Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
2005 Volume IV: The Sun and Its Effects on Earth

The Sun in Our Lives

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The unit entitled: *The Sun in Our Lives* is to be used in a third grade class as part of the science curriculum. Part of the reason for creating the unit is to fill in the gaps in the New Haven science curriculum. The science curriculum in New Haven consists of a set of standards and a few science kits at each grade level. These kits cover a limited number of the required topics. Presently, our third grade curriculum consists of two kits: one on plants, and the other on chemicals or white powders. For the rest teachers are left to come up with their own materials. In many cases this does not happen consistently resulting in the fact that science is either overlooked or done in a haphazard way. While the Earth and its place in the solar system is part of the curriculum there are no specific materials available to teach this subject. Creating this unit will give me the opportunity to develop a thoughtful way of presenting the material to my students.

The unit is organized around a group of questions. It helps both my students and me to focus on our goals for learning. The following is an outline of the unit:

I. Where did the Sun and planets come from?
II. How is a star born?
III. What is the anatomy of the Sun?
IV. How does the light and heat from the Sun help us on Earth?
V. Why do we have night and day and the seasons?
VI. How does the Sun affect the weather?
VII. What is the future of the Sun?

In teaching the unit hands on activities will be stressed as a way to help students understand the concepts as well as to increase their interest and excitement in the unit. Connections to other areas like reading and writing will be made through the use of appropriate level science texts, creative writing, and report-writing opportunities. Students will use science journals to record observations and the results of experiments that are completed. I also hope that students will do a culminating project which they can share with other classes in our school.

Where did the Sun and the planets come from?

What is now believed to be the story of how our universe and everything in it including our solar system came into being is referred to as the "Big Bang Theory." One of the things I think is important to point out to students is that scientific theories are not just off the top of your head speculation. That is they may start out as that but for them to have any credibility they must reflect and take into consideration what information is already known. As was pointed out in some of the readings the development of the Big Bang theory had to take into account what was scientifically accepted as characteristics of the universe.

Three of the most important ideas that any theory that explains the formation of the solar system would have to explain would include:

> 1. The terrestrial planets (Mercury, Venus, Earth , and Mars) which are composed of rocky substances and are relatively small compared to the larger Jovian planets (Saturn, Jupiter, Uranus, and Neptune,) are compose primarily of hydrogen and helium. Pluto belongs to neither category and is icy.
> 2. All of the planets orbit the sun in the same direction and in the same plane.
> 3. The terrestrial planets orbit close to the sun and the Jovan planets orbit a greater distance away as if in their own subgroup.(1)

The Big Bang Theory suggests that the universe began some 13.7 million years ago.(2) In his book *The First Three Minutes,* Steven Weinberg describes near the beginning of the universe when the temperature was at 100,000 million degrees Kelvin. The universe was "filled with an undifferentiated soup of matter and radiation."(3) It is incorrect to thing of the "bang" as an explosion akin to a bomb going off. There was no destruction of material but rather the rapid expansion of the universe. The universe began cooling off and as it did the collisions of different particles were able to combine and form new forms of matter. Along with the matter, radiant energy spread out in all directions. All of the matter spread outward evenly and very fast.(4)

As the matter spread collisions took place and as molecules mixed new elements formed. Hydrogen was one of the first formed. Over time hydrogen has been recognized as the building block of the universe. It is the most abundant element found in the solar system and Helium is the second. Together these two gases make up 98% of all the mass of material in the solar system. The predominance of hydrogen and helium does not only occur in our solar system, but the entire universe. In addition to hydrogen and helium, lithium and beryllium which are among the lightest elements also emerged. As the young universe expanded it began to cool in regions with slightly more mass than others gases clumped up due to gravity. The gases became like clumps and the swirling material formed the early galaxies. Within theses early galaxies the first stars were born. The heavier elements were made much later by thermonuclear fusion in stars. The dust particles were only possible through the formation and death of some particularly massive stars.(5)

