Life: Our Solar System and Beyond"

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Having grown up during the days of the space race to the Moon, I can remember vividly watching the launching of the various space flights and reading about the mysteries of outer space. As a third grade student, I remember being assigned the task of making Mercury for the class model which was to hang from the ceiling of the classroom. Although my Mercury was a small circle of no more than three inches in diameter, I fondly remember how much time I spent deciding on a color and then painstakingly applied paint to that small circle which I regarded as my masterpiece.

In remembering this simple event, I realize that in doing this unit, I hope it can produce moments that students will long remember and may even influence them to study science as a life's career. I know that my students are very enthusiastic about the topic. They are fascinated with any discussion about the stars and outer space. Since this unit is going to try to include discussion about the possibility of life on other planets in our Solar System or beyond, I found it intriguing that a preliminary talk with my students about what they knew about outer space and the planets led to an almost immediate mention of aliens. We made a web of what they knew and it was amazing how their first thoughts were of Martians, and UFOs. For them, any discussion of the Solar System would have to include other life forms.

The goals of this unit on Astronomy and Cosmology is very much in keeping with the goals of the New Haven School System. At present a discussion of the planets is part of the third grade curriculum. I'm afraid that in the past most of the study of science topics if done at all has been strictly based on the reading of a text book. While this assessment of science education may seem harsh, it is upheld by a recent survey in the March/April 1996 issue of *Learning Magazine,* that the average elementary school in the United States spends three hours a week on science instruction, and that Connecticut averaged the least amount of time. Students in grades 1 to 4 spent 36% of their science time in lecture or whole class discussion and 21% of their time reading textbooks and doing worksheets. For many schools a lack of materials to do hands on science also limits the scope of the science curriculum.

A possible solution to the weak science education our students now experience can come from adopting the basic recommendations listed in the Science Education Standards that were released in December of 1995. They suggest that teachers need to plan and continually reassess the science curriculum. The curriculum should match the curiosity and interest of the students. Students need to be in an atmosphere that fosters curiosity and questioning. Teachers need to encourage "all" students to participate in the activities. If the environment is flexible and supportive, students will get into investigations that may go well beyond the regular science period. Of course equipment, materials, and tools must be available for students to carry on their own investigations. Scientific investigation should encourage students to collaborate with one another and talking about what they're learning. Scientific skills and the value of scientific inquiry should be taught.

In trying to include these standards into the teaching of this unit at Hill Central, it will be an added advantage that we are also a Library Power School. This program empowers students as learners in a research based environment. The teacher along with the library media specialist leads children on the path to unlocking the information they want to know. Instead of lecture or dull worksheets, students will be actively piecing together information through their own research in books and on the internet. They will need to take notes, write letters, draw charts, or graphs, make models or dioramas, to complete a report. I think it is apparent that this is a completely different role than most teachers were trained for.

In addition to the Library power grant our school is also going to be home to one of the Yale Teacher Institute's first Teachers Centers. The center will contain a computer for teachers to access the Yale Institute resources as well as internet information, and to link teachers throughout the system in order to share curriculum ideas.

Much of the recommended changes proposed by the New Standards center on the theory of "constructivism." The concept has been around for years, and is based on the research and theories of Jean Piaget who believed that children learn by interacting with people and objects in the environment. As children interact they piece together how the world works. When things don't make sense or "fit" into their understanding, they adapt their ideas to include their new findings. This constant change continues even into adulthood. Teachers need to play a vital role in this process by providing students with opportunities where students can create, build, discuss, compare, collaborate, and experiment. Instead of providing the information teachers provide opportunities for students to gather their own information. In this process the teacher becomes a facilitator going from large to small groups or individuals. Textbooks become a resource for students like any other reference books.

During the past two years I have been involved with a Bilingual Science Program that has encouraged both Anglo and Bilingual teachers to use the constructivist approach as a way to improve language acquisition. Students do hands on lessons and keep a journal. Through the project students increase their vocabulary and thinking skills as they talk with their science partners about the experiments they are carrying out. When they write in their journal they are reviewing what they did in carrying out their experiment and what they thought would happen and why they got the results they did.

The unit will stress the use of "process skills". What are these skills? We all know that scientist do a lot of fascinating investigations. They study data from outer space, try to develop cures for diseases or attempt to solve problems like that of soil erosion. Whatever project scientist deal with they rely on some very basic skills called process skills. These same skills students use in science, however, have value which goes far beyond a science lessons. These skills can help them in problem solving of all kinds, and in understanding the world around them.

Process skills are usually divided into two levels: basic and integrated. These are the skills which a good science lesson should include:

1. Classification—using different systems to create order by showing the similarities between objects and events.

2. Communication—Sharing information with others through writing, drawing, talking, making diagrams, or charts, mappings, or using symbols.
3, Inference—Making explanation or logical interpretations of what is observed.
4. Measurement—Quantify amount with metric units of measure such as size, weight, temperature.
5. Observation—Using the five senses to gain information about objects or events. This information can be quantified (size, weight, temperature) or qualified (description of events and objects).
6. Prediction—Making forecasts of future observations.
7. Relationship between Time and Space—Describing spatial relationships and their change in time. This could include a study of shape, symmetry, motion, and rate of change.

