unit

2 *Sun & Stars*

Prior Knowledge

The student has

1. referred to the north, south, east and west as directions
2. counted to 100
3. shown two- and three- digit numbers on a place value chart
4. subtracted two- and three-digit numbers with renaming and regrouping using manipulatives
5. multiplied single-digit numbers in arrays
6. divided two-digit numbers by forming equivalent groups
7. graphed and read information from graphs
8. used fractions such as 1/2, 1/3, 1/10.

Mathematics, Science and Language Objectives

Mathematics

The student will

1. use numbers through one million to discuss/describe number, distance and temperature
2. compare large numbers using subtraction, division and "times"
3. sequence the planets in our solar system by size and/or distance from earth using given data
4. find points on a plane using two dimensions
5. use "sphere" to describe stellar bodies
6. compare two objects using **times,** as well as **"more than"**
7. use the logical sentence structure: If ..., then ... .
8. describe closed paths as circular, elliptical; parabolic paths are not closed
9. use integers.

Science

The student will

1. describe stellar objects using terms such as stars, planets, satellites, orbits and light
2. say that stars are objects that produce their own energy in the form of light and heat
3. list star characteristics as color, brightness, distance from earth and size
4. say that a star's color depends on its temperature
5. demonstrate how light and heat are important to living things such as plants
6. describe the difference among stars, planets, meteors, satellites and comets

7. list the nine planets of our solar system
8. list and describe at least four types of stars
9. describe our sun as a yellow star that is about average in temperature and small in size
10. say that the gravity a stellar body exerts depends on its mass
11. describe how stars can be seen as patterns called constellations
12. say that our sun is the only star in our solar system, but not in the universe
13. demonstrate moon phases and a lunar eclipse
14. demonstrate how stellar objects stay in orbit.

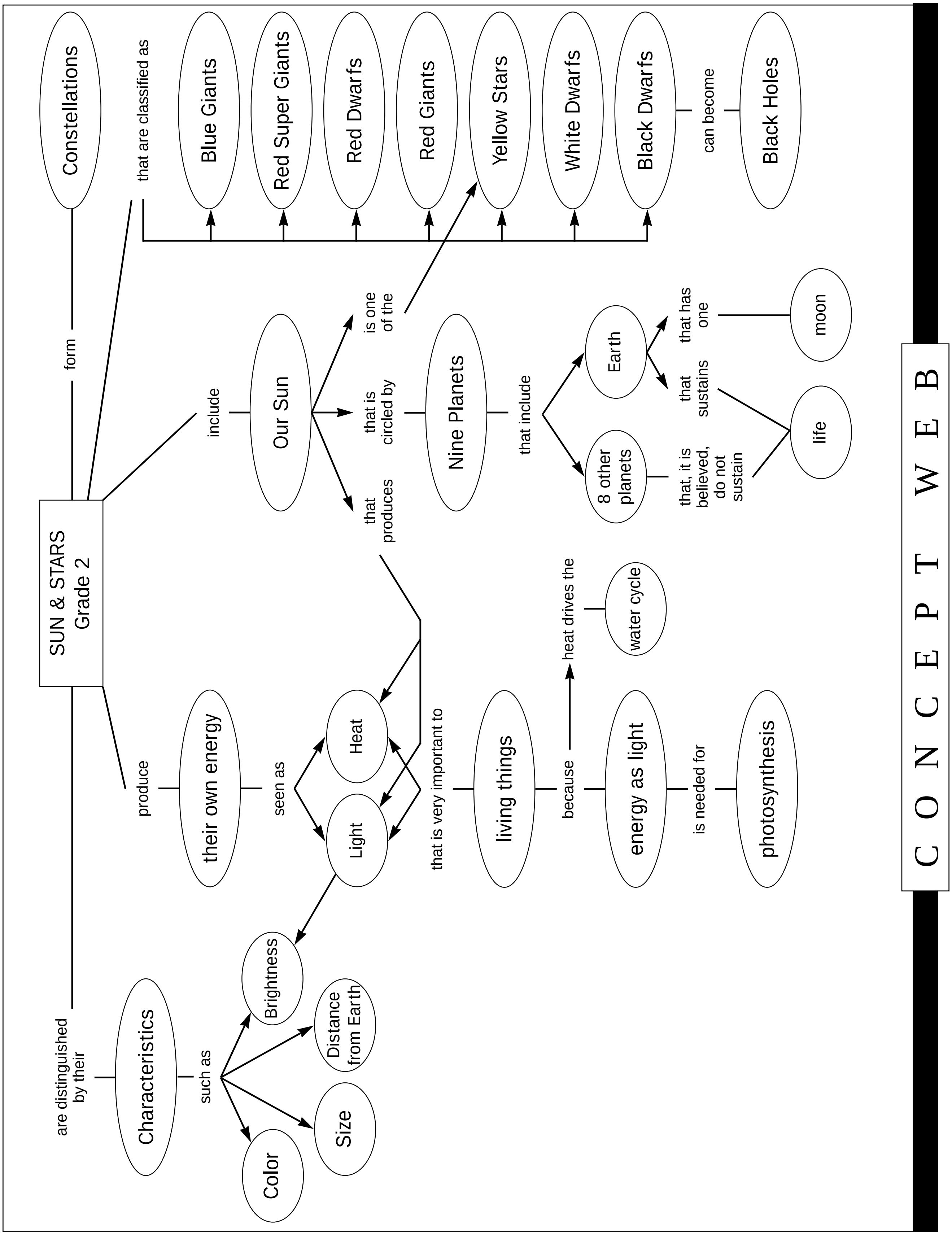
Language

The student will

1. engage in dialogue/discussion
2. define terms, using them to discuss new ideas
3. listen to narration
4. write complete sentences in a theme journal
5. read for information, organize and report on information and data gathering
6. create stories, using theme-related vocabulary.

V O C A B U L A R Y

sun sol	earth tierra	sky cielo	rotate rotar	revolve girar	space espacio
bright brillante	dim opaco	star estrella	telescope telescopio	shade sombra	solar system sistema solar
sphere esfera	glowing brillar	gases gases	hydrogen hidrógeno	helium helio	core centro
sunspots mancha (s)	particles partícula (s)	eclipse eclipse	atmosphere astmósfera	corona corona	solar flares resplandor solar
astronomers astrónomos	reflect reflejar	planets planetas	orbit órbita	gravity gravedad	asteroids asteroide
craters crater (es)	comet cometa	meteor meteoro	meteorite meteorito		


CONCEPT WEB
SUN & STARS
Grade 2
form
Constellations
that are classified as
Blue Giants
Red Super Giants
Red Dwarfs
Red Giants
Yellow Stars
White Dwarfs
Black Dwarfs
can become
Black Holes
include
Our Sun
is one of the
that is circled by
Nine Planets
that include
Earth
that has one
moon
that sustains
life
8 other planets
that, it is believed, do not sustain
that produces
produce
their own energy
seen as
Heat
Light
that is very important to
living things
because
heat drives the
water cycle
energy as light
is needed for
photosynthesis
are distinguished by their
Characteristics
such as
Brightness
Distance from Earth
Size
Color

Teacher Background Information ● ● ●

Before the 16th century most people in the Western World, that is to say Europe, believed the earth was the center of the universe and the sun, moon, stars and all of the other "heavenly" bodies revolved around it. The path the earth traveled was called an **orbit.** Copernicus, a Greek astronomer, was the first person to say the sun was the center of a system composed of the earth and some other planets that revolved around the sun. He also believed that the earth's path around the sun was circular, and that a few stars, which he called **planets,** also moved through the sky in circles around the sun and were similar to earth.

