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# Is There Life Out There?

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## Introduction

Being reared by a single mother with only a tenth grade education, I can say that it was my mother who influenced me along the paths that I have taken in life. Throughout my primary school years, I struggled academically. In order to ease my educational hardships, I was placed in Chapter I classes. These classes were implemented to help lower achievers stay focused academically and socially. Upon entering middle school, I was mainstreamed into regular education classes. It was my sixth grade science teacher, Mrs. Simmons, who sparked my curiosity in the field of science. She was the teacher that I yearned for as a child. It was the way she explained difficult concepts using a hands-on approach when teaching science to all of her students that I particularly enjoyed. I can remember having to remain in class during break time and after school just to complete assignments for Mrs. Simmons. She was always determined to make sure that all of her students felt successful in her science class.

The yearning to become a teacher seemed to evolve from the paths that I traveled throughout my life. My mother embedded in me the importance of developing a thirst for knowledge, and to work towards getting a quality education. In fact, my most memorable recollections are of times when "teachable" moments took place right at home. Spelling tests, oral book reports, current event discussions, lectures, etc. often occurred around our kitchen table. I grew up realizing that education truly started at home. Though I lived in a single parent home, I grew up with a parent who cared and made me try my best at whatever I was doing. I've never forgotten this, and how important this continues to be in my life. I feel that my life could have easily been like so many of my students: no real guidance or support, no one to teach the value of hard work and determination, or no one to encourage and cheer for you. These things are a few of the essentials that a teacher must be willing to provide to promote student success. I know that I have a lot of love and encouragement to give my students and that teaching is my gift.

Finally, my approach to teaching is not wrought from formal coursework in pedagogical technique, but rather by my own experiences. Like most educators, I have learned that a teacher can make the critical difference in how a child is perceived. I have been fortunate to have had excellent teachers, like Mrs. Simmons, throughout my academic development. I hope to be remembered by my students as a teacher who ignited an interest in science beyond the confines of the classroom.

## Student Demographics

I currently teach eighth grade science in a middle school setting within the inner-city of Atlanta, Georgia. Luther Judson Price Middle School is a Title I school with around 900 students enrolled in grades 6 $^{th}$ through 8 $^{th}$ . In my school setting, the majority of the students are African-American raised in single-parent homes (mostly by a grandmother). The racial analysis is about 95% Afro-American, 3% Hispanic, and 2% White, with more than 90% of the students receiving free and reduced lunch. These students live in project housing and the father is usually absent from the home. The neighborhoods are riddled with crime and drugs and there is a high rate of teenage pregnancy. Home visitations are common for me because I see a lot of my childhood years through the eyes of my students. If I am not willing to go over and beyond for my students, "who will"? When teaching astronomy to these groups of students, I must keep in mind that the only foundation that they have in this area is from annual field trips to the Atlanta Planetarium. For example, if I asked my students how the planets were created, many would probably answer "by God".

## Rational

Since I've been teaching 8 $^{th}$ grade Earth Science in the Atlanta Public School System, I have noticed that many of my students have complained about the idea of learning about the history of our Solar System. This unit is created to help encourage the need for more inner city children to consider the field of space research as a possible career choice. I have created this unit in hopes that it will enhance my students' knowledge of space science. If presented as an inquiry-based approach, the use of information can greatly affect a person's mind and way of thinking. In this unit I plan to succeed in peaking my students' interests in space science, hopefully persuading them to further enhance their knowledge of space science, with the intent that this then will lead to an interest in a scientific career later in their lives.

This interdisciplinary science unit is designed to allow students to make predictions, qualitative observations and discoveries about the Solar System through experimentation and exploration. The unit will involve hands-on activities which engage students and encourages them to think about and question the abundance of life throughout our Solar System. Furthermore, this interdisciplinary science unit incorporates mathematics and language arts for a more complete understanding and appreciation of the Solar System.

## Objectives

In this unit, students will broaden their understanding of our Solar System and Universe. Students will extend their understanding of planets and stars to include the structure, and age of our Solar System. They will continue to develop their scientific inquiry skills by gathering and synthesizing information from teacher recommended websites and other sources about how our Solar System was formed. The driving force of this unit will be addressed through the "Georgia's Quality Core Curriculum Standards and Objectives" in the field of

Astronomy which states the students will: **Standard #21:** Describes the components of the Solar System. **Standard #22:** Identifies and describes stars and star systems. **Standard #23:** Compares and contrasts theories on the origin of the Universe. **Standard #24:** Describes how information is obtained about space. **Standard #25**: Describes the history of the space program and examines its effects on our lives. **Standard #26:** Describes the relationships of the motions between the Sun, Moon, and Earth.