The hydrogen and helium formed clouds. As the clouds cooled they swirled and shrank becoming early galaxies. In the early galaxies there could have been no planets like the rocky Earth forming because there was only hydrogen and helium but no carbon. It would be some time before carbon was produced.(6)

The galaxies that formed differed in shape. Some were elliptical and some were spiral. They are enormous – trillions of miles wide. Sometimes the galaxies smashed into one another. Material from these collisions spread around and in certain instances combined. This led to the birth of the first stars. These early stars ended up providing the chemicals for the different galaxies. The smaller stars turned hydrogen into helium and then helium into carbon and on up to the development of more complicated elements. The larger stars made heavy metals like iron, gold and uranium. As time past these stars exploded they showered the galaxies with metal and chemicals. These supernova remnants scattered across space.

As new stars formed they incorporated the heavy elements which could only come from earlier stars. We can therefore be pretty sure that our Sun is a descendent of some of these earlier stars, because in addition to hydrogen and helium our earth contains heavy elements that could only have come from previous stars. Since the Sun is 5 billion years old there has been lots of time for stars to form and die.

Our solar system was formed from a cloud of interstellar material made mostly of hydrogen and helium and other chemical elements such as carbon, oxygen, and silicon. There were also some interstellar grains which are believed to be made of silicates, iron compounds, carbon compounds, and water frozen into ice. The transformation of this cloud began when the gravitational attraction between the particles in the densest part of the cloud caused it to collapse inward. It did not fall into itself but because it was rotating it flattened much like what happens when a pizza maker would toss the round shaped piece of dough into the air to help flatten it. This process took a few million years. The disk or solar nebula condensed into the planets while the bulge in the middle became the Sun.(7)

The development of the planets occurred in two stages. First, dust condensed and clumped together to form planetesimals. Later, the planetesimals joined together to form planets and satellites.(8)

All of the planets revolve around the Sun in the same direction which must be indicative of the way the cloud turned while the process of collapse was happening. The terrestrial planets are similar because event though the temperature was hotter near the sun the materials making up the terrestrial planets remained partially of molten rock. The iron-rich minerals sank to the middle while the silicon-rich minerals floated to the top. This iron core gave rise to the magnetic fields in the terrestrial planets.(9)

Like the terrestrial planets, the outer planets began with planetesimals which were accumulating more and more materials. However because the outer solar system had lower temperatures gas atoms were moving very slowly and could be gathered by these out planetesimals along with the rocky materials. The core of rocky material was able to suck up the gases and in that way the outer planets except for Pluto were formed with enormously thick hydrogen envelopes surrounding rocky cores. The main difference between the terrestrial and Jovian planets is that it was cold enough in the outer regions where the ice particles and ice coated dust grains could survive. Since there was a great deal of icier material there to form solid objects the Jovian planets are much larger than the terrestrial planets.(10)

Some of the remaining planetesimals crashed into the new planets making large craters. They also may have caused the tilted rotation axes of some of the planets. Today some of the planetesimals survive as asteroids and comets.(11)

What is the Anatomy of the Sun?

The Sun is in fact a star, and a rather unremarkable one at that. It is of average size and is categorized as a yellow dwarf. It is composed of six layers or parts: the inner core, radiative zone, convection zone, photosphere, chromosphere, and corona. The first three form the interior; the next three constitute the solar atmosphere.

Inner Core: The inner core is the center of the Sun. It is where nuclear fusion takes place and where the energy of the Sun comes from. Despite its density the Sun is gaseous throughout because the high temperature gives the atoms so much energy of motion that they are unable of bond with one another to form a liquid or solid substance.