Soon after Copernicus, a mathematician named Johannes Kepler observed that the true movement of the earth and other planets was not what Copernicus believed. Using his knowledge of mathematics, Kepler changed the round path or orbit to an elongated circle called an **ellipse.**

Copernicus' theory as modified by Kepler was again modified by Galileo, who was one of the first astronomers to study the sky with the use of a telescope. People did not want to believe that the **earth was not the center** of the universe. Galileo set up a telescope in the center of town and asked the scientists of the day to observe the sky, in other words, to engage in scientific inquiry. The scientists refused and Galileo was later convicted of heresy, partly because of his support of the Copernican model of the solar system.

Since the day of Galileo, many scientific advances have made it possible to design and construct new telescopes that give us information about outer space. Although Galileo and the other astronomers were correct about the sun being the center of our solar system, no one has claimed to have found the center of the universe!

Current thinking describes stars as self-luminous objects that shine by radiation produced in continuous nuclear and other processes within the stars themselves. By contrast, planets shine because they only reflect light. As far as its properties can be compared to other stars, the sun is a typical star. It has a mass more than 300,000 times that of the earth and a radius of 696,000 km (432,200 miles). Star temperatures can range around 5,000 to 20,000˚ C. Our sun's temperature is about 6,000˚ C, which puts it in the medium range.

Information about stars depends on scientists being able to know the stars' distances from earth. One important way to calculate these distances is to look at their luminosity. The luminosity of shining objects varies with the distance of the object from the observer, and we use that principle to calculate the distance of stars. Thus, we accurately know stellar distances for nearby objects, but the distances of stars in the more remote parts of the galaxy we can only estimate.

How the universe and stars formed is a question astronomers continually study. The solar system in which we live came into being many millions of years ago. There may be other solar systems in our own galaxy; perhaps 100 million stars have orbiting planets, thus making other solar systems. There are perhaps about two or three million solar systems that have planets capable of supporting higher forms of life, similar to that on earth. The chances are, however, that we may never get to know or study any of the possible life-bearing planets.

Advance preparation

In preparation for **Activity** — Plants and Sunlight, as below.

Students bring several plants to class or plant some beans in several pots. Keep one half of the pots in the sunlight and water them, and keep the other half in a closet or some other dark place and water them also. Beans will need about seven to eight days to germinate and begin to grow.

L E S S O N F O C U S

■ **LESSON 1** *Our Solar System Is Not Alone Out There!*

BIG IDEAS Our sun, the earth and its moon are not alone in the universe — there are many other stellar bodies that accompany them. We use very large numbers to describe the universe.

■ **LESSON 2** *Stellar Bodies Beyond Our Solar System*

BIG IDEAS Star, comets, meteorites, novas and asteroids are only some of the stellar bodies in outer space. We can compare sizes, distances and brightness by using the notion of "times."

■ **LESSON 3** *Stars Produce Their Own Energy*

BIG IDEAS We can see stars with a telescope because they emit self-produced energy; this energy travels as light for millions of miles and for millions of years.

■ **LESSON 4** *Our Sun Is a Small Star*

BIG IDEAS Living things exist on Earth because of sun energy. We can see stars as light that has traveled for millions of miles.

■ **LESSON 5** *Our Sun's Family — The Planets and Their Satellites*

BIG IDEAS The sun in our solar system has 9 planets traveling in elliptical orbits around it.

■ **LESSON 6** *The Moon Is Our Nearest Neighbor*

BIG IDEAS As the earth's follower, the moon affects the earth in many important ways. We know the distance from Earth to the moon because humans have calculated the distance and traveled there.

■ **LESSON 7** *Constellations*

BIG IDEAS We see light from faraway stars as reliable patterns called "constellations". These patterns in the sky guide travelers on earth at night and tell astronauts where they are in space.

O B J E C T I V E G R I D

Lessons	1	2	3	4	5	6	7
Mathematics Objectives							
1. use numbers through one million to discuss/ describe number, distance and temperature	•	•	•	•	•	•	
2. compare large numbers using subtraction, division and “times”	•		•		•	•	
3. sequence the planets in our solar system by size and/or distance from earth using given data	•	•	•	•	•	•	•
4. find points on a plane using 2 dimensions							•
5. use “sphere” to describe stellar objects	•	•	•	•	•	•	•
6. compare 2 objects using “times”, as well as “more than”	•				•	•	
7. use the logical sentence structure: If ...., then	•	•	•	•	•	•	•
8. describe closed paths as circular or elliptical; parabolic paths are not closed					•	•	
9. use integers.		•	•				
Science Objectives							
1. describe stellar objects using terms such as stars, planets, satellites, orbits and light	•	•	•	•	•	•	•
2. say that stars are objects that produce their own energy in the form of light and heat			•	•			
3. list star characteristics as color, brightness, distance from earth and size			•	•	•		
4. say that a star’s color depends on its temperature			•	•	•		
5. demonstrate how light and heat are important to living things such as plants				•			
6. describe the difference among stars, planets, meteors, satellites and comets			•	•	•		
7. list the 9 planets of our solar system	•				•		
8. list and describe at least 4 types of stars			•	•	•		
9. describe our sun as a yellow star that is about average in temperature and small in size			•	•			

Lessons	1	2	3	4	5	6	7
10. say that the gravity a stellar body exerts depends on its mass						•	
11. describe how stars can be seen as patterns called constellations			•				•
12. say that our sun is the only star in our solar system, but not in the universe	•		•		•		
13. demonstrate moon phases and a lunar eclipse						•	
14. demonstrate how stellar objects stay in orbit.				•	•	•	
Language Objectives							
1. engage in dialogue/discussion	•	•	•	•	•	•	•
2. define terms, using them to discuss new ideas	•	•	•	•	•	•	•
3. listen to narration	•	•	•	•	•	•	•
4. write complete sentences in a theme journal	•	•	•	•	•	•	•
5. read for information, organize and report on information and data gathering	•	•	•	•	•	•	•
6. create stories, using theme-related vocabulary.	•	•	•	•	•	•	•

LESSON 1 *Our Solar System Is Not Alone Out There!*

BIG IDEAS Our sun, the earth and its moon are not alone in the universe — there are many other stellar bodies that accompany them. We use very large numbers to describe the universe.

Whole Group Work

Materials

Book: **The Sky Is Full of Stars** by F.M. Branley and **Why the Sun and Moon Live in the Sky** by E. Dayrell.
Many and varied reference books, pictures and films on stars, planets and space
Chart for each student to record nightly observations of the sky
Place Value Chart (PVC)
Word tags: stellar bodies, gravity, million, universe, earth, moon, solar system, sphere

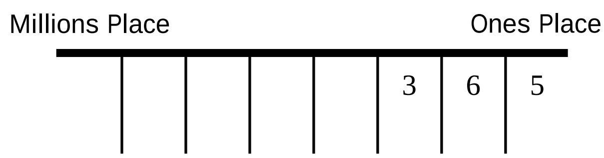
In preparation for this unit ask the children to go outside on several nights (ask a parent to go with them) when it is clear, not cloudy, and dark enough to see the stars to make the following observations to bring to class. (Put these questions on a chart and review them periodically for the students to work on each night.) See **Activity** — Star- and Moon-Gazing.

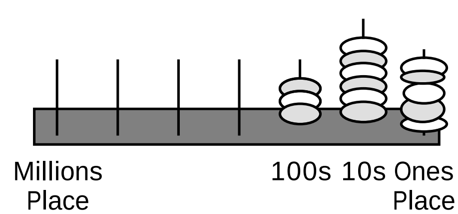
1. How many stars were you able to count in two minutes?
2. Were some brighter than others? Were some twinkling?
3. Did they shine in different colors? What colors did you see?
4. Find the star you think is the brightest. Where is it — in the north, south, east or west?
5. Can you find some patterns in the sky? What do these patterns make you think about?
6. Where was the moon on the different days that you saw it? Draw its shape and bring your drawing to class.

