Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
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# Astronomy and Me: Moons Over New Haven

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I teach 3rd grade at Wexler-Grant Community School. We are a school that begins with Headstart and ends with 8th grade. We have an interesting history. We were two separate K-5 schools at one time, Helene W. Grant and Isadore Wexler. The two schools are in very close proximity to one another. Approximately one mile separated the two schools. All of the schools in New Haven are being rebuilt or remodeled. As schools were being refurbished, a few were combined. With the merging of our two schools, grades 6-8 were added. Our Student Population is approximately 90% African-American and the remaining 10% is made up of White and Hispanic. This shows a change in the community. Five years ago the population of our school was 98% African-American and 2% White and Hispanic. Many of our students in our school have never left the state of Connecticut. Many of them have never been out of New Haven. Teaching in New Haven can certainly be tough because some students seem to come to school for reasons other than learning. You certainly have to have a thick skin to work in our school. You also have to bring enough enthusiasm for yourself as well as the rest of the class.

Science is, and always has been, one of my favorite subjects. It also happens to be my students' favorite subject. Every class I have taught, most, if not all of my students, love science. I'm not sure if they love the experiments or love the fact that the subject generally tends to be very hands-on. In 3rd grade the two major science kits that are done are chemical tests, and plant growth and development. STC® (Science and Technology for Children) kits are the staple of science for the elementary school. However, some kits require a lot of time to set materials up and also to put them away. For this reason, science can be difficult to squeeze in the elementary schedule. Literacy takes up most of our time. We have to squeeze in Mathematics and try to incorporate Social Studies. Science is often neglected and/or not given the proper time that is needed to truly teach all of the many aspects that incorporate science. Many of our kids think that science is just doing "cool experiments." They don't understand why or the procedures that scientists use to lead up to the actual experiment as well as what scientists do after the experiment is complete. Teachers have a lot of work to do to make science more integral. This unit, I believe, will be a step in the right direction. My unit will give an overview of the solar system. We will then learn about Galileo Galilei, one of the first pioneers in astronomy. The unit will then focus on the Earth's Moon as a basis and model to prepare the class for study of Jupiter's moon Europa and Saturn's moon Titan. All three moons are very different from one another so it will make for a nice contrast. The curriculum unit will take you through each step that will be taught in succession. Let's take a walk through the solar system and get an overview of all of the planets and other various bodies that inhabit our solar system.

## Overview

Our solar system is made up of eight planets and three dwarf planets which orbit the Sun. [1] The Sun is a star which is similar to billions of other stars in our galaxy. The Sun is much bigger than anything else in our solar system. It is so big that more than one million Earths could fit inside it. The Sun is about 150 km away from earth. The Sun is an average sized star with a diameter of approximately 1,400,000 km. Like other stars, the Sun is a shining, burning, ball made up of hydrogen and helium gas. The energy that is generated in the core of the Sun is the source of light and heat in our solar system. It can take up to a million years for the energy produced in the Sun's core to reach the surface. The surface of the Sun or, photosphere, reaches a temperature of about 5,500 ◦C. At night, we are able to see the planets because they reflect the light of the Sun. They do not generate their own light.

The four planets closest to the Sun are Mercury, Venus, Earth, and Mars. These four planets are called terrestrial planets. Terrestrial comes from the Latin word *terra* which means earth or land. These four planets are called terrestrial planets because they are similar to Earth. The terrestrial planets are relatively small and are made of rocky material, and have solid surfaces like the earth. Here are some interesting facts about each of the four terrestrial planets. Mercury has a diameter of 4,880 km. Mercury circles the Sun in 87.97 days and turns on it's axis in 58.65 days. Mercury has 0 moons. Venus has a diameter of 12,104 km. Venus circles the Sun in 224.7days and turns on it's axis in 243 days. Venus has 0 moons. Earth has a diameter of 12,756 km. Earth circles the Sun in 365.2 days and turns on it's axis in 23.93 hours. Earth has 1 moon. Mars has a diameter of 6,794 km. Mars circles the Sun in 686.98 days and turns on it's axis in 24.62 hours. Mars has 2 moons. [2]

The next four planets are very different from the terrestrial planets. These planets are called giant planets or gas planets. They are also called Jovian planets, meaning planets that are like Jupiter. The giant planets, Jupiter, Saturn, Uranus, and Neptune are much different than the terrestrial planets. The giant planets are much larger than the terrestrial planets, thus, the name. The giant planets are made mostly of gas and don't have solid surfaces. Here are some interesting facts about each of the four giant planets. Jupiter has a diameter of 142,800 km. Jupiter circles the Sun in 11.86 years and turns on it's axis in 9.8 hours. As of February, 2004, Jupiter has 63 known moons. Many of them have not been named. Saturn has a diameter of 120,000 km. Saturn circles the Sun in 29.46 years and turns on it's axis in 10.2 hours. Saturn has 34 named moons and a total of 60 as of today!. Uranus has a diameter of 51,800 km. Uranus circles the Sun in 84.01 years and turns on it's axis in 17.2 hours. Uranus has 21 named moons and 6 unnamed moons. Neptune has a diameter of 49,500 km. Neptune circles the Sun in 164.79 years and turns on it's axis in 16.1 hours. Neptune has 13 known moons. Four moons were discovered in 2002 and one in 2003 and have yet to be named. [3]