## Teaching Strategies

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The major thrust of this unit is to have my students work towards mastering critical thinking skills. Essentially, I plan to promote interaction among the students by including learning in cooperative group settings often. This will allow each member to achieve more. Discussions will be lead by asking open-ended questions that do not assume the correct answer. Critical thinking is often demonstrated best when the problems are naturally clear and do not have a correct answer. Open-ended questions also encourage students to think and respond creatively without fear of giving the wrong answer. Sufficient time must be allowed for students to reflect on the questions asked or problems posed. Critical thinking seldom involves quick judgments. Therefore, posing questions and allowing ample time before seeking responses helps students understand that they are expected to reflect and to consider, and that the immediate response is not always the best response. Teaching so that all students will be able to transfer the information through using critical thinking skills is a must. Therefore, I must provide opportunities for students to see how a newly acquired skill can apply to other situations and to the student's own experiences. Throughout this unit, multiple assessment techniques such as writing, group work, discussions, demonstration models, and real life problem solving will be used to assess student mastery of the material presented.

## Cross-Curriculum Connections

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**English Language Arts**

When reading informational texts, students extract data about the formation of our Solar System and practice literacy skills in the preparation of reports. Students can read informational texts about science and science fiction stories and distinguish between them.

**Mathematics**

When students study the celestial sphere grid system, they can apply their knowledge of coordinates.

**Social Studies**

When studying the history of human description of the Universe students can consider the relationships among science, religion, and government.

## Overview

In years past, the likelihood of life beyond the Earth was a topic usually set aside for science fiction writers. Today, scientists from a variety of fields are seriously considering the idea that "life" may have existed in other places in our own Solar System.

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 "The word "life" means any type of organism with the same (or closely similar)
physical and chemical make-up as living things on Earth; it has been assumed that
the range of conditions for active life that is found for Earthly creatures can be
applied outside the Earth. It is… possible that this is true, that any form of
activity that could be called "life" in a wider sense can occur only within the
narrow range of conditions found on the Earth and its neighboring planets. But it
is equally possible that the life forms that we find on Earth are just those that
have evolved and developed because they are suited to Earthly conditions; forms
that have remained primitive on Earth might, in the conditions on a different
planet, have evolved and developed." (Ovenden 75)
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The recent study of life in the Universe, Astrobiology, has sparked new philosophical theories. One theory addressed by David Darling in *The Maverick Science of Astrobiology* projects "... the view that life may be able to adapt to all sorts of bizarre extraterrestrial regimes, perhaps including some that are on neighboring worlds in the Solar System. " (Darling 53) Over the past twenty years, some scientists have begun to look at the possibility that life may exist outside Earth. Life has been found flourishing in some unexpected places. Microscopic organisms have been found in deep sea volcanic vents and hot springs with almost boiling water. They have also been found in the frozen lakes of Antarctica and within rocks deep under the surface of the Earth. Life has proven to be surprisingly adaptable and robust. These life forms have been denoted as "extremophiles".

My students must understand that, as Earth was first formed, it was an extremely hostile place. Realizing that the large impact craters on the Moon, and other planets and moons in the Solar System, are proof of a time when the planets were common targets for large asteroids and comets. This is important because students tend to think that this was the way that the planets and moons were created not realizing that they were often subjected to collisions with sometimes very large interplanetary objects. The energy released by the largest of these impacts could have been capable of boiling the oceans into a thick steam atmosphere and sterilizing the surface of the Earth, keeping in mind that something like this is what probably caused the extinction of the dinosaurs. The scars of this atrocious time, which are still shown by the Moon, were erased long ago from the surface of the Earth by our ever-evolving planet. Fossil evidence in the form of simple organisms living 3.5 or even 3.8 billion years ago indicates that life apparently began on Earth almost immediately after the sterilizing impacts had ended. Students must be able to realize that this new life started as small microscopic life and eventually evolved into more complex forms of life. Collectively, the discoveries of life in extreme environments and the evident speedy source for life on Earth contend that life may be plentiful in the Universe and may exist or have existed elsewhere in our own Solar System.