Encountering the Idea

For the first lesson read **Why the Sun and the Moon Live in the Sky** to the students. After reading the story, ask: How would you feel if you always went to someone's home to visit but that person never visited you? When should a promise be kept? Always? Sometimes?

[1]Place Value Chart (place the digits in the appropriate place in the chart, for example, 365) and Trading Chip Boards (place the appropriate number of chips on the nail that corresponds to the correct place value).





How would you feel if you were pushed out of your home? Why didn't the sun stop the water? Do you think that was the thing to do? Why?

Do you think that our solar system is alone in the universe? What other stellar bodies are found in the universe beside the sun and the moon? Is earth a stellar body?

After the discussion, ask the students to go outside and look for the moon, to look for any stars they may be able to find, but **not to look at the sun.** After returning to the classroom ask the students if they were able to see the moon? (You generally, can't see the moon in the day). Is this always true? Why? Or why not? Did you see stars? Then the students can dictate other questions to add to the chart. They will try to answer those questions that night as part of their continuing work on the unit. They may select the questions that are the most interesting for them, or they may wish to try to answer all of them.

Tell students that before going to the learning centers, they should record the information from the previous night's observations on their charts. Who counted the stars? Were all the shining objects in the sky stars? Was the moon out? Did you see some shapes on the moon? Do you know what they are? What color were the stars? (White, red, blue.) Were they twinkling? What was the first star you were able to see last night? Can you name some of the stars? Did you see some patterns that looked like pictures drawn out of shining dots of light? All of these questions are very interesting, and we will be discovering the answers to these as we study this unit.

Exploring the Idea

At the Science Center, the students

1. begin work on **Activity** — Star- and Moon-Gazing
2. begin work on **Activity** — Our Solar System.

The class needs to take time to organize itself into groups to construct the model solar system. The first step is to design the model by studying the suggestions in the activity and dividing the work into groups. For example: groups of two to three students select one planet and **research** the information on it, construct the planet according to the information they receive and report their findings to the class. Then use the material to make a class Big Book. Parents may be interested in working with the class to help the students construct and hang the planets, or help in other ways.

At the **Mathematics Center,** each student makes a laminated Place Value Chart or uses a Trading Chip Board to:

1. begin the **Activity** — Comparing with "Times." (It is important to initiate this activity before the students begin on the activity on large numbers.)
2. begin the **Activity** — What is a Million?
3. begin the **Activity** — Large Numbers. The students may want to repeat parts of the latter two activities until they begin to get a feel for the notion of a large number like **million.**

Getting the Idea

Show pictures of stars and/or planets from books, posters or magazines. Show word tags with names of various stellar bodies. Define stellar body as any object in space that is a star, like the sun; a planet, like earth; a satellite, like our moon; a comet; or a meteor (a "shooting star"). Stars have the shape of a sphere, or a ball. Discuss the idea that there are many, many more stellar objects in space besides our sun, the earth and its moon. Talk about the universe as comprising more than the stellar bodies we are able to see.

Ask: How many stars are there? How far away are they? What is a "shooting star" (or a meteor)? Would you like to travel to the moon? Why are there both night and day?

When we look up into the early evening sky, we usually see only three things that look different — we may see the setting sun as a bright half-orange, or maybe violet; we see the moon that can appear very large as it rises; and then we see some bright dots of light, some larger and brighter than the others but very much of the same appearance. Not all of these small bright dots of light are the same type of stellar bodies — they are very different. In the following lessons we'll discover what makes these stellar bodies different.

On a daily basis the students describe new observations they have made and record them in their **Moon-** and **Star-Gazing** charts. As they learn new concepts, students include these in the daily discussions.

Organizing the Idea

At the **Writing Center,** the students make a chart for the words "sun" and "moon" and supply different words that begin with each letter of the word, for example:

S is for sunrise	M is for moonlight
U is for universe	O is for orbit
N is for near	etc.

Applying the Idea

Problem Solving

Students respond to these ideas:

1. Is this true? If it is a shiny object in the night sky, then it is a star. (The moon shines, but it is not a star.)
2. Is this true? If it is a star, then we can see it shine in the sky. (There are more stars that exist than we can see because they are very far away.) Explain your answers and demonstrate with pictures, if you wish.

Closure and Assessment

Using either a PVC or a Trading Chip Board, students working in pairs take turns finding large numbers in books and/or newspapers and placing them on the PVC, saying their names and checking each other's work.

During the **Exploring the Idea** phase, the students begin construction of the three-dimensional model of the solar system. Assess students' participation and mastery of the concepts as they work on the mural and models.

List of Activities for this Lesson

- ▲ Star- and Moon-Gazing
- ▲ Our Solar System
- ▲ Comparing with "Times"
- ▲ What Is a Million?
- ▲ Large Numbers

ACTIVITY

Star- and Moon-Gazing

Objective

Students become aware of characteristics of stellar bodies by making and recording observations.

Procedures

1. Make Star- and Moon-Gazing charts to take home. See **Activity** — Finding Our Way, Lesson 7.
2. After recording the data obtained over several nights, students report to the class.

Star-Gazing

Stellar Body	Date	Brightness	Color	Position (sky) (N, S, E, W)	Patterns
Polaris					

Moon-Gazing

Shape	Date	Color	Surface Features

[1]First, find Polaris, the North Star, and use it to compare to the brightness of other stars. Are other stars brighter, less bright, or as bright as Polaris?

ACTIVITY

Our Solar System

Objective

The students make a three-dimensional "scale" model of our solar system, name the planets and color-code them to suggest their temperatures.

Materials

Different-size buttons and juice, soup and soft-drink can tops

Large pictures of the nine individual planets with details about surface features, number of moons, rings, etc.

Meter stick; masking tape; glue; colors; ball of heavy string

Procedures

1. Students make spherical masking tape models of each of the nine planets.
2. Use different-size buttons as diameters for masking-tape spheres to represent the smaller planets, Mercury, Venus, Earth, Mars and Pluto.
3. The planets closest to the sun are rocky planets because they are made of solid materials. Students can color these planets with darker brown colors. (Earth is a rocky planet, but astronauts describe it as **The Big Blue Marble** when looking at the earth from outer space.)
4. Use cans of different sizes as patterns for Jupiter, Saturn, Uranus and Neptune. Remember Jupiter and Saturn are much larger than the others. As the students research each of the planets, they can decide which color or combination of colors will make each planet distinct from the others.
5. The last three planets are called icy planets. Because they are so far from the sun they get very little heat and their temperatures are very, very cold. Some scientists believe there may be other planets farther out in the solar system than Pluto. (Light blue may suggest an icy climate.)
6. Label the planets and indicate their size in relation to Earth.
7. Hang each planet and its name from the ceiling in an auditorium or large room, a distance from the sun as given on the table below. Measure the distances from the sun with a meter stick. Select a room that is large, at least 80 meters on the diagonal; hang the sun in the center and the planets in concentric circles around the sun, but not in a straight line. If no large room is available, you can place the sun and planets on a wall in the hall for other classes to see. You need at least 40 meters from the sun to Pluto.
8. Your planets are now in rough-scale distance from the sun. Close your eyes and try to image how far they really are in space.