Our solar system also has 3 dwarf planets. Pluto, Ceres, and Eris are classified as dwarf planets. A dwarf planet is a celestial body that orbits around the Sun, it is not a satellite, it has enough mass for its self-gravity to overcome rigid body forces so that it takes on a nearly round shape, but unlike planets, it has not cleared the neighborhood around its orbit. Pluto was classified as a planet for 76 years until 2006 when the 26th General Assembly for the International Astronomical Union reclassified Pluto as a dwarf planet. Pluto is small and icy very different from the terrestrial planets and the giant planets. Pluto does have a moon named Charon. The dwarf planet Eris also has a moon.

Our solar system is relatively flat, like a disk. It also has billions of smaller objects orbiting the Sun. There are

comets that swing in extremely elongated orbits that take them close to the Sun and then billions of miles away from it before they head back. There are thousands of rocky asteroids that orbit between Mars and Jupiter. They are in a region of space appropriately named the Asteroid Belt. There are also thousands of small, icy bodies that orbit the Sun that are in the cold, dark area of space beyond about 7 billion miles beyond Neptune. This dark area of space is called the Kuiper Belt. The comet-like bodies found within the Kuiper Belt are called the Kuiper Belt Objects. Our solar system is surrounded by a host of icy bodies that extends almost halfway to the nearest star. This swarm of icy bodies is called the Oort cloud. Next, we'll take a look at one of the "fathers" of modern astronomy, Galileo Galilei.

## Galileo Galilei

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Although many people believe that Galileo invented the telescope, this is a misconception. However, Galileo was one of the first people to turn his telescope towards the heavens to view celestial bodies. What distinguished Galileo from other early astronomers was that Galileo was the first to publish the results of his observations and he created a sensation. [4] Galileo was the first born child of Vincenzo Galilei and Giulia degli Ammannati and was born on February 15, 1564 in Pisa, Italy. He became a student at the University of Pisa where his father wanted him to study medicine. Galileo became a mathematician and eventually became a lecturer at the University of Pisa in 1588. Galileo became the chair of mathematics at the University of Padua in 1592. He stayed there until 1610. In 1609 Johannes Kepler published his Astronomia Nova which contained his 1st two laws which were that planets move in an elliptical orbit with the Sun as on of the foci and a planet sweeps out equal areas in equal times. In May of the same year, Galileo heard about an invention in the Netherlands that allows you to see objects that are far away as if they are close by. This invention was to eventually be called a telescope. It was invented by a man named Hans Lipperhey. He discovered that holding two lenses up some distance apart brought objects closer. In June of the same year, Galileo recreated the invention he had heard about and created a 3 power telescope. In the Fall of 1609, Galileo made improvements to the telescope and began to observe celestial bodies. In December of 1609, Galileo made a series of observations of the moon starting on November 30th and ending December 19th. Galileo could only see about a quarter of the Moon's surface at a time. He would have to move his telescope each time to see more of the Moon's face. On January 7th, 1610, Galileo observed three bright little stars by Jupiter. By January 15th, Galileo had figured out that Jupiter had four little satellites. Today they are called the Galilean Satellites. When Galileo published his findings that Jupiter had 4 moons that orbited it, it caused a wave of controversy. At that time everyone believed that everything in the sky orbited the Earth. [5] In February of 1610, Galileo continued making observations and made maps of star formations. Galileo observed many things with his telescope. He saw craters and mountains on the moon, sunspots on the Sun as well as the rings of Saturn. The rings appeared as "horns" because his telescope could not resolve the gap between the rings. [6] Galileo began to travel all over Italy sharing his observations. Others around the world began to verify and expand upon his observations. In December of 1610, Galileo confirmed that Venus goes through phases like the Moon. He observed that Venus appeared small in its gibbous phase and appeared larger in its crescent phase. This was proof to him that Venus goes around the Sun. Galileo's published works were widely read and caused such a stir. This eventually led to the Roman Catholic Church getting involved. Galileo's publishing of the Sun having "spots" was on the verge of blasphemy and heresy. The church attacked Galileo's ideas because they could not be reconciled with certain Bible passages or with the writings of Aristotle and Plato. The Sun was a heavenly body and thus had to be perfect. Claiming that the Sun had "spots" was an attack on God's beauty

and perfection. Galileo was first censured by the church, then, he was excommunicated. Finally, Galileo was held under house arrest until his death in 1642. It is very important to know that you should never look directly into the Sun with a telescope. It could damage your eyes irreparably. It has been reported that Galileo was to have damaged his eyes from his observations of the Sun. There are safe ways to observe the Sun with a telescope and can easily be found on the internet.