## Background

Understanding the concept, when scientists consider the question of life on other worlds within our Solar System, they are thinking of microscopic bacteria-like life rather than multi-cellular plants and animals. Life as we know today, such as human life, is not the kind of life that scientist are searching for beyond Earth in the Solar System. It is microorganisms, rather than large, complex life forms, that are able to live in extreme environments. On Earth, microorganisms were the only form of life for billions of years. So what does life, any form, need to be able to survive on the Earth and elsewhere in our Solar System? Life requires a few basic things in order to survive, grow, and reproduce which include liquid water, a source of energy, and a breathable atmosphere although some anaerobic bacteria can dispense of the latter. Liquid water can be present in small amounts, but every thing we know about life on Earth suggests that access to some liquid water is essential. Sunlight makes a good energy source for life on Earth.

Although our own food supply is entirely dependent upon plants using the process of photosynthesis, many communities of microorganisms on the Earth thrive off the energy produced by natural chemical reactions that occur between water and rock, frequently in the presence of hot water such as in the vents at the bottom of the ocean. Rocks, water, and gases from the atmosphere or interior of a planet can also provide the elements necessary to generate living organisms.

Although the evidence for past life on Mars from Martian meteorites is still considered inconclusive by most of the scientific community, the announcement a few years ago of the discovery of evidence for past life in a Martiam meteorite found in Antarctica fueled a renewed interest in the idea of life on Mars. The announcement came about because of Mars' active volcanic history, as well as evidence that water did exist there in the past. Mars is a promising candidate in the search for life beyond the Earth. Of all the other planets in our Solar System, Mars is the most Earth-like in many respects. Despite the similarities between our world and our celestial neighbor, the surface of Mars is cold, very dry, and unlikely to support life. Billions of years ago, water flowed on the surface of Mars, indicating Mars had a wetter, and probably warmer, climate. However, in the present atmosphere of Mars, the melting and boiling temperatures of water are both zero degrees Celsius, so liquid water cannot exist. Despite the inhospitable surface, the discovery of life in extreme environments on the Earth suggests that life could also live underground on Mars today. The Martian subsurface probably contains a significant amount of water ice, and "perhaps" liquid water, which cannot exist on the surface. The presence of past volcanoes on Mars, which could melt ground ice and circulate water in the subsurface, would have provided an excellent environment for microorganisms. At very least, in the past, Mars has had all of the requirements for life that includes liquid water, an energy source, and the chemical building blocks of life.

Another possible candidate for life in the Solar System is the ice-covered moon Europa. Though it is slightly smaller than our own Moon, Europa is a major moon of Jupiter. The appearance and youth of the surface suggest that an ocean of liquid water may exist below a frozen shell of ice. If so, Europa fulfills one of the major requirements for life, which is access to liquid water. Below the surface of ice, and possibly ocean, Europa is a rocky moon. Even if an ocean no longer exists on Europa, it almost certainly did in the past. This leads scientist to understand that there could not be life on Europa.

The smog covered world of Titan, the largest moon of Saturn, is larger than the planets Mercury and Pluto. Titan is the only moon in the Solar System with a thick atmosphere; the surface pressure is more than one and a half times greater than that of the Earth's atmosphere at sea level. Titan is a fascinating world, but is it possible for life? The answer would have to be no because life must have liquid water to survive. Mars and Europa remain the best candidates beyond the Earth for finding either extinct or possibly living life in our Solar System. The atmosphere of Jupiter, which has water clouds and some organic molecules, has also been suggested as a place where life could exist. However, access to the chemical building blocks of life is limited and the unstable nature of the atmosphere would likely destroy any organisms that might be present. It is also possible that life could once have existed on Venus which is now a dry world with a surface temperature hot enough to melt lead. Unfortunately, any traces of ancient life would have been long destroyed by the completely hostile environment leaving no evidence that life ever existed on our neighboring planet. Io, the volcanically active moon of Jupiter, also may once have had water and the possibility for life like Venus, any water Io possessed in its past is now long gone and no traces of life can be expected to be found.