The integrated Process Skills include:

1. Controlling Variables—Holding all variables (factors in an experiment that may change) constant except one. Students observe the other variables that change in response. Combining the skills of measurement. Observation and prediction,
2. Defining Operationally—Measuring a variable in an experiment. Combines the skills of measurement and observation.
3. Experimenting—Beginning with observations and inferences to test. Combine all basic process skills.
4. Formatting a hypothesis—Making a generalization that includes all objects and events of the same type. Combining the skills of observation, inference, and prediction.
5. Interpreting Data—Drawing conclusions that may be used to make further inferences and for predictions or hypotheses. Combines the skills of inference, prediction, and measurement.

It is apparent that in utilizing the constructivist model the teacher is also incorporating the basic principles of the scientific method. Learning is not just getting the right answer for the teacher but a process of sharing hypothesis and different theories in order to accept and/or reject ideas about the world. That is why the students in such a classroom must feel that experimentation and failure are acceptable. Everyone's ideas are important and no idea need be rejected on sight until it has been discussed and thought through. Hopefully the constructivist model along with the commitment to research based learning and our computerized

Teacher Center will help this unit to fit that ideal.

The Unit: The Unit should run from five to six weeks in duration.

Introduction:

There are a few ways to introduce the unit. It might be with a film, story, poem, or informational article. For my third graders, I plan to use a story (see bibliography) called " A Space Story" by Karla Kuskin. The story is about a little boy who goes to bed each night asking his mother questions about the stars and the planets. He wonders if there is life somewhere out in space. The story segues into a brief mention of the planets in the Solar System. It ends with another boy somewhere else on Earth going to bed and wondering also about what there is in outer space This kind of open-ended story could easily lead to a lively classroom discussion at which time the teacher can suggest that the class will undertake a study of the possibilities of life in outer space.

At this point students might begin to construct a KWL (what I know, what I want to Know, what I learned) chart about their knowledge of outer space. Remember that the class would only be working on the first two columns of the chart. In lieu of this, a simple webbing to merely get children to express what they know about the solar system would also be acceptable.

While there are many choices on where to begin discussion within this unit, I feel that students would have to understand what we mean by life. I plan to have this unit build on the ideas we will have discussed in Social Studies about the basic needs of human beings—food, shelter, and clothing. We will expand from having spoken about our community on Earth to the universal neighborhood we inhabit in space. However since all we know is life as it exists on Earth, I would delve more into the chemical and biological reasons that life exists on Earth and expand outward into the Universe.

Background—What do we mean by life?

The Earth supports many extraordinary types of complex and intelligent life forms. Life on Earth is also highly sophisticated, self-reproducing and able to communicate. Scientist still question whether there has been enough time since the big bang for complete life to have formed as it has on Earth? Or could it be that a series of complex molecules from outer space hastened the development of life on Earth. In any event, regardless of where, there must have been enough time for intelligent life to develop in the Universe.

Life on Earth consists of complex vegetable and animal life—bacteria—viruses and large animals and trees. All of this is aided by the fact that the weather is neither too hot nor too cold. Our atmosphere protects the earth from deadly radiation. The chemical and biological environment are balances. All of the vast forms of life continue to survive. Along with the atmosphere the temperature also allows water to exist in liquid form.

Earth's average temperature is 15° Celsius which is well above freezing. This is 33° degrees Celsius higher than it would be if heated only by solar radiation. The extra warming occurs because the atmosphere of carbon dioxide and water vapor traps heat and warms the sea and land below. An increase in warming would make the earth uninhabitable much like Venus. (Ronan, p. 150)

In the 1960's the British atmospheric scientist James Lovelock and the American biologist Lynn Margulis and other colleagues who had been studying the checks and balances of life on the planet, concluded that there is no runaway warming because carbon dioxide and water vapor are recycled in different ways.

(Ronan, p. 150)

Remember that life has three main characteristics:

1. It is a thing that can nourish itself.
2. It grows and decays.
3. It reproduces or repairs within itself

All living things are based on the chemical element carbon (remind students that coal and diamonds are versions of carbon that they are familiar with). Why that element? Carbon has a special quality. It is unique in the way that it can link with other carbon atoms and with atoms of other elements. Carbon atoms can join together by sharing electrons. A carbon atom can link itself to another atom and at the same time join with other elements or compounds. In fact most carbon occurs in combination with other elements. Carbon compounds make up the living tissue of all animals and plants. (Ronan, pp. 156-157)

At room temperature pure carbon does not react. It needs heat. Then it combines with other elements. A carbon atom can form molecules that have a “ring” formation based on the linkage of six carbon atoms. These molecules are essential to many life processes including photosynthesis, and many are soluble in water an attribute vital to earthly life. Beside forming rings carbon atoms can combine with each other to make long chains or polymers. These polymers form the chemical backbone of complex organic molecules that are vital to the structure and maintenance of life—from supportive walls of plant cells to insulin—the hormone humans need in order to metabolize sugars.

Human beings and animals inhale oxygen and exhale carbon dioxide that is produced while burning food for their bodies. Green plants take carbon dioxide from the air and give off oxygen when light shines off them. In the light plants combine carbon dioxide with water to make food. The wide existence of carbon means that the temperature range of carbon-based life is enormous by earthly if not only celestial standards. It covers about 100° Celsius—the range between the boiling and freezing points of water. Within this are many types of organisms. At the higher end are some algae which can live in temperatures of 70° to 80° Celsius. Likewise, some bacteria grow actively at 90° Celsius. In the laboratory they can survive above the boiling point at 100° C. Likewise, some fish can survive in temperatures a few degrees below freezing. (Ronan, pp. 156-157)

Oxygen also plays an important part in the existence of living things, and in the composition of the atmosphere without oxygen the range of life on Earth would be restricted. If other basic constants found in nature were different the Universe would not be favorable to life as we know it. If the strength of electromagnetism were slightly weaker or stronger then hydrogen would not exist in its ordinary form. Heavier elements such as carbon and oxygen could not exist and there would be no living things as we know them. If the weak nuclear forces were slightly weaker then supernova explosions would not occur. A source of some heavy chemical elements would not have existed since supernova explosions spread heavy elements through space to be later incorporated into planetary systems. If gravity were weaker, then it could not crush material in a star the size of the sun strongly enough to ignite thermonuclear reactions. Only very massive stars could shine by nuclear processes and such stars would probably have lifetimes too short for any evolution of life to occur.