Radiative Zone: This section of the Sun is the largest part of the Sun, and includes the core. Energy travels in this zone through radiation. This layer is the inner 70% of the Sun. through here on its way to the top layer. Light from the core moves through the radiative zone as photons. Because the gas is so dense there the photon moves extremely slowly. It will go less than an inch before it is reabsorbed by an atom. It will then be reemitted but will soon be reabsorbed. This constant absorption and readmission slows down the photons like cars in stop and go traffic. It will take almost a million years for a photon to reach the surface.(12)

Convection Zone: This area carries the energy up to the surface. It comprises the outer 30% of the Sun. The gas warms up and rises and then cools and sinks back. Scientists know this because of granulation which occurs at the surface when hotter gases emerge among the cooler gas at the surface. The gas then releases its heat into space and returns down to continue the convection process.

Photosphere: This is the part of the Sun that we can see. It is the surface of the Sun but we couldn't stand on it – it is made of gases. The sunlight emanates from this thin layer thus giving the illusion that it has a hard surface. Because of its high internal temperature the Sun is gaseous throughout its volume.

Chromosphere: This layer of gas above the photosphere can only be seen with the help of a special telescope. This layer of gas has much lower density than that of the photosphere. Its temperature reaches about 4500K at the bottom of the chromosphere and increases to about 25000K at the top.(13)

Corona: This is the outermost layer of the Sun which is usually only seen in photos taken during solar eclipses. It is very thin and faint. However, the temperature shoots up in the corona to around a million degrees Kelvin which is contrary to what one expects.

Solar Wind: While the Earth's gravity keeps the atmosphere from escaping the Sun's corona has such high temperatures that some of the gas does escape. This flowing gas is called the solar wind. Every second about a million tons of material is ejected by the Sun into the solar wind. Still with its large mass the Sun will eject only a few tenths of a percent of its total mass during its lifetime.

Granules: These are light colored regions with darker boundaries that are about 1000km (600miles) wide.(14) The photosphere is covered with this pattern blotchy pattern. The pattern is a result of the convection process. The rising hot gas gives off the lighter color but as the gas cools it moves out toward the boundary and sinks giving off the darker shade. This process is a continuous one.

Sunspots: These are not permanent features of the photosphere but occur in an 11-year cycle. When sunspots occur in large numbers the sun is said to be in an active stage. Sunspots are irregularly shaped dark regions in the photosphere. They vary greatly in size although most common ones are a few tens of thousands of kilometers wide. Sunspots can last from a few hours to a few months. Each sunspot has a dark center core called the umbra and a less dark border called the penumbra. A sunspot is a region where the temperature is relatively low which is why it appears darker than the surrounding area. Typically the umbra is about 4300K while the penumbra's temperature is around 5000K. This is quite a bit lower than the typical temperature of the photosphere is 5800K.(15)

Prominences: These are filaments that are appearing with the darkness of space behind them. They appear as bright arching columns of gas. They can go tens of thousands of miles above the photosphere. They can last for a few hours to a few months.

Solar Flares: These eruptions occur within a group of sunspots. The temperature rises quickly and a huge amount of particles and radiation are tossed into space. These eruptions can cause disturbances that spread out into the solar atmosphere.

Coronal Mass Ejections: When these eruptions occur they are more massive than the solar flares. More than a billion tons of high temperature gas is blasted into space at speeds of hundreds of thousands of kilometers per second.

If solar flares or coronal mass ejections happen to be aimed toward the Earth, the stream of material can reach us in a few days. When it reaches the earth it can interfere with satellites, and disrupt electrical and communications equipment.

How is a star born?

The Sun is a star. It was born in what is termed a nebula or giant nebula. These are giant clouds made up mainly of hydrogen gas molecules and are usually referred to as GMCs or giant molecular clouds. These clouds are gigantic and range in size from 1,000 to 2,000,000 solar masses. They can have a density of 200 molecules per cubic centimeter.(16)

You usually find a lot of gas and dust within these clouds – mostly hydrogen and helium. It takes several million years while gravity pulls this dust close together. As the material is pulled together, gas gets extremely hot and the pressure increases. When the gas reaches higher temperatures a nuclear reaction starts. The hydrogen atoms smash into each other making helium and the star begins to shine.