When faced with the question, "what about life beyond the Solar System?" Astronomers are searching for extra-solar planets and are developing instruments and techniques to make planets like those in our Solar System easier to detect. NASA is also planning space-based missions, which may have the chance of not only detecting Earth-like planets around other stars but also of gathering information about the atmospheres of such planets. Life has changed the composition of the Earth's atmosphere over time. Examining the atmospheric composition of an extra-solar Earth-like planet may allow us to detect life on distant worlds. Planetary systems around other stars hold the promise of not only microscopic life, but perhaps larger life forms. Of course, if technologically advanced life were to exist on planets beyond the Solar System, they could be sending out radio messages indicating their presence. It is that possibility that is being pursued by means of radio searches for intelligent signals such as the SETI (Search for Extra Terrestrial Intelligence) project.

Most scientists believe the Solar System began as a cloud of dust and gas. Gravity pulled the cloud in, making it smaller and denser. As it shrank, the cloud heated up and the Sun formed. The outer region of the cloud flattened out and shaped into a disc, which spun around the new Sun. Particles of gas and dust within the disc bumped each other, which made them stick together and form large lumps. These lumps grew into planets, all of them revolving around the Sun. One group of rocky lumps never grew into planets and these are what we call asteroids, or perhaps they did, but a large collision broke it up.

Our Sun is a star. It is the star closet to the Earth. It is the star we see in the daytime. It is the center of our Solar System. The Sun is so big that more than a million Earths would fit inside it. It looks small because it is so far from Earth. Like all stars, our Sun is a ball of very hot gases. It gives off light and heat. The Sun makes energy in its center. Nuclear conversions of Hydrogen into Helium take place, releasing energy. The outermost 30% layer of the Sun is boiling gases. This is why the Sun looks like a ball of fire. We couldn't live without the Sun. It gives us heat to stay warm. It gives us light to see by. Plants need the sunlight too. It helps plants make food for us to eat and Oxygen for us to breathe.

Mercury is the nearest planet to the Sun and is also the smallest, except for Pluto. It can be seen for a short time just before sunrise or after sunset because it is so close to the Sun. Mercury has almost no atmosphere. With no air, and no clouds, the weather forecast on Mercury would be very simple; unbearably hot by day and freezing cold at night.

Venus is easy to see in the sky because it is very bright. Only the Sun and Moon are brighter than Venus. Venus is often called the sister planet to the Earth. It is almost the same size as the Earth and the nearest planet to us. But thick clouds completely cover it. The thick atmosphere makes Venus a very dangerous place to explore. This is because it mainly consists of a gas called carbon dioxide which we cannot breathe. It also traps the heat so that Venus is much hotter than Mercury, but on its entire surface.

Earth is a beautiful blue planet with white swirling clouds and is unique in many ways. This is the planet where humans live in. It is the only planet that has liquid water on the surface. About two-thirds of the Earth is covered with oceans of water. In colder parts, the water freezes into ice and there are droplets of water in the clouds. Most elements of the Earth are very rare including Nitrogen and Oxygen. The abundance of Noble Gases is low and do not combine with any other elements which leads to an element being lost. Earth coupled with water of volcanic activity emits Oxygen, Carbon Dioxide, and Water Vapor. This allows more CO2 to be released into the atmosphere which causes Earth's temperature to rise. Most of the CO2 is absorbed by rocks and some by the trees of Earth. Every time a tree dies the CO2 is released back into the atmosphere.

Mars has a thin and wispy atmosphere made almost entirely of carbon dioxide. At the north and south poles of Mars, there may be ice-caps. This kind of ice is known as dry ice. The surface of Mars is a stony desert with sand that is so tiny that you would need a microscope to see them. The winds of Mars easily stir up vast dust storms, which cause the pinkish glow in the Martian sky.

Asteroids are small, have very little gravity, and are hard to see in space because their rocky surfaces don't reflect a lot of light. The space between Mars and Jupiter is filled with a population of irregularly shaped chunks of debris called asteroids. Objects in this asteroid belt are made of rock and metal, mostly nickel and iron. Scientists believe the asteroids are pieces of a planet that never formed on a planet that broke up. An ongoing gravitational tug-of-war between Jupiter and Mars may have prevented the pieces from bonding together. Other asteroids are not part of this belt and some have paths which cross the Earth's orbit.

Jupiter is not a solid planet. Unlike the solid planets closest to the Sun, Jupiter is a huge ball of gas. Jupiter rotates very rapidly, once every ten hours. This is so fast that the planet bulges at the equator. The rapid rotation also causes high wind speeds in the upper atmosphere, where the clouds are stretched out into colorful bands. Different parts rotate at slightly different rates, and this speed difference causes the bands and their various colors.