In setting up objectives for the unit I would like to begin with exploration of the earth and its relationship to the Sun. Children should understand that:

1. The Earth rotates on its axis that is tilted.
2. The Earth revolves around the Sun and its trip takes approximately one year.
3. What determines the seasons is the tilt of the Earth. In summer the northern hemisphere is tilted toward the sun and in winter the Earth is tilted away.
4. How a solar eclipse occurs.

If your school has access to one of those models of the Earth, Moon, and Sun relationship it would be a good tool for students to see the rotation and revolution of these bodies. Students might also make popsicle stick puppets of the three planets and practice showing how they interact. Children might get into groups of threes and try to simulate the relationship between the Moon, Sun and Earth. In an effort to integrate the whole curriculum it might be suggested that the gym teacher have students try to model these movements.

Background Info—The Moon

The Moon is what is called a natural satellite. It is our nearest neighbor and approximately one quarter the diameter of the Earth. Students may not realize that the moon also rotates. It has what is called a “synchronous rotation” which means that its rotation period is exactly equal to its orbital period. This is why we see the same side of the Moon. In going through the relationship between these two bodies with children my goals would include that children discover:

1. How the Moon formed.
2. What conditions are like on the Moon.
3. How does the Moon move?
4. What are the phases of the Moon?
5. What is a lunar eclipse?
6. How does the Moon effect tides on the Earth?

At this point the Sun should be brought into the equation and the fact that the Earth is a planet and the Sun is a star should be explored. The following questions should be covered:

1. What is the difference between a star and a planet?

2. What is the life cycle of a star like the Sun.
3. What are constellations?
4. What keeps the Solar System in orbit?

Background Info—Stars begin as interstellar clouds—made mostly of hydrogen and helium. Since the temperature is low the gas molecules cannot support themselves against gravity and so they form clumps. As the gravitational force increases the cloud falls together and becomes a protostar. There are usually many clumps in these clouds so stars usually form in groups. The gas clumps flatten into disks and then into protostar which develops a hot dense core. If it is a smaller massed star like the Sun its life will proceed as follows. It will become a yellow star like our Sun is today. When it consumes 90 percent of the hydrogen in its core, which will take approximately 10 billion years(our sun has used up about half of its hydrogen) the core will shrink and grow hotter. When the hydrogen is nearly gone the rising temperature will make the remaining hydrogen burn faster. As the energy flows out of the suns outer layers it will expand and the outer edge will cool and turn red. Then it will turn into what is called a Red Giant. It will continue to shine red for about a billion more years. Then it will shrink and grow hotter turning into a Yellow Giant—smaller than its Red Giant phase but much larger than its original yellow stage. During this final stage the Sun will be taking its last deep breaths. Now it will be consuming its helium and will once again change into an even larger and more luminous Red Giant. This will be its final moments. Once it quickly consumes the remaining gas and forces the rest into space, the Sun will be very hot but with no energy supply it will cool and dwindle to a white dwarf phase. When a white dwarf cools to 20,000 Kelvin it is then called a black dwarf. (Arny, pp. 390-391)

If the sun had a higher mass it would have a somewhat different fate. High mass stars pass from their original size to the Yellow Giant then to Red Giant. However, when a large mass star runs out of fuel it explodes becoming a supernova. A massive star usually develops a large iron core which cannot support itself against the force of gravity and so it collapses in less that a second, triggering a cataclysmic explosion which shoots the heavy elements it has made into space. Such a star does not become a white dwarf but rather a tiny compressed ball of neutrons—a neutron star—or for a larger mass object, an even denser object—a black hole—the final victory of gravity.

After covering the basic Earth, Moon, and Sun relationships the next question becomes: What is the Solar System ? Students should really be able to do most of the research on this end. Working in teams they should be able to go out and do research to find out what is in the solar system. At this point a classroom chart should be erected so that students can research planets and put down information in the larger chart so that the class can compare and contrast the planets. This will help my students to understand why the earth is the only planet that we know has life on it.

While I don’t want to reproduce information about the planets which are available in most science and reference books, but I would like to tie in the aspect of how each fails to be a conducive place for life as we know it.

Background—The Planets—Mercury, Venus, Earth and Mars are called Terrestrial Planets because they have size and structure similar to Earth. They orbit the inner most part of our Solar System and tend to be rocky worlds too small and too warm to have the hydrogen covering that the outer planets have. They also tend to have no moons. Only the Earth has a Moon and Mars has two tiny asteroids that orbit it.

Mercury—the smallest planet which was named for the Roman deity who was a messenger of the gods because it changes position in the sky faster than any other planet. It resembles our Moon and has a mass one twentieth that of the Earth. Mercury has an odd rotation it spins three times for every two orbits it makes around the Sun.