The star is now an adult and will continue to burn hydrogen for a long time. Our Sun, for example, is in this phase of life and it will be 5 billion years or so before it uses up all the hydrogen at its core. Stars in this phase are called dwarf (even though they might be 10 times bigger than our Sun) because this is the smallest they will ever be during their life.

As our Sun expands it will finally explode. Later, after it cools it will be termed a white dwarf because its size will be comparatively tiny and it will be white hot.

However, since it will have no source of energy it will soon become cold and remain as a cold dark dense body.

How does the light and heat of the Sun help the Earth?

Of course without the Sun the Earth would be dark, but beyond the darkness the Sun is intricately involved with everything that happens here. Perhaps the most important event which we take for granted namely; photosynthesis would be impossible without the Sun. By that process the Sun's light, water, and air cause plants to make the food they need to grow. Without sunlight there would be no green plants. However, not only would plants disappear but the animals like cows, sheep, insects or fish that depend on green plants for food would also disappear. All animals either eat plants or animals that eat plants. Without sunlight all forms of life would cease to be. Since our food chain rises from plants to animals to human beings, without the process of photosynthesis there could be no life on this planet.

Even if there were another food source our lives would be more difficult without what we term natural resources. Imagine a life without automobiles, airplanes, or the possibility of heating or cooling our homes. We get energy from the Sun. From before the age of dinosaurs there was vegetation that died and then was buried underground or under the oceans. As time went on this vegetation was turned into what are termed fossil fuels like gas, oil, or coal. What we term Earth's natural resources would not exist without the sun. Those natural resources needed the sunlight to form. Even now we are still trying to harness the power of the Sun to heat our homes, power automobiles by developing solar collectors and solar cells.

Light from the Sun provides us with illumination. Without the Sun we could not see. Light from the Sun travels at 186,282, miles per second (299,792 kms per second). Even at this fast speed it takes about eight minutes for light to reach the Earth. Light is any source of illumination. It can be found in nature like the Sun or man made light like the light bulb.(17)

All light travels as waves. The distance between the crest (top) of the waves is the wave length. As the wave lengths get wider the frequency becomes lower, and conversely the shorter the wave lengths the higher the frequency. For us the most important part of the light spectrum is natural sunlight which is called white light or visible light. This is the light we can see. However, if light is put through a prism the white light breaks up into 7 colors of visible light: red, orange, yellow, green, blue, indigo, and violet, as well as infra-red and ultra-violet that we cannot see.

Every element gives off a different set of spectral lines. This is how scientists study the sun and other objects out in space despite them being so far away. The stars are classified by the color they appear to us on earth. As the temperature of the star increases the bluer the star appears to be.

How do we have night and day and the seasons?

The Sun seems to follow a path in the sky and because of this observation many early sky watchers thought that the Earth was the center of the solar system and that the Sun orbited around it. Now we know that the opposite is true. We know that this appears to happen because the Earth rotates. The Earth rotates from west to east so the Sun seems to rise in the east and set in the west. When the Earth turns away from the Sun it seems to set. It grows dark and we experience night time. The sun seems to move across the sky as it rises and sets but in reality we are moving relative to the Sun. Likewise the stars seem to move but in reality they are pretty much stationary relative to each other. We on Earth are the ones in motion.

The seasons occur because the Earth is tilted on its axis. The tilt stays nearly the same and in the same direction as it moves around the sun. Because of this consistent tilt the Sun's rays fall more directly in the Northern part of the Earth for part of the year and directly on the Southern part of the Earth for the other part of the year. A flat surface captures more of the Suns rays than a tilted one. Therefore in the summer the Northern Hemisphere receives the rays of the Sun most directly while in the winter it receives them less directly and so it is colder. This is also enhanced because the tilt of the Earth means that in summer we not only receive the Sun's rays more directly but for a longer period of time. In the winter not only do we receive less direct sunlight, but we receive sunlight for less time because the tilt causes winter days to be shorter. The tilt is also responsible for the seasons being reversed in the Northern and Southern Hemispheres.