Before the widespread use of the telescope, people could not clearly see what was happening in the nighttime sky. Much of their ideas and beliefs about the universe were based on philosophy and religion. Galileo began the trend to observe and measure objects in the sky. This showed that the worlds above seemed to obey the same physical laws that were known to work on earth. An example of this was Galileo was able to determine the height of mountains on the Moon after observing their shadows move on the Moon's surface. [7] To think that an ordinary person could actually know something about distant worlds just by writing down what is seen and then applying basic mathematics to the problem was a revolutionary idea. Due to Galileo's extensive observations of the Moon, we will next take a look at Earth's Moon.

## Earth's Moon

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The Moon is the only satellite orbiting the Earth that is natural. It was called Luna by the Romans and the Greeks had two names for it, Selene and Artemis. Many other cultures had names for the Moon in their mythologies. After the Sun, the Moon is the second brightest object in the sky. The Moon does not produce its own light. It reflects sunlight from its surface. The Moon orbits around the Earth once per month, and as it does, the angle between the Earth and the Moon and the Sun changes. These changes that we see are the cycle of the Moon's phases. The time between new moons is 29.5 days. This is slightly different from the Moon's orbital period around the Earth since the Earth moves a significant distance in its orbit around the Sun in that time. The Moon is sometimes classified as a terrestrial planet because of its size and composition.

The Soviet spacecraft Luna 2 was the first to visit the Moon in 1959. The Moon is the only celestial body to have been visited by humans. The first landing on the Moon was on July 20, 1969. The last time humans set foot on the Moon was December 1972. The Moon is also the only extraterrestrial body from which samples have been brought back to Earth. A small spacecraft named Clementine did some very extensive mapping of the Moon in 1994. The Moon was mapped again by Lunar Prospector in 1999.

The gravitational force between the Earth and the Moon causes some interesting effects here on Earth. The gravitational attraction of the Moon is stronger on the side of the Earth nearest to the Moon and weaker on the opposite side. Since the oceans on Earth are not perfectly rigid, it is stretched out along the line toward the Moon. From the prospective of the Earth's surface, we see two small bulges. One bulge is in the direction of the Moon and the other one is directly opposite. When looking at ocean water, the effect is much stronger than in the solid crust. Thus, the bulges in ocean water are much higher. Also, because the Earth rotates much faster than the Moon moves in it's orbit, the bulges move around the Earth about once a day giving the Earth two high tides per day.

The Moon's rotation always keeps the same face toward the Earth. When the Moon goes through its phases, we are still seeing the same side. This special rotation is called synchronous rotation. This means that the Moon takes exactly as long to rotate on its axis as it does to make one orbit around the Earth. This also means

that there is no "dark" side of the moon. All parts of the Moon get sunlight half of the time. At times, one can see slightly more than half of the Moon's surface. This is because the Moon appears to "wobble" slightly over the course of its orbit. It seems as though the Moon is rocking back and forth around its north-south axis and to nod up and down in a north-south direction. This phenomenon is called libration and allows viewers of the moon to see 59% of its surface. The Moon is not really wobbling. We are able to see more of the Moon's surface because its orbit around the Earth is slightly elliptical. As a result, the Moon's orbital motion is not able to keep pace with it's rotation at all points around the orbit. In addition, because the Moon's rotation axis is not exactly perpendicular to the plane of its orbit, the Moon appears to nod up and down.

There is no atmosphere on the Moon. However, the spacecraft Clementine has produced evidence that suggests that there may be water ice in some of the deep craters near the Moon's south pole which are permanently shaded. The spacecraft Lunar Prospector has produced supporting evidence of this possible ice as well as evidence that there may be ice at the north pole also. The Moon is too small of a planet to have an atmosphere. The surface gravity on the Moon is low. Its gravity is only about one-sixth as large as the gravity here on Earth. This low gravity would not allow gas molecules to stay near the Moon's surface. The gas molecules would easily escape into space. With there being no atmosphere on the Moon, there is nothing to scatter the sunlight, so the daytime sky on the Moon is as black as the nighttime sky on Earth.