Venus—is named for the Roman Goddess of love. It is closest in size to that of the Earth. Venus has a dense atmosphere that exerts a pressure 100 times greater than that of Earth. Its atmosphere is 96 percent carbon dioxide. Venus also spins slower than any other planet in the Solar System. It also spins in the opposite direction of the other planets. Some scientist think that as a young planet it was struck by a large planetesimal that slowed Venus and set it spinning backward. Because of a slow rotation it has a very long solar day—117 Earth days and on Venus the sun rises in the west and sets in the east.

Mars is named for the Roman God of war because of its reddish color Although it is about half the diameter and one tenth the mass of Earth, it is still very Earth like. On a warm day the Martian temperature at the equator reaches 700 K. Although it is often swept with dust and patchy clouds the atmosphere is generally transparent enough for astronomers from earth to view its surface clearly. It is a familiar place—polar caps of white with the rest of the planet being reddish in color. (Arny p. 199)

The seasons on Mars are more extreme than on Earth because the Martian atmosphere is much less dense and does not retain heat very well. Liquid water could not exist on Mars given its present atmosphere. There is no rainfall from the clouds because the atmosphere is too cold and contains too little water. Mars may not always have been so dry (there are numerous channels in its highlands that show that water once flowed there) but for a planet to have liquid water it must have a warm atmosphere with a pressure similar to that of the Earth's.

Although the first four terrestrial planets are rocky spheres the rest of their attributes are very different. The differences arise usually from their mass and radius, internal activity, and distance from the Sun.

Mass and Radius: Low mass, small radius planets are cooler inside than larger bodies. Thus, Mercury is relatively inert, Mars which is slightly larger was once active while far more active surfaces are found on Venus and Earth.

Internal Activity—Mercury was probably never very active and never had much atmosphere. Mars has a thin atmosphere. These two planets have lower mass, and smaller surface gravity compared to Venus and Earth so that they have had difficulty retaining what little gas they once had. Mercury has no atmosphere today and Mars has only a small amount of its original atmosphere. On the other hand, Venus and Earth have extensive atmospheres. The atmospheres that do remain on Venus, Earth and Mars have probably changed quit a bit over time through chemical processes. The atmosphere of all three was probably nearly the same—primarily CO_2, but with small amounts of water and nitrogen. These atmospheres have been altered by sunlight, tectonic activity, and in the Earth's case life.

Sunlight—Sunlight can affect a planet in several ways. Of course it can warm the planet depending on its distance. Thus one would expect the Earth and Venus to be warmer than Mars. On a planet like Venus the atmosphere is so warm that it would be impossible for water to condense and turn to rain. Because Venus has that thick warm covering water vapor can rise higher without condensing. On the Earth water vapor condenses at about 30,000 feet. The Earth's upper atmosphere has virtually no water vapor. (Arny, p. 220-221)

Content of water—the difference in the content of water has led to vast differences in the content of mass at the lower latitudes. At high altitudes the sun's ultra violet rays can break up water molecules into oxygen and hydrogen atoms. Being very light the hydrogen atoms could escape. It is believed that over billions of years Venus lost those hydrogen atoms and there by also completely lost water. Being that the earth does not have water vapor in the high levels of its atmosphere it has been able to retain water. Water is necessary to make chemical changes that profoundly altered the Earth's atmosphere. CO2 dissolves in water and as rain falls through the atmosphere it pick up CO2 and on impact it chemically reacts with silicate rocks to form carbonates virtually locking up some of the CO2 in rock and removing it from the atmosphere. (Arny, p. 221)

Biological Processes:

Biological processes also remove CO2 from the atmosphere. CO2 is used to make organic material such as cellulose of which they are composed. The CO2 is locked up there until the plant decays or burns releasing the CO2 back into the air. A more permanent removal comes when rain carrying CO2 runs into oceans where sea life exist. Sea Creatures use the CO2 to make shells . As these creatures die they go back to the bottom of the sea where they form sediment that eventually changes to rock. Thus CO2 is chemically and biologically swept out of the atmosphere and locked into the Earth's crust. With the CO2 removed our atmosphere has mostly nitrogen left. In fact Earth has about the same amount of nitrogen as Venus. (Arny, p. 222-222)

Our atmosphere is rich in oxygen which no other planet in the solar system has in such abundance. Earth's oxygen is the product of green plants breaking down H2O molecules during photosynthesis. Life could form on Earth because, due to a relatively low temperature the CO2 released by volcanism could be bound in rocks, and never build up too much. This process is not as efficient for larger temperatures like that on Venus, and so the CO2 increased, and further increased the temperature leading to the Greenhouse effect. The great difference between Earth and Venus may be basically the fact that the atmosphere was swept nearly free from CO2 but also the processes produced oxygen. In fact if all the buried carbonated rock released its CO2 except for the oxygen our atmosphere would be very much like Venus's.

The outer planets are those beyond Mars. These giant planets are found in the area where solar heat is minimal. The low temperature—150° Kelvin (over 100 degrees below zero on the Fahrenheit scale) and large mass allowed the planets to retain hydrogen and helium, and produce hydrogen rich gases—like methane, ammonia and water. The terrestrial planets are of smaller size in part due to the limited amount of silicate and iron rich materials which they are made of. On the other hand, the outer planets (Jupiter, Saturn, Uranus, Neptune, and Pluto) are larger in size because of the abundance of these gases. The outer or Jovian planets are composed mainly of gaseous and liquid hydrogen and its compounds. Although these giant planets have cores of molten rock matter, they have no solid surfaces and consequently have no surface features like mountains, and valleys. They appear different primarily because of their atmosphere. Pluto is the exception to this rule. As the smallest planet it has little in common with the giant planets and it is more like one of the larger moons which are made of ice and rock.