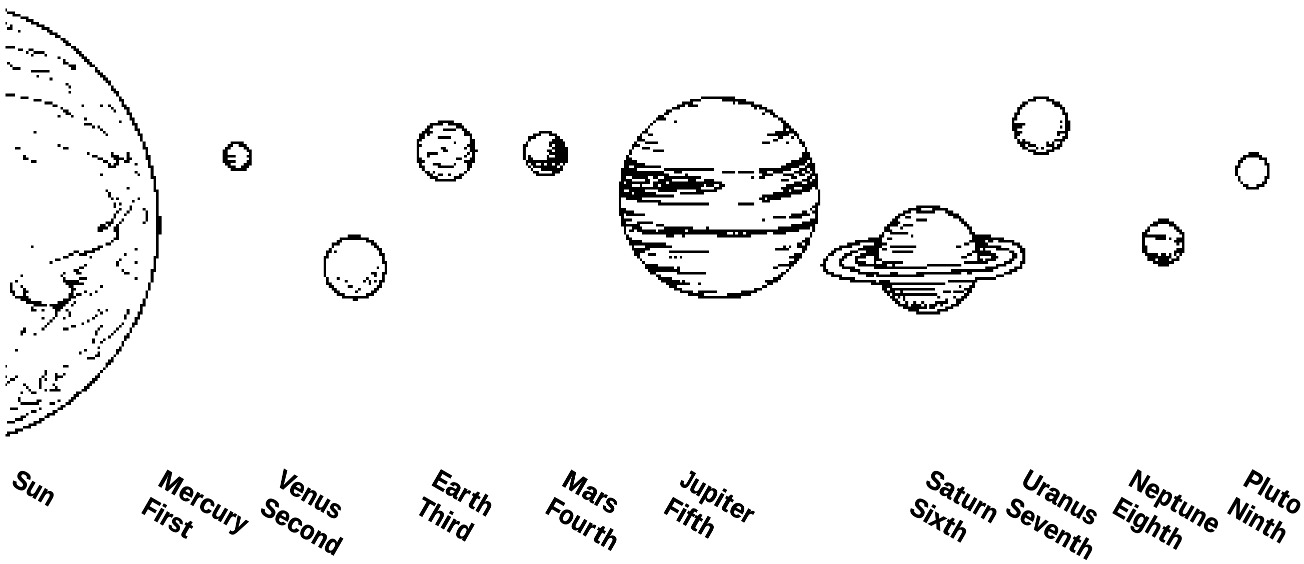
Note to Teacher

The measurements suggested to represent the distance of each planet from the sun were computed by using a unit of distance called an *astronomical unit* (AU). The distance from the earth to the sun, 149,600,000 kilometers (93,000,000 miles), is one AU. The distance of one meter has been assigned to each AU.

*Students can make the sun and the larger planets by inflating a balloon to the desired size and then covering with masking tape. Coat the tape with paper that has been covered with glue and shaped with mountains and other imagined features of the planet.

Planet	Distance from Sun	Relative Size
Mercury	39 centimeters	1 (smallest button)
Venus	72 centimeters	4 (same as Earth - Very large button)
Earth	1 meter	5 (small juice can top)
Mars	1 1/2 meters	3 (slightly larger button)
Jupiter	5 meters	9 (larger than Saturn) largest
Saturn	9 1/2 meters	8 (two times larger than Uranus)
Uranus	20 meters	7 (same as Neptune)
Neptune	30 meters	6 (four times bigger than Earth)
Pluto	39 meters	2 (smallest button)

ACTIVITY
Sequence of Planets in the Solar System (p.3 of Solar System Model)



Locate and hang the planets in a manner that will give a three-dimensional perspective. Do this by not hanging the planets in a straight line. (See Lesson 5, **Activity** — Partial View of the Solar System.)

Students add other details to the model as they wish, e.g., comets, asteroids, etc., as they learn about them in subsequent lessons.

ACTIVITY
Comparing with "Times"

Objective

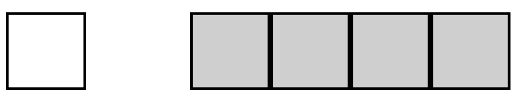
The students describe relative sizes of objects using the word "times".

Materials

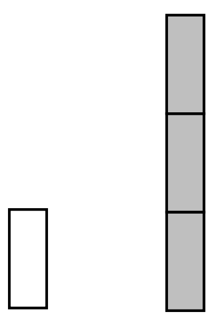
Two transparent containers, one approximately twice as large as the other
Sufficient number of marbles to fill to fill the two containers
Large pictures showing the two areas as shown below
Small plastic bags (or some other transparent containers) to help count marbles

Procedure

1. Place two transparent containers (milk containers, 1/2 gallon or one-liter/three- liter soda bottles) filled with marbles at the front of the class.
2. Students guess the number of marbles in each container and record the guess.
3. After making their guesses for both containers, the students count the marbles by placing them into baggies by 10s, then by 100s.
4. After they have counted the marbles, the students put them back into the containers and label the containers with the number of marbles contained in each.
5. Show students a picture like the following and tell students that the size of the earth can be compared in size (volume) to the sun and giant stars the same way we compared the marbles to the containers.



Tell the students the second picture is four "times" bigger in area than the first (the smaller one) because you can fit four of the small ones on the larger one.



In this illustration, the second picture is three times taller than the first one and has three times the area because we can fit three of the small ones on the large one. You can use the words "times" to compare things using numbers.

Using a PVC or a trading chip board the students "trade" 10 ones for one 10 and "trade" 10 10s for one 100. They say that the 10s place is "10 times" greater than the ones place and each place to the left is "10 times" greater than the place on the right.

ACTIVITY

What Is a Million?

Objective

The student become aware of the number one million by estimating how many volumes of an encyclopedia it would take to read a million words.

Materials

One volume of an encyclopedia (a volume that has few illustrations to make estimates more accurate)
Place Value Chart (PVC)

Procedures

Part 1

As a whole group activity the students do the following:

1. Using a PVC, the students review place value to the highest place studied.
2. The teacher points out that each place stands for 10 “times” the place to the right, e.g. the 10s place is “10 times” the ones place; the 100s place is “10 times” the 10s place, etc.
3. Extend the place value pattern to show the one millions place.
4. Students design a plan to count the letters on a page using the PVC.
5. Discuss the idea of “estimating”. The students’ determination of the number of words in the encyclopedia will be an estimate and not an actual count.

Part 2

1. Working in pairs, students implement the plan to estimate the number of letters in a page, in 10 pages, in 100 pages, and so on, in the volume.
2. The students show the estimates on the PVC.
3. The students estimate the number of volumes it would take to count one million words.

Discussion

The number one million is not large enough to count the stars in the universe.

NOTE

One estimate: in one volume of 1000 pages of the Encyclopedia Britannica 1965, it was estimated that each page (without illustrations) contains 1500 words. The entire volume contains approximately 1000 x 1500 words or 1,500,000. Depending on the print size and the number of pages in a given book, estimates about how many pages it takes to get to one million words will vary.

ACTIVITY

Large Numbers

Objective

Students use a PVC to explain the importance of numbers in everyday affairs and place given large numbers on the PVC.

Materials

Several copies of the daily newspaper
One calculator per student group

Procedures

1. Using the newspaper the students search for and list the uses of numbers in the news stories, ads, etc.
2. The students locate the largest and smallest numbers found in the newspaper and write them out on the PVC*.
3. (Optional step if students have learned to roundoff numbers.) Using the PVC, the students round each number to the largest place shown (or to a given place), e.g. if a house costs $57,500 they round it to $60,000; $213,700 to $200,000; a budget for $2,327,000 to $2,000,000, or to a place given by the teacher.
4. The students say whether the largest number found in the newspaper was exact or an estimate. (What made them make that decision?)
5. Using a calculator the students display the largest number the calculator can accept. Put this number on the PVC. What number does the display show?

***Place Value Chart**

millions	100 thousands	10 thousands	thousands	hundreds	tens	ones

Tell students that in this activity, they will look for large numbers in the newspaper to see how we use large numbers and what these numbers look like written out. Although the numbers students read in the newspaper may be very large, they are not even close to the number of stars there are in the universe.

6. **Discuss:** The number one million is too small to estimate the number of stars in the universe.

LESSON 2 *Stellar Bodies Beyond Our Solar System*

BIG IDEAS Stars, comets, meteorites, novas, and asteroids are only some of the stellar bodies in outer space. We can compare sizes, distances and brightness by using the notion of "times".