Saturn is a frigid world, with a cloud composition and a wind system similar to that of Jupiter. Saturn's beautiful rings do not touch the planet. The rings are tilted at a 29% angle. This means that they slowly change their appearance when viewed from Earth. The rings are mainly made of billions of tiny particles and each speck is orbiting Saturn. They all orbit the planet as if they were unrelated satellites.

Uranus is mainly made of hydrogen and helium, but one-seventh of its atmosphere is methane. This gas makes it appear bluish in a large telescope. The axis of Uranus is tilted by more than a right angle, which means its north pole actually points below the planet's orbit. This gives Uranus rather strange seasons. One pole faces the Sun and has a constant sunlight for about forty years. This end of the planet then goes into complete darkness for about another forty years while the other pole of the planet faces the Sun. It also appears to rotate backwards, in the opposite direction of all other planets.

Neptune is a similar planet to Uranus, though it is not tipped over on its side and is a little smaller than Uranus. Like Jupiter, Neptune has a wind spot, although Neptune's is darker. There is also a smaller dark wind spot that turns around in the opposite direction to the larger one. Both of the wind spots are swept along by winds blowing as fast as 2,100 km an hour, the fastest winds in the Solar System.

Pluto, the farthest planet from the Sun, is an oddity. It is the smallest of all the planets, smaller than our Moon and less than a third as big as the largest moons in the Solar System. We do not know very much about Pluto because it is very small and very far away. Pluto is the only planet that has never been visited by a space probe from Earth.

Occasionally a strange "star" seems to appear bright in the night sky, only to disappear a few weeks later. This is not really a star. It is a comet. Actual stars are made of gas. Nevertheless, comets are large lumps of snow and dust, more like enormous dirty clumps of snow than stars. Comets may look bright, but unlike stars they do not make their own light. Comets are seen only when they come close enough to the Sun for its light to shine on them. When a comet does get close to the Sun, its snow becomes extremely hot and turns into a glassy cloud that streams out behind the shooting comet and is known as the tail of the comet.

## Lesson Plans

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**Lesson #1: How Much Rock is in an Icy Moon?**

***Purpose***

Students will calculate the percentages of rock and ice in the moons of the outer planets.

***Background***

This activity teaches simple calculations and graphing, and how to use data from a graph. The idea is to figure out the percentages of rock and ice in a number of the satellites (moons) of the outer planets (Jupiter, Saturn, Uranus, Neptune, and Pluto). The students construct a graph of the amount of rock versus the density of the moon, using a simple equation. They then determine the percentage of rock from the densities of several moons and enter the answers in a table.

There are some hidden assumptions in the exercise that you may wish to discuss with the students. One is that we know the densities of rock and ice. The activity assumes that rock has a density of 3.5 grams per cubic centimeter. This is reasonable for the rocks that make up the interiors of the planets and most asteroids. However, if the rocks contained significant amounts of water bound in their minerals, a density of 3.5 would be too high. If the rocks averaged 2.5-3.0 grams per centimeter, typical of many water-bearing minerals such as clays, the calculation would underestimate the percentage of rock in each moon. Unfortunately, how much water is contained in the minerals of the icy satellites is not known. Also, in the larger satellites (and in planets), rocky materials are compressed deep inside them, making minerals with higher densities than they have at low pressures. This causes the average density to be higher than 3.5, and would translate to a smaller percentage of rock. We also use the density of water ice, but it is possible that some of the moons contain some other "ices," such as ammonia. Nevertheless, water is certainly the most abundant ice in the satellites. The activity ignores these complications, and to a first approximation, the answers are accurate.

Ice and rock could be distributed inside a satellite in a number of ways, such as chunks of rock in a matrix of ice. However, because ice behaves in a plastic way (it flows, like it does in glaciers), the rock will fall through it, accumulating in the centers of the icy satellites. The fact that many of the icy satellites heated up to the melting temperature of water helps smooth the way for the rock to fall to the center. It goes to the center, of course, because it is denser than the ice. So, a drawing of an icy satellite would have a rocky core surrounded by an icy mantle.

*In Class*

The graph could actually be constructed by calculating the densities of a moon when the percentage of rock is 0 and when it is 100, and connecting the points by a straight line. Some alert students may mention this when they notice they are plotting up a perfectly straight line.