Jupiter is the largest planet in radius and mass. It is larger than all the other planets in the Solar System combined. It is a bit more than 10 times the Earth's diameter and 300 times its mass. Jupiter rotates once every 10 hours and spins so fast that its equator bulges significantly. The clouds on Jupiter move around in a jet stream more swiftly than that on Earth.

Saturn was thought to be the only planet with rings but in 1977 thin rings were found to be going about Uranus and so astronomers decided to see if Jupiter might also have a ring. Jupiter's ring is thought to be made of tiny particles of rock and dust held in orbit by Jupiter's immense gravitational attraction. However, these tiny particles are gradually captured by Jupiter's magnetic field and drawn down into the atmosphere. The ring is replenished by Jupiter's tiny satellites that occasionally collide and fragment.

When Galileo first observed Jupiter he saw a five moons orbiting the planet. Other moons have been found and the number now exceeds 16. Most of these could not be seen from Earth and were identified by pictures sent from the Voyager space craft. The Galilean satellites—Io, Europa, Ganymede, and Callisto are very large. All but Europa are larger than our Moon. Ganymede has a diameter larger than Mercury's making it the largest moon in the Solar System.

Saturn is the second largest planet and is about 10 AU from the Sun. Saturn is named after the Roman god of harvest. Saturn's diameter like Jupiter's is about 10 times that of the Earth. Like Jupiter, Saturn radiates more energy than it gets from the sun which suggests it too has its own heat source. While both Saturn and Jupiter have hot interiors and similar composition, the differences in their appearance can be linked to Saturn's greater distance from the sun. In this colder climate ammonia gas freezes and this veils the atmosphere making marks below the clouds indistinct.

The rings of Saturn were first seen by Galileo. To him they looked like handles on either side of the planet. In 1659 Christian Huggens a Dutch scientist observed that the rings were detached from Saturn and circled it. The rings are very wide but very thin. The rings extend about 30,000 kilometers above the top of Saturn's atmosphere to a little more than twice the planets radius (136,000 kilometers or 84,000 miles).

Despite their immense breadth they are less than a few hundred meters thick—thin enough for stars to be seen through them. The rings are relatively small—only a few centimeters to a few meters across. Though they cannot be seen individually with a telescope, radar signals bounce off them.

Like the rings of Jupiter, those of Saturn are subject to the forces of gravity. As particles are falling into Saturn's atmosphere more material is added. It is believed that the satellites going around the planet may have their orbits altered leading to collision and the addition of new particles to the rings.

Saturn has several large moons and a dozen smaller ones. Titan the largest Saturnian moon has a diameter of 5,000 kilometers or 3,000 miles making it slightly bigger in diameter than Mercury. Titan is large enough to have its own atmosphere and gravity. The moons in order of size are Titan, Dione, Iapetrusm, Encladus, Tethys, and Mimas.

Uranus, while small compared to Jupiter and Saturn is still much larger than the Earth. Its diameter is 4 times that of Earth and its mass is about 15 times greater. At 19 AU from the Sun (more than twice Saturn's distance) Uranus is visible only as a blue but featureless disk.

The ancients did not know about Uranus and it was discovered by Sir William Herschell. He was an amateur astronomer who had emigrated to England. He liked to hunt comets with his sister Caroline and he first observed the planet in 1781. In ancient Greek Mythology, Uranus was the father of Cronas and was identified as God of the heavens.

Uranus' atmosphere is rich in hydrogen and methane. It is the methane that gives it its deep Blue color. Uranus is also surrounded by a set of narrow rings. These rings are composed of small particles. The rings of Uranus are very dark which indicates they are not made of or covered by ice like the bright rings of Saturn. Instead they may be made of carbon particles or organic-like material.

Uranus has five large moons and about ten smaller ones. Like Jupiter and Saturn they form a regular system and are probably composed of mainly ice and rock. The five larger moons are Titania, Oberon, Ariel, Miranda, and Umbriel. The moon Miranda has a different surface than any other in the solar system. It has different regions which display different surface areas. One region is wrinkled while an adjacent one has hills and craters. Some scientist think Miranda was shattered by contact with another body. The pieces were gathered back by the mutual gravity producing this unique patchwork appearance.

Uranus' rotates on an axis which is tipped about 90 degrees with respect to its orbiting plane, so that its equator is really perpendicular to its orbit. That is it spins on its side. Furthermore, its moons also have a similar tilt. Some astronomers speculate that during its formation—Uranus was struck by an enormous planetisimal whose impact tilted the planet and splashed out material that formed its moons.

Neptune, named for the Roman God of the sea was discovered independently in the 1840's by John Couch Adams, an English astronomer, and Urbain Leverrier, a French astronomer. There was controversy about who first discovered it, but these two were both credited. Since Uranus seems to not be following its predicted orbit, they speculated that it was being disturbed by the gravitational forces of another planet. Galileo saw Neptune in 1613 while observing Jupiter's moons. He recorded seeing a dim object whose position changed with respect to the stars but he did not further investigate, leaving the discovery to be made two centuries later.

Neptune is probably similar to Uranus and Saturn. It is composed of mainly water, hydrogen, helium, and hydrogen compounds such as methane. Neptune is also blue in color which is caused by the methane. Unlike Uranus, Neptune has distinctive cloud belts. Neptune also has rings but they are very narrow and more like those of Uranus than Saturn. They are probably composed of particles from small satellites or comets that have collided and broken up. There is more dust in Neptune's ring than in Saturn's or Uranus's.