The surface of the Moon is broken into two primary types of terrain. There is the heavily-cratered and very old highlands terrain. There is also the relatively smooth and younger terrain called *maria* . The maria makes up about 16% of the Moon's surface. The maria terrain has huge impact craters that were later flooded by molten lava. A mixture of fine dust and rocky debris produced by meteor impacts called regolith, covers most of the surface. The maria are the large dark areas on the Moon's surface *. (See Figure 1* ) They form a pattern that sort of looks like a human face. This is what began the phrase "the man on the moon." For reasons yet unknown, the maria are concentrated on the near side. Virtually all of the craters on the Moon are a result of the Moon being bombarded meteors. No matter how big or small the crater, they are all called impact craters. Most craters have a circular shape because when a meteor collided with the Moon, it created a shock wave in the Moon's surface at the point of impact. This shock wave usually produced a circular crater no matter what direction the meteor was moving. It is believed that meteors and asteroids, some as large as tens of kilometers across, struck the Moon forming basins. These basins would then flood with lava which would flow from the Moon's interior through the cracks in Moon's crust. The hardened, solidified lava formed the maria that we see today. Surprisingly, when the Moon's far side was photographed by the Soviet spacecraft Luna 3 in 1959, there was almost no maria there. Scientists presume that the Moon's crust is thicker on the far side. It is believed that even the most massive impact from a meteoroid would not be able to crack through the crust and let lava flood onto the surface. Thus, the far side of the moon has very little maria.

(image available in print form)

*Figure 1* Image Courtesy of NASA

## Europa

The next moon we are going to explore is Europa. Europa was discovered by Galileo in 1610. Europa is the second of the Galilean satellites. The Galilean satellites are the four satellites Galileo discovered orbiting Jupiter. Those four satellites were named Io, Europa, Ganymede, and Callisto. They were named after the four lovers and companions of the Greek god Zeus in Greek mythology. The Roman name for the chief god in mythology was Jupiter. Europa was a Phoenician princess who was abducted to Crete by Zeus. Zeus had taken on the form of a white bull. It is also Jupiter's fourth largest satellite. It is slightly smaller than the Earth's moon. It is similar in composition to the terrestrial planets. Europa is mostly composed of silicate rock. It has a thin outer layer of ice. The Galileo spacecraft recently sent back data that suggests Europa has an internal structure that is layered. It is also believed to have a small metallic core.

Europa's surface is unlike anything in our solar system. It is extremely smooth. There are few features that are more than 100 meters high that have been seen. Europa has very few craters. There have only been three craters larger than 5 kilometers in diameter that have been found. Scientists believe that this is an indication that Europa has a young and active surface. The precise age of Europa's surface is yet to be determined. The images of Europa's surface strongly resemble pictures of sea ice on Earth. *(See Figure 2)*

(image available in print form)

*Figure 2* Image Courtesy of NASA

The most striking feature of Europa is the series of dark streaks that criss-cross the entire moon. *(See Figure 3)* The larger streaks are about 20 kilometers across with diffuse outer edges and a central band of lighter substance. The most current theory of their origin is that they were produced by volcanic eruptions or geysers. Europa has been determined recently by the Hubble Space Telescope to have a weak atmosphere. Out of the many satellites in the solar system, only five others, Io, Ganymede, Callisto, Titan, and Triton are known to have atmospheres. The atmosphere of Europa is composed of oxygen, however, it is different from the oxygen in Earth's atmosphere. It is believed to not be biologic in origin. Scientists believe that the atmosphere is most likely generated by sunlight and charged particles hitting Europa's icy surface producing water vapor which is then split into hydrogen and oxygen. The hydrogen escapes leaving the oxygen.

(image available in print form)

*Figure 3* ImageCourtesy of NASA

There have been several spacecraft that have flown by Jupiter to give us more data about the Galilean satellites. Pioneers 10 and 11 flew by Jupiter in 1973 and 1974. They sent back images that were low in resolution but yielded tremendous amounts of data. Voyagers 1 and 2 flew by Jupiter in 1979. The Voyager spacecrafts sent back tens of thousands of images of much better quality than the previous Pioneer spacecrafts. The Galileo spacecraft was launched and entered into orbit of Jupiter in 1995. The Galileo spacecraft has produced the most extensive data yet of Jupiter and its moons. The Voyager spacecrafts did not get a good look at Europa. However, the Galileo's primary mission is to focus on Europa. Galileo's first two close encounters of Europa generated images that supported earlier theories that Europa's surface is very young. The images also showed that there is some sort of activity occurring. There are also images that show regions of Europa that look a lot like pack-ice on polar seas during the spring thaws on Earth. *(See Figure 4)*

Scientists believe that there is a layer of liquid water beneath the ice surface of Europa. Scientists believe that this subsurface ocean is anywhere between 50 and 100 kilometers deep.