*Extensions*

As an extension, students could be asked to draw the interior of one of the icy satellites, to scale. This is tricky: the graph gives the percentage by volume, which would need to be converted to percentage of radius. Volume is related to the radius cubed, so the rocky core extends outward much further than you would expect. For example, Earth's metallic core is only 1/8 its volume, but extends from the center of the planet to half its radius (the cube root of 1/8). Thus, if a satellite is half rock and half ice by volume, the decimal fraction of its radius taken up by its rocky core is 0.79 (the cube root of 0.5, or 1/2). That is, 79% of the satellite's radius is rocky core, and the remainder is ice. A satellite that is only 25% rock by volume has a rocky core that occupies well over half its radius, 0.63 (or 63%).

On Earth and the other planets, ice is not a constituent of the interiors. Instead, metallic iron is present in their cores. The percentage of rock can be calculated the same way as for an icy satellite, using the percentage and density of iron instead of ice. However, the density of rock is too low to make accurate predictions because rock compresses quite a bit deep inside the inner planets.

*The Fun Extension Using Algebra*

Finally, for classes where students have taken some algebra, an interesting extension is to determine the percentage of rock in one satellite. This puts a little algebra into a more interesting context than figuring out the time when a train leaving Chicago going 60 miles an hour will meet up with a train leaving Kansas City traveling 45 miles per hour and how far they will be from Chicago.

The suggestion is to calculate the percentage of rock in Callisto, which has a density of 1.8 grams per cubic centimeter. The students can start with pretty much the same equation used in the exercise:

$D = (3.5X+0.9Y)/100$

where D is the density of the moon, X is the percentage of rock, and Y is the percentage of ice. (The 100 is there to convert the percents to fractions.) The constants 3.5 and 0.9 are simply the densities of rock and ice, respectively.

The problem is that we have one equation with two unknowns. This dilemma can be solved by a substitution. Because we have only two components, rock and ice, the percentage of one is 100 minus the percentage of the other:

$$Y = 100-X$$

Substitute this into the equation:

$$D = [3.5X+0.9(100-X)]/100 \quad D = (3.5X+90-0.9X)/100 \quad D = (2.6X+90)/100$$

We know that D, the density of Callisto, is 1.8, so

$$1.8 = (2.6X+90)/100$$

Multiplying both sides by 100,

1. 2.6X+90
2. X = 180-90 2.6X = 90 X = 90/2.6 X = 34.6

Jupiter's satellite, Callisto, is 34.6% rock.

Students can then check to see if it agrees with their result from the graph. You can also check the result for pure rock (D=3.5) and pure ice (D=0.9).

**Lesson #2: How Much Do You Weigh?**

***Purpose***

To understand that weight is a measure of gravitational attraction and that this force is not the same on each planet.

*Background*

Gravity is a universal, natural force that attracts objects to each other. Gravity is the pull toward the center of an object; let's say, of a planet or a moon. When you weigh yourself, you are measuring the amount of gravitational attraction exerted on you by Earth. The Moon has a weaker gravitational attraction than Earth. In fact, the Moon's gravity is only 1/6 of Earth's gravity. So, you would weigh less on the Moon. How much would you weigh on the Moon and on the other planets?

*Procedure*

1. Write your weight (or an estimate) here:
2. For a different planet, multiply your weight by the number given in the "New" Weight Chart.

Example for the Moon - for a person weighing 60 pounds on Earth: 60 x 1/6 = 10 *A 60 pound person would weigh 10 pounds on the Moon!* This example uses weight in pounds, but you can do this activity using any unit you wish.

3. Follow the example and fill in the blanks in the "New" Weight Chart. Show your work.

**"New" Weight Chart**

| Planet | Multiply your Earth weight by: | Your "new" weight |
|---|---|---|
| Mercury | 0.4 | |
| Venus | 0.9 | |
| Earth | 1 | |
| Moon | 0.17 | |
| Mars | 0.4 | |
| Jupiter | 2.5 | |
| Saturn | 1.1 | |
| Uranus | 0.8 | |
| Neptune | 1.2 | |
| Pluto | 0.01 | |

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*Extensions*

An extremely nice on-line activity to calculate your weight on the planets and moons is available at . Another on-line activity with a fill-in table is available at , from NASA Goddard Space Flight Center.