Neptune has two large moons—Triton and Nereid, and about a dozen smaller ones. Triton is larger than Mercury and it orbits backwards (counter to Neptune's rotation). It has enough of a mass that it can hold an atmosphere of gases around it making it only the second moon in the solar system to have an atmosphere. The other large moon Nereid is also unusual in that its orbit is highly elliptical compared with that of other moons in the Solar System. This along with Triton's retrograde orbit lead many scientist to speculate that Neptune's satellite system was seriously disrupted at one time perhaps also giving birth to Pluto.

Pluto is named for the Greek and Roman god of the underworld. It was the last of the nine planets to be discovered. Clyde Tombaugh, an astronomer at Lowell Observatory in Arizona first found it in 1930. He examined pairs of photos for over a year searching for objects whose position changed between exposure. That is the telltale motion that distinguishes a planet from a star.

Pluto's distance from the sun and its size make it a dim object. For years scientist could only tell that Pluto was smaller than the earth. In 1978 James Cristy of the U.S. Naval observatory discovered a moon circling Pluto. This allowed astronomers to measure Pluto's radius and mass. Pluto's moon is Charon, named for the boatman who ferries dead souls across the river Styx to the underworld. It takes Charon only 6.4 days to circle the planet. Pluto's mass is 0.002 times the Earth's , making Pluto the least massive planet. Charon and Pluto's motion show that they have tipped rotation axis similar to Uranus. Pluto's diameter is a little less than one fifth that of the Earth, and Charon though small is surprisingly large in relationship to Pluto. It is slightly one half Pluto's diameter.

Galaxies:

After covering our solar system then students should have come to understand the uniqueness of our planet. At this point the teacher may want to cover other elements within the solar system such as comets, meteor and asteroids. Once the Solar System has been covered it is now time to expand the neighborhood to include our galaxy—the Milky Way and other Galaxies. This is the largest subdivision of the universe if we think of it in terms of a community. A galaxy is an immense cloud of millions to hundreds of millions to hundreds of billions of stars. Each star moves in its own orbit held in its place by the forces of gravity within the stars. All of the galaxies are extremely distant from the Earth.

There are three main types of galaxies based on their shape. The first is a spiral which has two or more winding arms coming from the center. Within the spiral category there are two closely related types. The first is called a barred spiral which has arms coming off of an elongated central area. The arm comes from the core of the galaxy. The other spiral, the normal spiral, has a disk shape with no evidence of any arms. The second type of galaxy is elliptical in shape and has smooth features. The last type are called irregular because they show no distinct shape.

Other galaxies are continually moving away from us. This happens because space itself is continually expanding. The expanding Universe is not like a bomb which throws fragments in all directions. A good analogy is a raisin cake baking in the oven. As it cooks the cake expands, and causes the raisins to move away from each other. The expansion of space carries the galaxies further apart. This motion is in no way attributable to the galaxies. Although space is expanding those objects within space are not expanding. The solar system and the galaxies themselves are held together by their own gravity and other forces.

Big Bang Theory—the theory supposes that the universe began a finite time ago in a high temperature, high-density state. In trying to understand the origin of the universe it must be remembered that because we do not fully know the workings of energy and matter, we cannot go back to the exact time of the explosion. It is theorized that the material that existed was a dense mass smaller than an atom. Most importantly it should be remembered that the big bang did not occur in a specific place but that it filled the entire volume of the universe from the first moment. The big bang occurred everywhere and we are inside the remains of that event.

At some point you may wish to have students do some research on astronomers of the past. This kind of exercise lets them know that it has taken humans a long time to piece together information about the universe. Often theories and beliefs were proved wrong. However, being wrong didn't stop people from continuing to refine their knowledge about the world.

Background:

People have been observing the sky since ancient times. The Chinese observed eclipses of the Sun and Moon between three and four thousand years ago. In the second century A.D. an Egyptian named Ptolomy said that the earth was the center of the universe with the sun going around it. People held this view for about the next 1,300 years. In 1543 a polish astronomer named Nicolaus Copernicus said that the theory was wrong and that the sun is actually at the center of the universe. Most people didn't believe it.

About 50 years later an Italian scientist named Galileo said he has concluded that Copernicus' idea was correct. In 1609 he built one of the first telescopes and used it to study the moon, the planet and the Milky Way. His agreement with Copernicus' theory meant that he was disagreeing with the Catholic Church which still believed that Ptolemy was correct. Galileo was kept under guard in his house until he died in 1642. He was not forgiven by the church until 1980.

Born the same year as Galileo was the Danish nobleman Tycho Brahe who also believed that the earth was the center of the Universe. Although his elaborate theory about the Universe was incorrect, he is revered for the observational work he did. He did not have a telescope since they were not invented until after his death. He did use other instruments to help him make very accurate observations about the positions of the stars, Sun, Moon and planets. It is hard to believe the accuracy of his measurements given the fact that his observations were made with the naked eye peering along sights on large instruments.

Johannes Kepler was one of Tycho Brahe's assistants. He took Tycho's observation and discovered how the planets move. His three laws of planetary motion stated that the orbit of the planets was elliptical not circular. The second law says that the movement of the planets in their orbit is not at the same speed. They speed up as they get nearer the Sun. The third says that there is a relationship between the length of the orbit and the size of the orbit.

In the year that Galileo died another astronomer was born, He was Sir Issac Newton. He studied the motion of the planets and suggested many laws about movement and gravity that are still used today. He was the first to explain that gravity extends through space and is the force that keeps the planets in their curved orbits. Newton also made a special reflecting telescope that used mirrors.