(image available in print form)

*Figure 4* Image Courtesy of NASA

## Titan

Titan is the fifteenth and largest of the known satellites of Saturn. In Greek mythology, the Titans were a family of giants. They were the children of Uranus and Gaia and they sought to rule the heavens. They were overthrown and succeeded by the family of Zeus. Titan was discovered by Christian Huygens in 1655. It was originally thought that Titan was the largest moon in the solar system. This belief was held for a long time. Recent observations have revealed that Titan's atmosphere is so thick, that its solid surface is slightly smaller than Jupiter's Ganymede. Nevertheless, Titan is larger in diameter than Mercury and larger and more massive than Pluto.

Titan is composed of half water ice and half rocky material. It is believed to be distinguished by several layers with a 3400 kilometer rocky center. The rocky center is surrounded by several layers composed of different crystalline forms of ice. There are very few if any craters visible, which is an indication that the surface is very young. If there are any "lakes" they are more likely to be slushy than liquid. The basins are not filled with liquid at all times. The interior of Titan is still believed to be hot. The surface of Titan has a temperature of about 94 Kelvin. Water does not sublimate at this temperature. Sublimation is when molecules changes from a solid to a gas without becoming a liquid first. Thus, there is very little water vapor in the atmosphere. Scientists have made note that there is a lot of chemistry going on on Titan. This has resulted in a very thick smog.

Of all the satellites in our solar system, Titan is the only one that has a substantial atmosphere. This atmosphere is composed mostly of molecular nitrogen with no more than 6% argon and a few percent of methane. Interestingly, there are also trace amounts of at least a dozen other organic compounds such as ethane, hydrogen, cyanide, carbon dioxide, and water to name a few. The organics are formed as methane which dominates the upper atmosphere of Titan. It is destroyed by the sunlight which leaves this haze surrounding Titan which is very similar to the smog found over large cities on Earth but much thicker. These conditions are similar to the conditions on Earth early on its history when life was just beginning. It is this thick hazy, smog like atmosphere that makes it very difficult to see Titan's true surface. In addition to the deep smog like haze, there are scattered clouds in Titan's atmosphere. ( *See Figure 5)* These clouds are believed to be composed of methane, ethane, or other simple organic materials. It is believed that other more complex chemicals in small quantities must be responsible for the orange color as seen from space.

Titan was observed by the spacecraft Voyager1. One of Voyager 1's principal foci was Titan. Voyager 1 came within 4000 kilometers of the surface. In just a few minutes of observation, more was learned about Titan than in the previous 300 years. In late 2004, the Cassini orbiter spacecraft began to record data of Titan with many instruments. The Cassini orbiter had a series of close encounters with Titan resulting in all types of data. Then, in January 2005, the Cassini orbiter launched a probe named the Huygens probe. The Huygens probe actually

landed on the surface of Titan and sent back images from the surface of Saturn's largest satellite.

(image available in print form)

*Figure 5* Image Courtesy of NASA

Scientists are beginning to get an understanding of Titan's surface. They are combining all of the data that they are receiving from various resources. Large ground based observatories, the Hubble Space Telescope, the Cassini orbiter, and the Huygens probe have all combined to provide valuable data, but it is still incomplete. The Cassini orbiter has instruments that can penetrate the thick haze. It has a radar mapper that can see right through the haze and the Huygens probe shows the surface clearly. However, the Cassini orbiter images are very vague and the Huygens images are so few in number and only cover a very, very small area. There have been some exciting images that have been recorded. The Hubble Space Telescope has recorded a huge bright "continent" on the hemisphere of Titan that faces forward in its orbit. This "continent" has a preliminary name of Xanadu. There are some darker regions that suggest oceans or lakes. The Huygens probe has shown images of what could be drainage channels and possible shorelines.

## Why These Three Moons?

Our solar system is a wondrous place. It is filled with fantastic places to observe and hopefully one day visit. With Jupiter and Saturn and Uranus having so many moons, why focus on Titan and Europa as well as our very own Moon? One of the main goals of the unit is to compare moons that are very different in composition. The reason for choosing different types of moons is that I would like the students to build moon rovers that are customized for the terrain of each moon. One of the fourth grade science kits is called Motion and Design. The kit uses K'NEX™ pieces that students use to design their own vehicle. I would like to expand on that and use the pieces to build moon rovers. The idea is the class will build one together that can be used on our Moon. They will then be divided into groups of two and randomly choose either Europa or Titan. They will research the composition and terrain of their respective moons and build a rover that is customized for that moon. The students will then have to give a presentation about their moon rover and explain their design and elaborate on their choices and decisions.