Question: Where do the multiplication factors come from? Answer: Each number is the gravitational attraction, relative to Earth's, of each planet in our Solar System. Remember, gravity is the force of attraction between two objects and is influenced by the mass of the two objects and the distance between the two objects. You can use any unit you wish for your weight.

The "New" Weight Chart can be built as a spreadsheet; thus adding database-computer skills into the activity. This great idea was shared by Mary L. Wyatt, University of Michigan-Dearborn, School of Education. [7 DEC 1999]

**Lesson #3: Lunar Life Support**

***Purpose***

Students will design and build models of life support systems for a settlement on the Moon.

*Background*

A future lunar base will have to be a self-contained habitat with all the life support systems necessary for the survival of people, animals, and plants. In this series of activities, the students will be designing and building models of nine life support systems which are crucial to our successful settlement of the Moon.

The nine life support systems are:

- Air Supply Student Pages.
- Communications Student Pages.
- Electricity Student Pages.
- Food production and delivery Student Pages.
- Recreation Student Pages.
- Temperature control Student Pages.
- Transportation Student Pages.
- Waste management Student Pages.
- Water supply Student Pages.

*Preparation*

Review and prepare materials listed on the student sheets. Separate student activity sheets are included for each of the nine life support systems. Spaces for answers are not provided on all sheets, so students will need extra paper.

*In Class*

After dividing students into teams, you may want to have each person assume a role on the team, e.g., organizer, recorder, researcher, builder, artist, writer, etc. Distribute a student activity sheet to each team.

Each team must define the requirements of their system, exploring how these requirements are currently being met on Earth. Team members will research the limitations and/or opportunities posed by the Moon's environment.

The and maps of the Moon should be used as resource materials.

Each team will decide how the system will operate and what it will contain. A key part of the problem-solving process is the students' ability to evaluate the system solution in terms of whether it provides the greatest good and least harm to the persons and things affected.

Each model of a life support system must incorporate at least four facts from the "Moon ABCs Fact Sheet."

Models do not have to function physically, but each team member must be able to explain how the models should function.

*Wrap-up*

Have each team share what they have learned with the entire class.

1. Did the students find that the Moon's environment placed limits on their designs of life support systems?
2. Did the students find opportunities for development on the Moon that could not happen on Earth?
3. Summarize the aspects and conditions of the Moon which make life support such a challenge.

## Bibliography

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### Works Cited

This resource was used to explore the possibility of life beyond Earth.

This resource was used to explore events and facts about our Universe.

### Teacher Resources

This resource was used to explain the birth of the stars.

This resource was used to understand the research of Space Science.

This resource was used to lay a framework for the study of science.

This resource was used to better understand the "politics" of Space Science.

***Holt, Rinehart, and Winston***. Holt Science & Technology: Earth Science. Austin, Texas, 2001.

This resource is the actual science textbook and teacher's edition guide.

This resource was used for a deeper understanding of the Universe.

This resource was used to help explain what is known about our Universe.

This resource was used to help bring in real-world examples about our Universe.

### Student Resources

NASA's Solar System Exploration. May 1999. NASA. 21 April 2001 http://sse.jpl.nasa.gov/.

Fun and exciting website for students to learn about space exploration.

Planets. October 1999. SEDS. 21 April 2001 http://seds.lpl.arizona.edu/ Solar-Max. 1999. NASA.

21 April 2001

http://sunearth.gsfc.nasa.gov/.

Students can gain a wealth of knowledge from participating through this website.

Solarviews. 1995-2000.

Calvin J. Hamilton. 21 April 2001

http://solarviews.com/eng/homepage.htm.

Wonderful website for teacher-lead instruction in class.

### Websites (All lesson plans are from the following websites)

Lesson Plan #1

http://www.spacegrant.hawaii.edu/class_acts/RockyIcyMoonTe.html

Lesson Plan #2

http://www.spacegrant.hawaii.edu/class_acts/Weight.html

Lesson Plan #3

http://www.spacegrant.hawaii.edu/class_acts/LunarLifeSupport.html

*Unless otherwise noted, all science facts and information in this unit were taken and combined from Barrow (1994), Maxwell (1998), and Holt, Rinehart and Winston (2001). I synthesized this information gearing it to meet the needs of the learners that I teach on a daily basis.