In the eighteenth century Caroline and William Herschel, a sister and brother, made their own 40 foot telescope to observe the sky with. They discovered the planet Uranus in 1781.

After covering these topics the unit would end with a survey of the modern space exploration. Students would then research different astronauts and well know people in the history of the modern space program. A look at the astronauts entry in the World Book Encyclopedia will reveal a list of people related to the space exploration. It is a good list to have students chose research subjects from. The names include: John H. Glenn, Alan Shepard, Yuri A. Gagarin, Valentina Tereshkova, Sally Ride, Neil Armstrong, Werner Von Braun, and Robert Goddard.

The unit would now be entering its final two week stage and so it would be appropriate for students to begin working on their final projects. I would like for students to create their own space alien, and describe where it comes from, and how it satisfies the need for food shelter and clothing—if appropriate. Students could make a clay model or diorama of the being and its habitat. I think that this part of the unit needs to be most flexible, as students should be allowed and encouraged to use their imaginations.

Possible weekly outline for the unit and Lesson Plans:

Week 1:

Day 1—Introduce the unit using a story, movie, poem, factual article, etc.
Do web or KWL chart of children's prior knowledge
Day 2—Discuss what constitutes life on earth.

Day 3—Give small groups of students graphic organizers to research information about the Earth, Sun, and Moon.
Day 4—Have students report back what they learned and begin keeping a class chart on the information gathered. Give students the opportunity to go to a science center in your classroom where they can use scientific models, flashlights, globes, etc. to work out the relationship between these bodies.
Day 5—You may have students do journal writing or a report on what they learned. Have them draw pictures—have them write Moon poems or combine their information into a class book on the Sun, Earth and Moon.

Week 2

Day 1—Have students choose a planet and again give them graphic organizers to find out pertinent information like mass, diameter, number of Moons, distance from the Sun, etc.
Day 2—Continue research.
Day 3—Fill in the classroom chart and begin analyzing and comparing the data.
Day 4—Begin working on a model of the Solar System See enclosed lesson plans.
Day 5—Continue work on model.

Week 3

Day1—Give students the name of one of the great astronomers such as Ptolemy, Copernicus, Galileo, Newton, Kepler, and the Herschels. Challenge students to find out what was their contribution to our knowledge of the Universe.
Day 2—Continue research.
Day 3—Have groups report about what they learned. Have students put these people into a timeline so they can see the progression of how ideas changed in regard to the Universe.
Day 4—Discuss the Big Bang Theory. Have students see the expanding universe by using the example of an inflating balloon with dots representing galaxies distributed on the surface.
Day 5—Discuss the life of a star. Have students make shoe box constellation models in which they draw the stars in a constellation and punch it out at the end of a shoe box. The other end has a hole for viewing. When held up to the light it appears much like in a planetarium. Students

can each do a different constellation and leave them in the science center for others to try and identify.

Week 4

Day 1—Give students the chance to research some of the modern pioneers in space flight and exploration.
Day 2—Have students report back on what they have learned. What qualifications does it take to be a scientist, astronaut.
Day 3—Take trip to planetarium if possible.
Day 4—Students should start preliminary work on their alien project.
Day 5—Continue project.

Week 5—Devoted to students working on project and writing accompanying narratives.

Week 6—Finish projects and display work for other classes and parents.

In doing this preliminary outline of the unit, it becomes apparent that there is a lot to be covered and that each activity could not be mentioned in detail. Of course, throughout the unit the children would be reading and listening to relevant literature both fiction and nonfiction. We would have numerous art projects, as well as, creative writing (poems and stories) research and report writing. The scientific approach , and the actual “work” of scientist would be stressed, so that children would see that scientific research is not static, but rather, a dynamic enterprise.

Lesson 1—Moon Photo Analysis

It may be difficult to do actual observation with student but in reading through some of the literature it is apparent that much of modern astronomy is comparing photos of objects. I thought that with some pictures of the moon and some of the terminology mentioned in the Arny book my students could look at photos and pick out certain characteristics.

Objective to recognize the following: craters—circular pits; maria (seas)—smooth dark areas; highlands—bright areas that surround the maria (they differ in color because they are made of different type of rock); rays—which are streaks that radiate out from the many lunar craters; and rilles which look like empty river canyons.

Materials lunar photos—either from books or procured from NASA.
Overhead projector

Procedure Review these characteristics with students using a number of different photos. As a follow-up pictures might be hung in the science center so students can practice analyzing the photos. There may be an observation sheet available for students to record what they see.

Lesson 2—Model of the Solar System

The model uses a track to show distance by number of laps and sizes are shown by using the following vegetables or objects almost that size.

Mercury—one fresh pea (the kind you eat) at 2/5 of a lap
Venus—one walnut at 3/4 of a lap
Earth—one slightly larger walnut at 1 lap
Mars—one dry pea (the kind you plant) at 1 1/2 laps
Jupiter—one cabbage (about 9 inches across) at 5 1/5 laps
Saturn—another cabbage (about 8 inches across) at 9 _ laps
Uranus—a big orange at 19 1/5 laps
Neptune—one grapefruit at 30 laps
Pluto—another bean (smaller than the first) at 39 2/5 laps (Jobb, pp. 99-101)

If your school has a track you can have your students take the objects and let them experience distance by walking the track.

Objective Students will definitely see the huge distances between the terrestrial planets which are all reached in 11/2 laps and the Jovian planets which take more than 38 more laps to reach.