Whole Group Work

Materials

Many and varied references on star-planets, space, etc.
Word tags: luminous (compare to Spanish "lumbre" - fire), comet, meteor, nova (compare to Spanish "nueva"), asteroid, meteor, meteorite, sphere

Encountering the Idea

Have you ever thought or heard talk about:
1. the birth of a star? How a new star appears in space? Have you ever thought that if a new star can begin, how can it end?
2. comets that appear quickly and also leave quickly — where do they go?
3. bright lights falling very rapidly to earth that people call "shooting stars"? Are these really "stars"?
4. a space belt called an "asteroid belt"?
5. a "black hole"?

Exploring the Idea

Divide students into at least five small groups. They research and create poster-and-chart reports on one of the following: star, comet, meteorite, nova or asteroid.

At the **Mathematics Center**, students
1. review **Activity** — Comparing with "Times", see **Lesson 1**
2. complete **Activity** — Numbers that Show Direction.

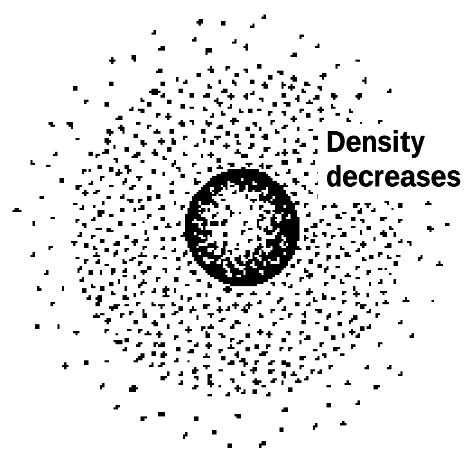
Getting the Idea

After student groups have had time to look for the information and have reported to the class, discuss the following main ideas.

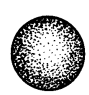
The Major Force in Space — the major force in space behind many of the processes that go on in the universe is gravity. We know that all bodies attract each other in a way that depends on their masses and the distance between them. Hydrogen gas and dust particles form enormous interstellar clouds that begin to attract each other because of these two forces and gradually draw closer together. Eventually (after millions of years) these huge clouds grow so large that the edges collapse inward and separate a huge cloud from the other particles in space. If the developing star has enough material or mass, the core—the center—begins to heat up enough to cause nuclear reactions.

A Star Begins — Stars, scientists believe, form when large masses of cosmic dust and hydrogen gas collect close together somewhere in the universe. When they heat up enough and hydrogen gas begins to burn in a nuclear reaction, a new star begins — it is a nova. Scientists believe that new stars are coming into being all the time. How long a star continues as a star depends on how much mass or material it started out with.

Red Giants — When the hydrogen that is fueling the star's nuclear processes is used up, the core, or center, starts to collapse. As the star grows, the process of turning hydrogen into helium moves away from the core and releases huge amounts of radiant (light) energy. The intense heat of the nuclear reactions causes the star's surface color to change from white to red. When this happens, the star grows into a vast red sphere. It grows so vast it is then called a "red giant." Someday, our own sun will use up its energy and begin to grow to the point of engulfing Mercury, Venus and possibly Earth and Mars, as the sun too becomes a red giant.

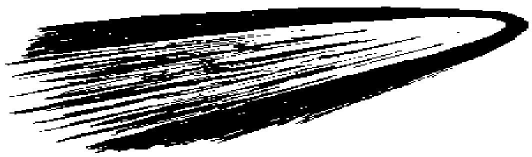


White Dwarfs — When there is no nuclear energy left in the red giant, the star collapses into a small dense star called a "white dwarf." Its atoms pack together so tightly that, in comparison, a sugar cube whose molecules were packed that tightly would weigh thousands of kilograms. Over many millions of years the white dwarf cools and gradually turns into black cinder. This is the fate of not only most stars, but of our sun also.



Black Holes — When a star with a large mass, more than three times the mass of our sun, begins reaching the end of its nuclear burning cycle, it shrinks until it is extremely dense, smaller than a white dwarf, and its gravity increases to the point that not even light can escape its pull. Any matter that comes close to a black hole is sucked into it by its extremely strong gravity.

Comets — Comets are the "different" kinds of members of the space community. They are luminous stellar bodies that may or may not come under the influence of the sun's gravitational field. When a comet's orbit comes near the earth's orbit, it is attracted to earth and we can see it because of its luminosity. Comets are the largest stellar bodies in the universe. A comet consists of its head, mostly condensed material, and as it approaches the sun, it develops a coma, which has hair-like structures that become the tail. Then the comet can be seen from earth with the naked eye. One comet had a tail that stretched to about 28 million miles. Comets, such as **Halley's Comet,** travel in elliptical orbits and have cycles in which they travel close to the earth and we can see them. Halley's Comet comes around about every 75 years. Other comets have parabolic orbits and therefore are seen only once.



Asteroid — Small bodies that are not self-luminous are called minor planets, or asteroids. These are small interstellar bodies that range in size from a few kilometers in diameter to as much as 620 miles or 1000 kilometers in diameter. Many thousands of asteroids orbit the sun between Mars and Jupiter. Some scientists believe these asteroids may have developed when a planet exploded. An **asteroid belt** is any place in space where many asteroids travel in groups.

Meteor — A meteor is a small particle of matter traveling through space that burns up and produces a light and a flash when it encounters the resistance of the earth's atmosphere. If there is sufficient matter in the meteor to survive its entry into the atmosphere, it strikes the earth and digs into the earth, creating a **crater;** then we call it a **meteorite.**

Organizing the Idea.

1. Students make a chart listing at least three known comets and when the comets were last seen.
2. At the **Language Center**, students make a list of root words that they can use later to guess the meaning of new words. For example: Astro, astral, asteroid, all these words mean "planet", or having to do with planets; nova, meaning "new"; etc.
3. Any new information that students have found they add to the model of the solar system.
4. Students give three examples of things or objects that they can compare using 'times". The students make a class chart of these examples. Every new example students can supply they add to the chart.

Using Times

The distance between Uranus and the Sun is ______ times greater than the distance between the Earth and the Sun (See **Activities;** Lesson One.)
Bobby's mother weighs ______ times more than Bobby.
Tomas ran 2 miles and Dolores ran 4 miles. Dolores ran ______ times the miles Tomas ran.

Applying the Idea

1. Suppose we represent the earth by a marble and a small container represents the sun. If **115 marbles** fit into the small container, we can say the sun is _______ **times larger in volume than the earth.** Explain this.
2. Suppose we represent the earth by a marble and the larger container represents a giant star. Then, if **345 marbles** fit into the larger container we can say the giant star is _______times ____________ the earth. Explain this.

Closure and Assessment

1. Given illustrations and models of stars, comets, novas, and other stellar bodies, students identify each and describe their place in the solar system or in the universe.
2. Students list at least two other ways that they can use numbers to show direction, or "opposites".