How does the Sun affect the weather?

The intense heat of the Sun determines the Earth's weather. About one third of all the light waves that reach the Earth are reflected back into space. The remaining two thirds are absorbed by the Earth. The sunlight passes through the atmosphere and heats the ground which in turn warms the air near the surface. The atmosphere keeps the warmth from escaping. This is what is termed the greenhouse effect. Like the windows in a greenhouse the atmosphere traps the heat inside. The balance of temperature is very important to life on our planet. If the temperature drops a few degrees everything would begin to freeze and another ice age could occur. If the temperature rose a few degrees the polar caps might begin to melt.

The difference in climate around the Earth is caused by the fact that the Sun does not heat the Earth evenly. The equator is where the rays of the Sun hit most directly. As you move north or south toward the poles the Sun's rays slant.

The unequal heating sets up air masses that move around the Earth. The colder masses become heavy and move downward while the warmer massed become lighter and rise. The air from the poles moves toward the equator and the equatorial air masses move northward. This continuing movement is the basis for the weather patterns that occur on the Earth.

The Earth is spinning from west to east at about a thousand miles per hour at the equator but slower at the poles.(18) The difference in speeds make the winds and ocean currents curve to their right in the Northern Hemisphere and to the left in the

Southern Hemisphere.

As the earth spins the irregular surface of the earth and the different amounts of water in the air cause many complex and unusual wind patterns. As the Sun shines on the Earth heat is absorbed at different rates. The trees and forests absorb most of the light rays that fall on them. However, the mountains and areas covered with snow reflect as much as nine tenths of the Sun's rays back. They remain snow covered throughout the seasons. Water warms and cools more slowly than the land. The oceans and other large bodies of water store heat from sunlight and release it slowly at night even during the winter. Land areas can't store as much heat as water. For this reason areas like the Midwest have rougher winters and warmer summers compared to areas along the coastline.

What is the future of the Sun?

The Sun will continue as it is now until it consumes about 90% of the hydrogen in its core. It has been calculated by scientists that the whole process for a star the size of our Sun would take about 10 billion years about half of which the Sun has already used up. When the hydrogen in the Sun's core is nearly spent its core will shrink and grow hotter. The rising temperature in the core will make the remaining hydrogen burn faster, producing more energy. This energy will flow outward through the layers of the Sun and lift them and cool them as they move further from the Sun's surface. The Sun will now be bloated and cool. It will turn into a red giant. Cool here is a relative term since the Sun will still give out more than 1000 times the energy of the current Sun even though the surface will be cooler. Anyone then on the Earth will only get a quick look because the expanding Sun will engulf the Earth. (19)

The Sun will shine as a red giant for maybe a billion more years and then will shrink and grow hotter and finally when it gets hot enough it will turn into a yellow giant. During this stage the Sun will start to pulsate as if taking slow deep breaths. As it consumes most of the helium in its core it will turn again into a red giant even larger and brighter than before. That intense brightness will signal its death. All of its energy will be streaming out into space forming a gaseous shell that will eventually disperse. The tiny core will be very hot but with no more fuel. It will cool and shrink into a white dwarf.(20)

Lesson Plans

Usually to introduce the unit I would some piece of literature: a poem or story. That is then followed up with a KWL chart. The KWL chart (KWL stands for What I Know, What I Want to Know, and What I Learned) is a graphic organizer that helps to track the learning process as we go through the unit. After the initial *What I Know* is filled in by the class students would then suggest what questions they have about the Sun. This would require the *What I Want To Know* column of the chart to be completed This list would be added to as the unit progresses and other questions arise. The class would add to the *What I Learned* column and at the end of the unit return to the questions we started with to see if they had been adequately answered. There is a strong possibility that students may ask a question that there is no answer for.