## New Haven Science Standards

We have taken a tour of our solar system and learned about the history of early astronomy. How does this fit in with New Haven's Science Standards set for its students? The standards that follow are based partially upon the *Connecticut Science Standards* ; *the 1996 National Science Education Standards,* formulated by the National Academy of Science; and by additional standards developed by the American Association for the Advancement of Science. There were many good science standards that applied. Here are the standards that are most applicable that will be used to teach this unit in New Haven:

## Content Standard 4.0 Earth Science

Students will develop an understanding of the structures, properties and dynamic processes of the earth, the solar system, the universe and the galaxy; they will be familiar with the origins, evolution, movements and interactions of these systems.

## Content Standard 4.0 Earth Science-Performance Standard 4.1

Students will become familiar with the fundamental properties, structures and dynamics of the earth.

a. Students will recognize the composition of some of the earth's solid rocks and soils, water and gases of the atmosphere.
b. Students will identify and describe different properties of these materials, both physical and chemical, and how they are useful to humans.
c. Students will gain knowledge of the properties of soil and the dependence of plant life on soil.
d. Students will recognize the existence of fossils and how fossils provide important information about the history and evolution of life on earth.
e. Students will identify and describe physical structures and features of land and water, such as mountains, deserts, oceans and freshwater bodies.

**Content Standard 4.0 Earth Science -** Performance Standard 4.2

Students will demonstrate familiarity with fundamental concepts and principles that govern objects in the day and night sky.

a. Students will identify objects in the sky, such as the sun, moon, planets and stars; they will observe and describe their features and characteristics.
b. Students will recognize that the sun produces light and heat necessary to maintain temperatures we experience on earth.

**Content Standard 4.0 Earth Science -** Performance Standard 4.3

Students will recognize that the earth and sky change over time.

a. Students will perceive that the surface of the earth changes continuously and that these changes result from dynamic earth processes.
b. Students will identify different weather patterns from day to day and season to season.
c. Students will explore and describe weather by measurable quantities, such as, temperature, wind direction and speed, and precipitation.
d. Students will identify and describe the patterns of movement of objects in the sky from day to day and season to season.
e. Students will explain the characteristics and patterns of movement of the moon.

## Lesson Plans

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The following lessons can be used to demonstrate and illustrate various aspects of astronomy.

**Lesson 1 - The Ever Expanding Universe**

Purpose: This lesson will demonstrate how scientists know that the universe is expanding.

Materials: 5" or larger balloons (enough for each student), measuring tape, ruler, magic markers, observation sheet (Appendix A)

Procedure: Working in pairs, students will lay the deflated balloons flat and use the ruler and magic markers to make two dots that are 1cm apart. One student will blow up the balloon partially. The second student will use the tape measure and measure the distance between the two dots. This will be recorded on their observation sheet (See Appendix A). The first student will continue to blow the balloon up approximately half-way. The distance between the two dots will be measured and recorded. The first student will then blow the balloon up to its full capacity (without popping the balloon) and measure the distance between the two dots and record the findings. The students can switch places and the recorder will then blow up his/her balloon and the second student will record the results. The students will then analyze their results and discuss what happened and why. They will then record their conclusions from the discussion on the same sheet.

**Lesson 2 - The Phases of the Moon**

Purpose: This lesson will illustrate how the Moon goes through different phases. The activities can be done over the course of 2 or three days.

Materials: tennis balls, a globe, flashlights, a darkened room, chart paper, LCD projector, computer

Procedure: The lesson will begin with a word splash to introduce the students to new words that they may not know. The words are written on chart paper and each word is explained and pronounced so that the reading of the text will be understood. The words in the splash are:

waxing crescent - The Moon looks partly but less than one-half illuminated by the sun. The fraction that we see of the Moon's surface that is illuminated is increasing.
waxing gibbous - The Moon looks more than one-half but not fully illuminated by the sun. The fraction that we see of the Moon's surface that is illuminated is increasing.
waning gibbous - The Moon looks more than one-half but not fully illuminated by the sun. The fraction that we see of the Moon's surface that is illuminated is decreasing.
waning crescent - The Moon looks partly but less than one-half illuminated by the sun. The fraction that we see of the Moon's surface that is illuminated is decreasing.
orbit - to go around something in a circular or elliptical fashion
phase - a series of steps

To make it even simpler for the students to understand give the definition of each individual word. Such as: waxing is to get larger, waning is to get smaller, crescent means a sliver shape like a croissant or crescent roll, and gibbous means more than half.

The students should already be familiar with the basics of the Moon due to the reading of "If You Decide to Go to the Moon" by Faith McNulty (author) and Steven Kellogg (illustrator) from a previous lesson. This book does an excellent job of explaining what entails in planning and preparation if you decided to visit the Moon. Using the LCD projector that is connected to a computer that is connected to the internet, show a very short but informative animation that shows the Moon going through its different phases. It can be found at this website:

http://www.astro.uiuc.edu/projects/data/MoonPhases/index.html

The website is DATA (Demonstrations and Animations for Teaching Astronomy) was developed by the Astronomy Department at the University of Illinois. This website gives a very interactive way of explaining and showing how the Moon orbits the Earth. It allows you to step through each portion of the orbit, slow down or speed up the orbit. It also has an animated larger moon that tells the percent of the Moon that is visible and what phase the Moon is in. After showing the demonstration to the class there are two activities that can be

done.