List of Activities for this Lesson

▲ Numbers That Show Direction

ACTIVITY

Numbers That Show Direction

Objective

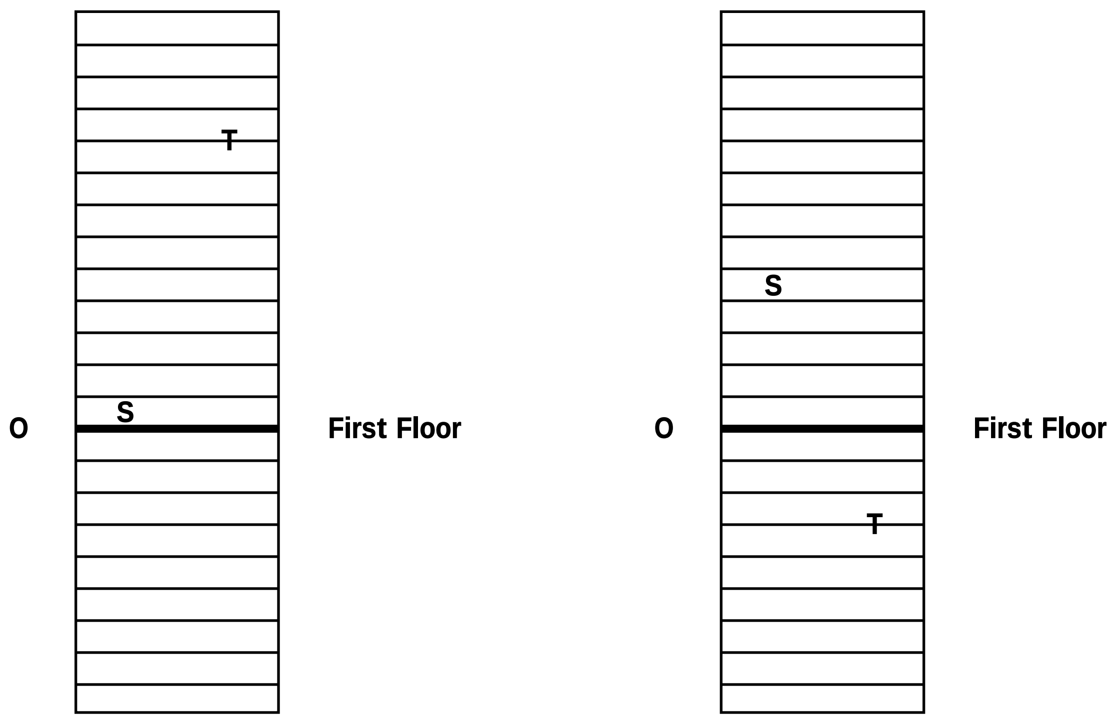
The students explore “directed” numbers by assigning numbers and their “opposites” to a variety of situations.

Materials

Two laminated charts, as shown below, with a square centimeter grid
Erasable markers (two different colors)

Exploration

Tell students they are going to give directions to a friend to help her find a treasure that’s hidden in a very tall building. The **S** is the starting point, and the **T** is the treasure. They are going to use a code so that other people can’t find the treasure. They will use the “secret words” **plus** and **minus.**



Procedures

Students work in groups of three.

1. One student locates the **S** and the **T.**
2. The second student, looking at the map of the building, tells the third student the directions—for example, **Plus 9—**and then erases the **T** so that no one else can see it.
3. The third student was not looking while the second student was looking at the map. Then the third student locates the treasure and puts a **T** on the correct floor.
4. When a student fails to locate the treasure, the students change places and tasks.

5. If the treasure is below the first floor, then the students use “minus” to tell the floor. The treasure in the second example is on **minus three.**
6. If the treasure is on the ground floor then the treasure is at **zero (0).**

After the students have had opportunities to play the treasure game, tell them they are using a new set of numbers. Some of these numbers are not new, for example, nine, three, zero and the other whole numbers students used to play the game. In this new set, however, each number except zero has an “opposite”, as they found out. This new set of numbers helps us give a “direction” such as up or down. These “directed” numbers have many uses besides giving a direction and are called the “integers”.

In using these numbers, we use a “+” (plus) sign for one direction, and a “–” (minus) sign for another direction. Notice that zero is the only number that does not have an “opposite”. The zero is where we begin giving the directions, **not where we are starting.** Where we start from is **S.**

Applying the Integers

1. Use the idea of “directed” numbers or integers to tell a jet plane where it is **above sea level.** Would you use **plus** or **minus** 30,000 feet? Why? (**Above** is usually given the designation of plus, while **below** is usually give the designation of minus.) How would you write this number? (+30,000 feet.) In your journal draw a picture of the jet, label where sea level is and label where the jet is in the air.
2. Use the idea of “directed” numbers or integers to tell a nuclear submarine where it is **below sea level.** Would you use **plus** or **minus** 700 feet? Why? (- 700 feet.) In your journal draw a picture of the sub, label where sea level is and label where the sub is in the water. In using directed numbers, or integers, when the number is a + 30, say, the plus is usually left out. It is **very important,** however, that if the number is - 16, for example, that you include the minus so that people know that you are talking about a level that is below zero.
3. Water freezes at 0˚ C and boils at 100˚ C at sea level. Suppose you read in the newspaper that the day’s low temperature was at - 12˚ C, what does that mean? Was the temperature hot or cold? What else does this number tell you? If you left a can of water outside, would it have frozen?
4. You look at your room thermometer and it reads 30˚ C (about 90˚ F). What kind of clothes are you going to wear?
5. In the wintertime, you go skating on some water that froze overnight and made a big frozen puddle. What is the temperature of the water? Choose one or more of the numbers that **could show** the water’s temperature. 0˚ C, or is it + 15˚ C, or is it - 5˚ C? Explain your choices.
6. If a star’s surface temperature is 20,000˚ C, what can you say about the star? If a star’s surface temperature is - 200˚ C, what can you say about the star?

LESSON 3 *Stars Produce Their Own Energy*

BIG IDEAS We can see stars with a telescope because they emit self-produced energy; this energy travels as light for millions of miles and for millions of years.

Whole Group Work

Materials

Book: **Energy from the Sun** by M. Berger
Flashlight or candle
Balloon covered with aluminum foil
Mirror
Word tags: reflect, absorb, telescope, horizontal, vertical

Encountering the Idea

Darken the room as much as possible. Flash a light and place the lighted candle near the aluminum-covered balloon. What do the students see? Is the light coming from the balloon? No, it reflects from the flashlight or the candle.

In the darkened room, hold a mirror to reflect the light of a flashlight, the candle or a match. Ask students to say where the light is coming from. (The mirror, match and the flashlight.) Is the mirror producing the light? No, the only thing that is producing light is the flashlight. The mirror only **reflects** the light. Take the batteries out of the flashlight. Ask what makes the flashlight give off light. (The batteries turn on the lightbulb.) Ask the students what makes the sun shine. (It generates its own energy through atomic processes that do not normally occur on earth.) What makes the moon shine? (It reflects light.)

Did the balloon produce its own light? Do human beings produce their own energy? (No, we have to get our energy from the food we eat.) Do plants produce their own energy? (No, plants produce their own food, but they produce it by using the energy from the sun.) Do animals produce their own energy? (No, they must eat food — they eat plants or they eat other animals.) In other words, the only thing that produces its own energy is the sun.

Exploring the Idea

At the **Mathematics Center**, the students begin **Activity** — Star Data.

At the **Science Center**, the students

1. complete **Activity** — Star Energy
2. complete **Activity** — Star Color Chart.

Getting the Idea

After students have completed the activity working with objects that emit or reflect energy in the form of light, we can see there are very few things in the universe that produce their own energy — stars generate their own heat and light, but other objects, including stellar bodies, only reflect the light.

1. Do human beings reflect light? How do you know? (If we didn't reflect light we couldn't see each other.)
2. Can a human being absorb light? How do you know? (When we sit out in the sun we get very hot.)
3. How do Venus, Mars and Mercury appear from outer space? (These planets look bright to our eyes because they reflect light. Since planets only reflect light, we can only see that part of the planet the sun is shining on. We say that the moon has a "dark side" because we can never see that side of the moon when the sun is shining on it.)
4. Does the sun have a "dark side"? (No, it shines in every direction because the sun is burning hydrogen all over its entire surface.)

Organizing the Idea

Students make a list to classify stars using color, brightness, temperature and distance from earth as descriptors. Using this preliminary list, students make a chart to add important information to as they receive it.

Stellar Body	Energy Type	Size	Color	Temperature
Star Sun Giant Dwarf			 yellow	 6100

The students make a list of the things that we have to count in millions, and things that we don't need large numbers to count. For example: people on earth, ants on earth, grains of sand, and so on. Every time they think of something that we count in millions, they add it to the list, as they add things that we count with small numbers.