Lesson Plan #1 Light Can Be Absorbed

Objective: To show students that light is absorbed by objects, and that darker colored objects absorb more light than lighter colored objects.

Materials: 2 regular drinking glasses of the same size and shape,

black paper or cloth – enough to wrap around one of the glasses,

white paper or cloth – enough to wrap around one of the glasses,

water, and a thermometer

Procedure:

1. Wrap one glass with the black paper or cloth and the other glass with the white paper or cloth.
2. Fill each glass up with water.
3. Put both glasses in a shady part of the room for 30 minutes.
4. Take the temperature of the water in both glasses. The temperature should be the same.
5. Now put both glasses of water in sunlight and leave them there for 30 minutes.
6. Take the temperature of each glass of water. The glass wrapped in black should have a higher temperature because it absorbed more of the light than the glass wrapped in white. The absorbed light was transferred to the water. The light energy was changed into heat energy.

Lesson Plan #2 Examining Light From The Sun

Objective: Students will separate sunlight or white light into colors by using a glass prism.

Materials: a glass prism, and a piece of white paper

Procedure:

1. Place the prism in front of a light source or sunny window so that the light goes through and falls on the paper.
2. Students should record what they see. What colors do they see?

Students should see that the white light breaks up into the spectrum of colors that you would see in a rainbow. Each of the colors is traveling on a different wavelength. When the waves pass through the prism each one bends by a different amount resulting in the spread of colors. The longest waves (red) bend least and the shortest ones (violet) bend most.

Lesson Plan #3 The Expanding Universe

This lesson includes two parts. First as the balloon is blown up the growing size

of the balloon represents the expanding universe. However, this only shows

two dimensions of the process. Coupled with this should be another

demonstration using a raisin cake which illustrates the interior expansion of the

universe.

Objective: Students will see the way the universe expanded after the "Big Bang."

Materials: a balloon, some small beads, glue, and a marker

Procedure:

1. Glue some small beads on the balloon to represent galaxies. With the marker put on a wavy line with an arrow pointing toward the end of the balloon to represent radiation.
2. As the balloon is slowly blown up it begins to expand and the beads on the balloon will also begin to move away from each other in an even and outward direction. This shows that the galaxies are not expanding but space is. The radiation wave that you drew will become longer showing that energy levels decrease as the universe expands.

Part Two: To show what is theoretically happening within the balloon students will mix raisins into a cake batter. The assumption might be that the raisins would all clump together. However the nature of the medium that they are mixed in separates the raisins and distributes them throughout the cake. This is much like what happens to galaxies in the universe. They do not change or expand. The fabric of space is moving the galaxies.

The galaxies themselves are not moving.

Materials: cake batter, raisins, knife, spoon (unless you have access to an oven at your school you will have to have an already baked raisin cake or two to cut open and show to your students).

Procedure:

1. Mix up the batter. Predict what will happen when the raisin are added.
Will they mix in the batter or separate?
2. Add the raisins and bake the cake.

3. Cut the cake so students can see that the batter has expanded as it heated and it has distributed the raisins throughout the cake.

Lesson Plan #4 A Model of the Solar System

There are countless ways to make a model of the solar system. In fact, there is a web site devoted to just this enterprise. It also includes a calculator that will give you the dimensions for each planet based on the dimension that you enter for the Sun. This site is listed in the bibliography of web sites at the end of this paper.

Objective: students will construct a model to show how big the solar system is, how far apart the planets are from one another, and how much empty space there is out there.

Materials: two large rolls of toilet paper (at least 200 sheets each), place cards for each of the planets, a large outside area, or long hallway

Procedure:

1. 1 A.U. equals the average distance between the Earth and the Sun. In this example 1 A.U. will be 10 sheets of toilet paper. As a result Mercury would be on the 4th sheet; Venus would be on the 7th; Earth on the 10th sheet; Mars 15th; Jupiter 52nd, Saturn 96th; Uranus 192nd; Neptune 301st; and Pluto 394th.
2. Begin rolling out the toilet paper and have students mark the place where each planet will go. This is a good and easy method for students to experience in a tangible way a sense of the unimaginable size of the solar system. Have students record their impression in their science journals.