Lesson 3—Phases of the Moon

Material

a piece of notebook paper
a large piece of paper divided into large squares large enough to draw observations

Objectives Students will keep nightly observations of the Moon in a notebook—recording if it was possible to see the Moon and if so drawing its shape. In class they will work with a small group to make an Moon chart recording their findings.

Lesson 4—Planet Models.

Materials a compass, ruler and pencil; different colored paints cardboard, scissors

Objective to create a model of the Solar System so children can see size relationships between the Sun and its planets.
Use the following scale and color. Remember that the radius given is for the model.

Mercury—_ inch—lead gray
Venus—11/4 inches—bright silver
Earth—l1/4 inches—blue and white
Mars—_ inch—red
Jupiter—15 inches—whitish yellow
Saturn—12 _ inches—yellow
Uranus—5 1/2 inches—blue
Neptune—5 _ inches—blue
Pluto—1/3 inch—dark brown
Sun—on this scale would have a radius of 145 inches (Peacock, p.18)

Lesson 5—How were Craters Formed?

Materials a large rectangular plastic container holding some moist sand
a small but heavy ball or stone.

Objective Students will experience what must have happened on the Moon and other planets as large objects collided with the surface.

Procedure A pair of students take turns throwing the ball or stone into the sand.
What happened to the ground? What shaped formed? What happened if you threw the ball harder? What happens if you just drop the ball with no force? Students should have their science journals and record in word and illustration what they learned.

Lesson 6—What holds the planet in Orbit?

Material a yoyo

open area so children can swing the yoyo over their heads.

Objective To show children that there are forces at work that keep the planets in orbit and that without that force they would either fly out into space or collapse.

Procedure If possible distribute a yoyo or other weighted sting to pairs of students. Have each child take turns swinging the yoyo and keeping it flying in a circular orbit. Question students as to what they had to do to get the yoyo flying. What if they slowed down the force with which they were turning the string. Have students draw and write their observations in their science journals. Discuss their findings.

Teacher's Bibliography

Arny, Thomas T. *Explorations: An Introduction to Astronomy.* Boston: Mosby, 1994.

College textbook that was part of the recommended reading for this seminar.

Carin, Arthur A. and Robert B. Sund. *Teaching Science Through Discovery.* Columbus: Merrill, 1975. Textbook for teaching science through discovery.

Authors offer philosophical background to this method, as well as, lessons in various areas of science including astronomy.

Gego, Peter C. *Science in Elementary Education.* New York: Macmillan, 1986.

Methods for studying and teaching elementary science.

Goldsmith, Donald. *The Astronomers: Companion book to the PBS Television Series.* New York: St. Martin's Press, 1991.

Discusses the most important astronomical discoveries of the century and illuminates the methods of over two dozen experts.

Hartmann, William K. and Chris Impey. *Astronomy: The Cosmic Journey.* Belmont: Wadsworth, 1994.

Recommended college text that covers background information found in introductory course in astronomy.

Jacobson, Willard J. and Abby Barry Bergman. *Science For Children: Book For Teachers.* Englewood Cliffs: Prentice-Hall, 1987.

Jobb, Jamie. *The Night Sky Book: An Everyday Guide to Every Night.* New York: Little, Brown and Company, 1977.

A concise overview of the stars, how to make observations, and the planets.

Ronan Colin A. *The Natural History Of The Universe From The Big Bang To The End of Time.* New York: Macmillan, 1991.

Explains the cosmos: its birth, its life, and its possible future.

Seeds, Michael A. *Foundations of Astronomy.* Belmont: Wadsworth, 1990.

College textbook covering the introduction to astronomy.

Children's Bibliography

Branley, Franklyn M. *Star Guide.* New York, Thomas Y. Crowell, 1987.

Describes the composition and behavior of stars and notes which ones can be seen at different times of the year.

Darling, David. *Other Worlds: Is There Life Out There?* Minneapolis, Dillon Press, Inc. 1985.

Examines the evidence which may support the possibilities of life elsewhere in the universe and discusses the efforts we have made to pick up signals from outer space.

———. *The Planets: The Next Frontier.* Minneapolis, Dillon Press, Inc., 1984.

Explains how each of the planets was most likely formed, and presents information on what makes each planet so unique.

———. *The New Astronomy: An Ever-Changing Universe.* Minneapolis, Dillon Press, Inc. 1985.

Examines the state of modern astronomy including X-ray, Gamma ray, infrared, and UV astronomy, and discusses future possibilities in the field.

Kohn, Bernice. *The Scientific Method.* Englewood Cliffs: Prentice Hall, 1966

Explanation of the scientific method with biographical sketches of different scientists, including Galileo, and how they used the method.

Peacock, Graham and Dennis Ashton. *Science Activities: Astronomy.* New York: Thomson Learning, 1994.

Astronomy experiments for children.

Shymansky, James A. and Nancy Romance and Larry D. Yore. *Journeys In Science.* New York: Macmillan Publishing Company, 1988.

This is the Science text currently used in 3rd grade.

Underwood, Juliette. *Geotrivia Space The Ultimate Trivia Adventure.* Skokie, Illinois: Rand McNally, 1995.

A fun book of question and answers, about different aspects of outer space.

VanCleave, Janice. *Janice Van Cleave's 201 Awesome Magica Bizarre and Incredible Experiments.* New York: John Wiley & Sons, 1994.

Science experiments for children from different areas of science including astronomy.

Wellington, Jerry. *The Super Science Book Of Space.* New York: Thomson Learning, 1993. Photographs, art, and activities, introduce the principles of astronomy and the devices used to measure and observe space.