1st Activity - Take the globe, the tennis ball, and the flashlight and have one student represent the Earth by holding the globe. Another student will represent the Moon by holding the tennis ball. Finally, the 3rd student will hold the flashlight representing the Sun. Holding the tennis ball slightly higher than the Earth, the student representing the Moon should be standing in a line with the other two students. The Earth should be in the middle, the student representing the Sun should be standing on the opposite side of the Moon shining the flashlight on the tennis ball. This represents a "Full Moon." The student holding the tennis ball should begin to walk around the Earth while keeping the same side of the tennis ball facing the Earth at all times. The side can be marked with an X to make it easier to keep the side facing the Earth. The student representing the Sun should continue to hold the flashlight in the original direction that the Moon started. When the Moon gets in front of the flashlight, this would represent the New Moon. The side of the Moon that is facing the Earth does not reflect any sunlight. The Moon can continue on its orbit until it is back where it started, representing a new full moon. The students can take turns being the Sun, Earth, and Moon. This activity can also be started as a new moon rather than a full moon. This should be done in a darkened room, the darker the better. There are other variations that can be done such as a solar eclipse when the Moon directly blocks the Sun and casts a shadow on the Earth or a lunar eclipse when the Earth blocks the Sun from the Moon and the Earth casts a shadow on the Moon. Students can then draw the phases as they observed them.

2nd Activity - Students can demonstrate the phases of the Moon in class or at home by taking a tennis ball, or similar sized ball, and holding it in front of a lamp with the shade removed. The lamp should be at one end of the room and the student should be at the other end. The student should hold the tennis ball up at arm's length in front of their face so that it is between their face and the lamp. This represents a new moon. They should then begin to move the ball slowly around their head from right to left. As the tennis ball "orbits" their head, they should be able to see it go through the same phases as the Moon. This works best in a very dark room with only one light source. Additional light causes multiple shadows which will make it harder to see the phases. Again, students can then draw the phases as they observed them.

**Lesson 3 - The Phases of the Moon, Past and Future**

Purpose: This lesson will allow students to identify phases of the Moon based on their birthdays.

Materials: computers connected to the internet, Moon sheet (Appendix B), gray or black crayons

Procedure: The students will be asked if they know what phase the Moon was in when they were born. They will then be asked if they know what phase the Moon will be in when they turn 30 years old. The students will understand that because the Moon orbits the Earth in a very predictable pattern, scientists can tell what phase the Moon was in in the past. They can also tell what phase the Moon will be in in the future. The students will be put into pairs and each given a sheet that has two pictures of the Moon. Their task is to access the U.S. Naval Observatory website which is located here:

http://tycho.usno.navy.mil/vphase.html

This is a virtual reality site that takes actual images of the Moon and shows the phase of the Moon for any date from 1800 to 2199. Students will have to input their birth date and see what phase the Moon was on that date. They will have to determine what the phase is. They will use the gray crayon to color in the Moon if necessary. The student will then have to calculate when they will be 30 years old and input that date. They will then follow the same procedure. The student will look at the phases of both Moons and write at the bottom

how the phases were similar or different. A variation of this can be to do their mom or dad's birthday or a sibling. This is especially if the phases are the same or very similar for when they were born to when they are 30.

## Appendix A

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Name _____

Date _____

**Directions:** Lay the deflated balloons flat and use the ruler and magic markers to make two dots that are 1cm apart. One student will blow up the balloon partially. The second student will use the tape measure and measure the distance between the two dots. Record the measurement below. The first student will continue to blow the balloon up approximately half-way. The distance between the two dots will be measured and recorded. The first student will then blow the balloon up to its full capacity (without popping the balloon) and measure the distance between the two dots and record the findings. Switch places and the recorder will then blow up his/her balloon and the blowing student will record the results. Analyze your results and discuss what happened and why. Record your conclusions from the discussion below.