Things we count in millions	Things we need small numbers to count
grains of sand	money in my piggy bank
people	my pet goldfish
insects	houses on my block
money	

At the **Writing Center**, students write and draw about the idea: The number one million is too small to count the number of stars in the universe.

Applying the Idea

The reflection of light is very important. As we said before, if things were not able to reflect light, we would not be able to see them. This is an important idea in several ways:

1. Why do football players wear dark coloring under their eyes when they are playing? (Dark coloring decreases the reflection from the sun in daylight or the stadium lights at night.)

2. Why do soldiers put dark color on their faces at night? (So their faces won't reflect light.)
3. Why do skiers were very dark sunglasses? (The glare of the snow is very bright.)

Something to think about

Do you think plants can grow on Mars? Take a position yes or no, and defend it.

Closure and Assessment

1. Will the sun run out of fuel to produce light at some point in time? What do you think of this idea?
2. How big is a million? Is the number one million big enough to count the stars in the universe? Do you think there might be a number that is large enough to count all the stars in the universe? Tell your partner about that number, if you think there is one.
3. What would happen to Earth if the light from the sun no longer reached Earth? Explain your reasons.

List of Activities for this Lesson

▲ Star Data

▲ Star Energy

▲ Star Color Chart

ACTIVITY

Star Data

Objective

The student uses a chart to compare given numbers by identifying each place value of the digits of the given numbers.

Materials

Copy of the chart given below for each student group.

Chart

STAR	TEMPERATURE in C°	DISTANCE in Light Years from Earth	TIMES BRIGHTER than Sun
SUN	6,100	3/20[2]	
Sirius	10,700	9	20
Canopus	7,700	99	1200
Alpha Centauri	6,500	4	1
Arcturus	4,800	36	90
Rigel	12,100	815	40,000
Betelgeuse	3,500	489	11,000
Beta Centauri	21,300	293	33
Alpha Crucis	21,300	391	2,700
Antares	4,300	293	4,400
Beta Crucis	22,300	489	4,800
Procyon	6,800	11	about 1
Deneb	10,200	1402	40,000

Problems

1. What is the **hottest** star listed and what is its temperature?
2. What is the **coolest** star listed and what is its temperature?
3. How many **times hotter** is Alpha Crucis then Deneb?
4. What is the **farthest** star? How far is it in light years?
5. What is the **closest** star? How far is it in light years?
6. What is the **difference** between the temperature of the hottest and coldest star?
7. What is the **difference** between the temperature of the hottest and medium stars?
8. What is the **difference** between the temperature of a medium star (Sirius) and the coldest star (Betelgeuse)?
9. How can you tell these temperatures and distances are only estimates?
10. Which are the **brightest** stars? Are they much brighter than our own sun? How do you know?
11. What does it mean when a star is **five times** brighter than the sun? (The light of five suns equals the light of that one star.)

[1]The Light Year is a standard of measure of distance. It is the distance light travels in one year. Since light travels at the speed of 670 million miles per hour, one light year equals 670 million miles x 24 hours x 365 days (an earth year), or about 5,900,000,000,000 miles.

[2]Since the earth is 93 million miles from the sun, it takes the light from the sun about 0.15 hour to travel from the sun to the earth — about 3/20th of an hour.

Discussion

1. Suppose that star, **Star Light,** has a surface temperature of 3000˚C. Another star, **Star Bright,** has a surface temperature of 21,000˚C.
2. Which of the following comparisons would you use? Star Bright is 18,000˚C hotter than Star Light. Star Bright is seven times hotter than Star Light.
3. Which comparison uses subtraction? What does that comparison tell you?
4. Which comparison uses multiplication? What does that comparison tell you?
5. Which method of comparison would you select and why?

TEACHER DEMONSTRATION

Star Energy

Objective

The student will say that the energy large stars produce is many times greater than the energy from our own sun.

Materials

Pictures of the stars in the night sky, of large, bright stars
Powerful magnifying glass; mirror; crumpled tissue paper

Procedures

1. Place a crumpled piece of tissue paper on a pie plate.
2. Using the magnifying glass, shine a ray of sunlight on the paper.
3. Focus the glass to a very small area on the tissue paper and then raise the glass slowly.
4. Students describe what happens to the tissue paper. (It will suddenly catch on fire and burn.)
5. Repeat the experiment, but this time instead of shining the sunlight directly on the tissue paper, first, focus the ray on the mirror and then reflect the ray from the mirror onto the paper. Students discuss what happens.

Getting the Idea

Our own sun shines on earth for several hours each day giving us large quantities of light and heat. Stars larger than our sun send out much more energy because they are many times larger than the sun. We don't see the light and feel the heat from those stars because they are millions and millions of miles away. We can see only small dots of light that have traveled that immense distance.

1. What do you suppose it would feel like on earth if Alpha Centauri took the place of our sun in the solar system?
2. Do you think we would feel the heat?
3. How many times hotter do you think it would feel here on earth?
4. What two things do we have to look at on the chart to answer these questions?

ACTIVITY

Star Color Chart

Objective

The student classifies stars using color as one indicator of their stars' differences in surface temperature.

Materials

Copy of the Star Color Chart, as below, for each student

Star Color Chart

Star Type	**Temperature K**	**Color**	**Examples**
Super Giants	20,000 to 50,0000	Blue	P Cygni
Giants			Antares
			B Centauri, Aldebaon
Dwarf	10,0000	White	Deneb, Serius B
Nova	An average star that suddenly leaves the main sequence and explodes becoming very luminous, then fades back to its original luminosity.		
Main Sequence (medium, average)	6 - 7,0000	Yellow	Sun, Procyon, Altair Centauri A, Cygni A
	4,5000	Orange	Arcturus
Pulsating	Alternating between hotter and colder		
Red Giants	2 - 3,3000	Red to very red	
Dwarf	-2500	Black (cinders)	
Black Hole	A collapsed star with such immense gravity that it swallows its own matter. The star becomes a black hole because no visible light can escape from its gravity's pull.		

Applying the Idea

1. Using your Star-Data Chart, classify as many of the stars as you can, such as white dwarfs, super giants and so on, using the star color chart. Try to guess what color they would show.
2. Problem: Many times we can identify the planet Mars as a bright red light in the night sky. Why does it look red? Is it a red giant? (No, Mars is not a red giant star; it is a planet that reflects red light.)

LESSON 4 *Our Sun Is a Small Star*

BIG IDEAS Living things exist on Earth because of sun energy. We can see stars as light that has traveled for millions of miles.

Whole Group Work

Materials

Book: **Millions of Cats** by W. Gág
Chart - Star-and Moon-Gazing
Reference books on the sun in our solar system
Word tags: corona, stars, stellar bodies, chromosphere

Encountering the Idea

Students report on what they observed the previous night. The students use the information they recorded the night before on their charts. Ask if all the lights looked the same. Ask if any of the stars looked red, yellow, blue? Did they differ in size, color and brightness? Why do you think these lights in the sky appear different — some in size, others in color and so on?

This lesson will focus on the only star in our solar system — the sun. What do we know about the sun, so far? As you give us these facts we'll write them on a list to use later to finish our solar system model. Write the suggestions on word strips.

Exploring the Idea

At the **Mathematics Center,** the students complete **Activity** — Star Candle-Power.

At the **Science Center**, students

1. complete **Activity** — Plants and Sunlight
2. complete **Activity** — An Energy Cycle
3. complete **Activity** — Star Types.

Getting the Idea

In these activities, we find that not all the lights that shine in the sky are what we call stars. As we learned in the first lesson, some stellar bodies emit, or send out, their own light, like our sun; but other stellar bodies only reflect light, like our moon. But even among the stars themselves, there are differences that make them appear different to us in the night sky.