Lesson Plan # 5 Detecting a Magnetic Field

Objective: Students will be able to see a magnetic field and understand the forces that are around the Earth.

Materials: iron filings, spoon, 3 clear glasses or containers, 3 bar magnets, 2 horseshoe magnets, plastic wrap, clear or light syrup, string, pencil

Procedure:

1. Pour a spoonful of iron filings into a jar of syrup. Stir well, and evenly pour some into 2 clear glass or plastic containers

2. Place 2 bar magnets under one container- 2 horseshoe magnets on the outside on opposite sides of the other container.
3. Fill the 3rd container with the mixture and wrap the bar magnet in clear plastic wrap. Tie it with string to the pencil and hang it in the container. Patterns should form that outline the magnets' magnetic fields showing the forces keeping each of the pairs of magnets away from each other.

Appendix A: Science Standards

This unit deals with topics that cover these standards in the New Haven Public Schools Science Curriculum.

Content Standard 1.0

Scientific Inquiry

Students will develop abilities necessary to conduct scientific inquiry, including posing a question, stating a hypothesis, developing and investigation, observing and documenting the process and recording and determining the results.

Performance Standard 1.1

Students will acquire and practice the ability to do scientific inquiry.

Performance Standard 1.2

Students will understand the process of scientific inquiry

Content Standard 4.0

Earth Science

Students will develop an understanding of the structure, 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.

Performance Standard 4.1

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

Performance Standard 4.2

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

Performance Standard 4.3

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

Bibliography

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* indicates books that are suitable for students to utilize

Ahrens, C. Donald, Meteorology *Today*

United States, Thomson: Brooks/Cole, 2003.

An introduction to weather, climate, and the environment

* Cobb, Vicki, and Josh Cobb. *Light Action: Amazing Experiments with Optics,*

New York, Harper Collins, 1993.

Explains what light is and explores the basic principles of optics through experiments.

* Davis, Kenneth C. *Don't Know Much About The Solar System,*

New York, HarperCollins Publishers, 2001.

Asks and answers questions about the sun, and the planets as well as cosmology,

the life and death of stars, astronomy, and space exploration.

Freedman, Roger A. and William J. Kaufmann III. *Universe,*

New York, W.H. Freeman and Company, 2005

A basic college textbook that tells about all aspects of the universe. Aimed at introductory astronomy students without a strong science or math background.

*Gibbons, Gail. *Sun Up, Sun Down,*

New York, Harcourt, Brace, Jovanovich, Publishers, 1983.

Describes the characteristics of the Sun and the ways in which it regulates life on Earth.

*___________. *The Reasons for Seasons,*

New York, Holiday House, 1995.

Explains how the position of the Earth in relation to the Sun causes the four seasons.

*Jaspersohn, William. *How the Universe Began* , New York, Franklin Watts, 1985.

Explains in simple terms how the universe began with the "big bang theory." Also describes the formation of the stars, planets, and our solar system.

*Olesky, Walter. *A New True Book: Experiments with Heat,*

Chicago, Children's Press, 1986.

Scientific explanations and experiments demonstrate the nature of heat, its sources, and how it travels and affects matter.

*Rhatigan, John, and Rain Newcomb. *Out –Of-This-World Astronomy: 50 Amazing Activities and Projects* , New York, Lark Books, 2003.

Introduces "the study of stuff in space," providing statistics, quizzes, activities and experiments about the stars and planets.

Schwabacher, Martin. *The Sun,*

New York, Benchmark Books, 2003.

Discusses the shift from an Earth-centered to a Sun-centered view of the Solar System, the Sun's composition, history, and likely future, and the importance of this star to life on Earth.