Balloon | Partially Blown | Half Blown | Fully Blown

Measurement |

in cm |

What did you observe happening to the dots? _____

Why do you think this happened? _____

## Appendix B

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Name _____

Date _____

(image available in print form)

*Image Courtesy of NASA*

The date you were born:_____

What phase was the moon in? _____

(image available in print form)

*Image Courtesy of NASA*

The date when you will be 30:_____

What phase will the moon be in? _____

How were the two phases similar or different? _____

## Bibliography


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O'Shaughnessy, Tam & Ride, Sally *Exploring Our Solar System* , Random House Children's Book, New York. 2003

Kerrod, Robin, *The Universe and How it Works* , Barnes and Noble Books, New York. 1993

See Diane Huot, YNHTI 2005

StudyWorks! Science Deluxe CD Rom

www.nineplanets.org

www.jpl.nasa.gov

http://starchild.gsfc.nasa.gov

http://tycho.usno.navy.mil/vphase.html

www.astro.uiuc.edu/projects/data/MoonPhases/index.html

aa.usno.navy.mil/faq/docs/moon_phases.html

www.space.com

www.antiquetelescopes.org

www.cartage.org.lb

## Children's Resources

There are a host of children's books that are written to explain the solar system and even our universe in child friendly terms that are easy to understand. Here is a small sample of what is available. New books are being written all the time.


Beasant, Pam. *1000 Fact About Space* , Kingfisher Books, New York. 1992

Berger, Barbara. *Grandfather Twilight* , Philomel Books/Putnam & Grosset, New York. 1984

Bess, Clayton. *The Truth about the Moon* , Houghton Mifflin Co., Boston. 1983

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Branley, Franklyn M. *Floating in Space* , Harper Collins, NewYork. 1998

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Davis, Kenneth C. *Don't Know Much About Space* , Scholastic Inc., New York. 2002

Driscoll, Michael. *A Child's Introduction to the Night Sky* , Black Dog & Leventhal, New York. 2004

Gibbons, Gail. *The Moon Book* , Scholastic Inc., New York. 1997

Hamilton, Virginia. *In the Beginning: Creation Stories from Around the World* , Harcourt, Brace, Javonovich, San Diego. 1988

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McNulty, Faith & Kellogg, Steven. *If You Decide to Go to the Moon* , Scholastic Press, New York. 2005

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Reid, Struan. *The Usborne Book of Space Facts* , Scholastic Inc., New York. 1987

Riley, Peter. *Straightforward Science: The Earth in Space* , Franklin Watts Publishing, Danbury, CT. 1999

Simon, Seymour. *Einstein Anderson Lights Up the Sky* , Viking Press, New York. 1982

Singer, Marilyn. *Nine O'Clock Lullaby* , Harper Collins, New York. 1991

Stott, Carole. *I Wonder Why Stars Twinkle and Other Questions About Space* , Kingfisher Books, New York. 1993

Sweeney, Joan. *Me and My Place In Space* , Scholastic Inc., New York. 1998

Thurber, James. *Many Moons* , Harcourt, Brace & World, New York. 1943

Vogt, Gregory. *Solar System Scholastic Science Reader Level 2* , Scholastic, New York. 2002

## Adult Resources

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In addition to the books and websites listed in the bibliography, here is a list of resources that teachers or parents can read to help their child learn more about astronomy. This is especially important for parents because the time that the students will be observing the nighttime sky is when they will be with their parents. School starts during the day and ends while there is still daylight. Encouraging parents to become an important part of their children's lesson empowers them to take a more active role in their child's education. This allows parent and child to take a space exploration together! Again, this is just a small fraction of the many wonderful books and websites that are available.

Carson, Mary Kay. *Space: Quick & Easy Internet Activities for the One-Computer Classroom* , Scholastic Inc., New York. 2001

Moore, J.E. & Evans J. *Sun, Moon and Stars* , Evan-Moor, Monterey, CA. 1986

Rogers, Kathy. *Stars & Planets: An Integrated Unit of Study* , ECS Learning Systems, San Antonio. 1993

Stone, Stacie. *Our Spectacular Solar System* , Copycat Press, Racine, Wisconsin. 1995

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Weiner, Wendy. *Science: Hands-On Minds-On Science* , Teacher Created Materials, Inc., Huntington Beach, CA. 1994

Zike, Dinah. *Science Pocket: The Solar System* , Ideal School Supply Co., Oak lawn, IL. 1987

See Yale New Haven Institute for related units by Diane Huot, Michelle Murzak, Marisa Ferrarese, Waltrina Kirkland-Mullins, Roberta Mazzucco, Julia Biagiarelli, Jennifer Esty, Larissa Giordano, Sam Jones, Nicholas Perrone, Hermine Smikle, Kenneth Spinka, and Maria Stockmal

www.abcteach.com

www.enchantedlearning.com

www.learningpage.com

www.exploratorium.com

http://neo.jpl.nasa.gov/neo/

## Notes

1. Professor Sarbani Basu Lecture 5/8/07

2. Roger Freedman and William Kaufmann, *The Universe* (New York: W.H. Freeman and Company, 2002) pg. 153

3. Freedman and Kaufmann pg. 153 and www.nineplanets.org

4. www.antiquetelescopes.org

5. www.cartage.org.lb

6. www.antiquetelescopes.org

7. www.cartage.org.lb