Singh, Simon. *Big Bang,*

New York, HarperCollins Publishers, 2004.

A highly readable account of why cosmologists believe that the Big Bang is an accurate description of the origin and evolution of the universe.

*Spangenburg, Ray and Kit Moser. *A Look at the Sun,*

New York, Franklin Watts Pub., 2001

Gives an overview of the Sun – its composition and where its energy comes from.

*Vogt, Gregory L. *The Sun,*

Brookfield, CT Millbrook Press, Inc. 1996

This is a book that gives some basic facts about the sun. It includes some good photos and a glossary of terms.

Weinberg, Steven. *The First Three Minutes,*

New York, Basic Books, Inc. Publishers, 1977.

A very accessible accounting of what is termed "the standard model" of the how the

early universe began. It was written with the general reader in mind.

Williams, Jack. *The Weather Book: An Easy Guide To The USA's Weather,* New York, Vintage Books, 1992.

This is a valuable introduction and guide to the science weather and climate. Covers basic weather terms utilizing places in the USA to illustrate examples.

Web Sites

Build A Solar System,

http://www.exploratorium.edu/ronh/solar_system

This site contains a calculator that helps you figure the dimensions of the planets based on your specifications.

Zoom Astronomy,

http://www.enchantedlearning.com/subjects/astronomy/stars/

This site offers information and some handy graphic organizers of the sun, and solar system that can be printed out for use in the classroom.

Exploring The Planets

http://www.nasm.si.edu/research/ceps/etp/ss/

National Air and Space Museum sponsors this site. Contains cute song "Our Solar System."

Astronomy Picture of the Day

Http://antwrp.gsfc.nasa.gov/apod/astropix.html

This site shows a new picture daily of some astronomical event that was taken within recent days.

A Map of the Milky Way

http://www.anzwers.org/free/universe/galaxy.html

This site shows some drawings of the Milky Way and shows the area which our sun is located and other notable areas in the galaxy.

Images of Suns, stars and solar-terrestrial effects

http://canopy,lmsal.com/schryver/public/homepage/coolstaroverview.html

This site gives a variety of thumbnail pictures of various pictures of the sun, solar flares, prominences, etc.

How the Sun Works

http://science.howstuffworks.com/sunl.htm

This site talks about the workings of the sun and includes some good diagrams.

How the Sun Shines

http://nobelprize.org/physics/articles/fusion/index.html

This site includes works by and about Nobel laureates as well as articles dealing with all aspects of science.

Kids Astronomy

http://www.kidsastronomy.com/index.htm

This is a good site for children. It gives information on all of the planets, stars, nebula, black holes, the universe, etc.

NASA

http://www.nasa.gov/home/index.html

This is the official web site of the National Space and Aeronautics Administration.

Curious About Astronomy? Ask an Astronomer

http://curious.astro.cornell.edu/index.php

This site which is sponsored by Cornell University grad students gives people a chance to submit questions for them to answer.

Nasa Kids

http://kids.msfc.nasa.gov/

This site is sponsored by NASA for younger students. It has a variety of activities for different levels

The Earth Sun Connection

http://sec.gsfc.nasa.gov/

This site's goal is to promote the understanding of the relationship between the sun, heliosphere, and planetary environment.

Endnotes

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1. Freedman, p. 167

2. Freedman, p. 638

3. Weinberg, p. 102

4. Freedman, p. 638

5. Freedman, p. 167

6. Freedman, p. 168

7. Freedman, p. 171-172

8. Freedman, p. 173

9. Freedman, p.175

10. Freedman, p. 175-176

11. Freedman, p. 176

12. Freedman, p. 385

13. Freedman, p. 391

14. Freedman, p. 389

15. Freedman, p.395-396

16. Freedman, p. 457-459

17. Freedman, p. 91-92

18. Ask An Astrophysicist http://imagine.gsfc.nasa.gov

19. Freedman, p. 19

20. Freedman, p. 494-495