For example, some stars are close to the earth, and some are very far. Scientists have been able to estimate the distance of the stars by the amount of light that reaches the earth, by the color of the light that reaches earth, and because scientists have been able to calculate the speed of light.

We can compare stars by size using large numbers and multiplication, or "times", using one of the stars as the unit, or as the reference. As we learned, some stars are dwarfs and some are giants, and still larger ones are supergiants when compared to other stars.

Stars also differ in color and brightness. The differences we see are related to the stars' distance from earth and to their temperatures. What experiment helped us understand that the brightness we see depends on the distance of the star?

We can see stars through a telescope because they produce and emit energy as light. That is the main characteristic of a star — **it produces its own energy through a process of changing matter into energy.** The amount of energy produced in this process of changing matter into energy makes the stars different in brightness, temperature and color.

Our sun is only one of millions of other suns. It is small in size — compared to the giants and supergiants. Because our sun is of average temperature, we classify it as a yellow star. As you learned, other stars we call white stars, and others are blue stars, but **all of them** make and emit their own energy.

Organizing and Applying the Idea

Students draw and/or write about:

- the ways planets and stars are alike or different
- what the difference is between an asteroid and a comet
- what a "shooting star" is.

Students make a chart listing the properties of the sun.

Closure and Assessment

1. Is the earth a star? Explain.
2. Is the moon a star? Explain.
3. When you look up at the sky at night and see a very bright light, can you tell whether it is a star, a moon or a planet? Explain and/or draw your opinion.
4. What can you say about how the sun compares to a giant star? Is it two times larger? Is it three times larger? How do you know?
5. Have the students look at the scale-model of the solar system and describe the relative sizes of the planets using the word "times".
6. Will the sun run out of energy to make light? What do you think of that?

List of Activities for this Lesson

▲ Star Candle-Power

▲ Plants and Sunlight

▲ An Energy Cycle

▲ Star Types

ACTIVITY
Star Candle-Power

Objective

The student says that the closer a light source is to an object, the more light the object will receive, and it will look brighter.

Materials

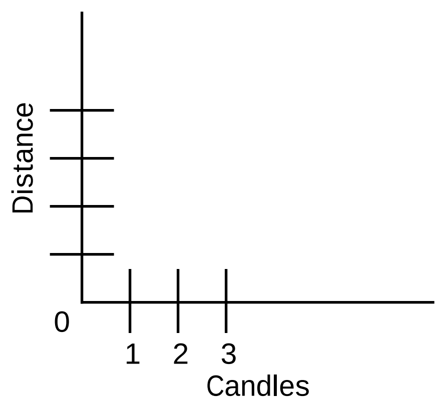
Several candles of the same size; tape measure
Chart to record number of candles and distance; chart to make a graph

Procedures

Darken the classroom as much as possible.

1. One student sits at one end of the classroom holding and looking at a picture with letters written on it. (Student's name, for example.)
2. A second student holds one candle close enough for the first student to be able to see the letters.
3. The second student moves away from the first student slowly and stops when the first student says it is hard to see the letters. Measure and record the distance between the candle (light source) and the observer (the first student).
4. Repeat the same procedure using two and then three candles that are tied together to make a single source of light. Measure and record the distances.
5. Students discuss the effects of distance on the amount of light received. They make a graph of the data and summarize their conclusions in their journals.

Number of Candles	Distance from source of light to observer
1	
2	
3	
4	



Getting the Idea

1. Why can we see light from a star that is millions of miles away? (Stars emit a lot of heat and light; we cannot feel the heat of faraway stars, but we can feel the heat from the sun.)
2. Are there stars in the sky that we don't know about? If you say yes, explain your answer, and if you say no, explain that also.

Problem Solving

You see two stars in the night sky. They look exactly the same size to you but one is brighter than the other. What can you say about the two stars? Are they the same distance from earth? Is one star hotter than the other? Explain.

ACTIVITY
Plants and Sunlight

Advance preparation

In preparation for **Activity** — Plants and Sunlight

1. Students bring several plants to class or plant some beans in several pots. Keep one half of the pots in the sunlight and the other half in a closet or some other dark place.
2. Place two small dishes with water in a sunny place; place two small dishes with the same amount of water in a dark place.

Objective

The students say that plants need sunlight, or star energy, to produce their own food; all other living things on earth need food from plants or from animals that eat plants.

Procedures

1. Students list the types of food various living things (animals) eat.
2. What do plants eat? (They make their own food through **photosynthesis.**)
3. Examine the bean plants. Describe the difference between those kept in the sun and those kept in a closet.
4. Students describe what happened to the water left out in the sun and water left in a shady place.

Discussion

1. The maximum surface temperature of Earth is 140° F. The maximum surface temperature of Mars is 50° F. The maximum surface temperature of Venus is 800° F. Do you think a human being or an E.T. could live on Mars? Without protection? With protection? On Venus? With and without protection? Why?
2. If there is life on Mars or Venus, would it look like an earth human being? Why? Why not?

ACTIVITY
An Energy Cycle

Objective

The students describe the sequence by which energy from the sun becomes a very important source of energy on earth as coal and oil.

Materials

Picture of a mature tree
Encyclopedia for children to read about how we produce oil and coal

Procedures

1. Show the picture of the mature tree to students. Ask them to find out how long it takes a tree to grow to maturity to begin producing new trees.
2. The students draw and label an energy cycle that includes: energy from the sun as light, converting to plant food energy through **photosynthesis** in green trees; dead trees becoming oil and coal over millions of years; the coal and oil being used as fuel in homes and in industry.
3. Students name other sources of energy. (Natural gas and gasoline that is a distilled product of oil are also products of the process that made oil and coal; we use coal and/or oil to generate electricity.)

Getting the Idea

Are coal, natural gas and/or oil replaceable? Why can they not be replaced? (The process that produced them practically stopped long ago; there are, however, peat bogs that are currently producing oil, but it is a very slow process. We are using up oil and gas much faster than it can be produced.)

Discuss with the students that every important source of energy on earth can be traced back to the energy that is received from the sun. Discuss the idea that many houses and other buildings now have solar collectors placed on their roofs to collect sunlight, to convert it into electricity.

ACTIVITY
Star Types

Objective

The students make comparisons using charts.

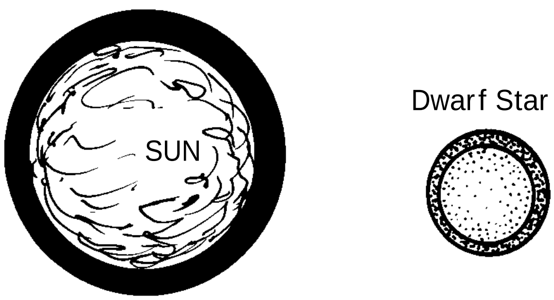
Materials

Copy of the STAR TYPES Chart

STAR TYPES

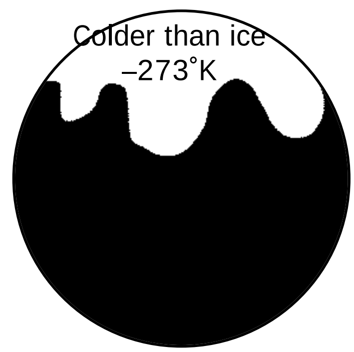
Dwarf Star

A star of small size, low mass, low brightness



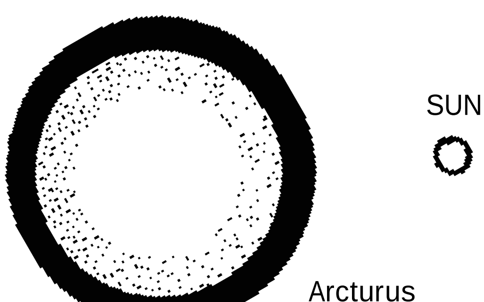
Black Dwarf

A star in its final stage of life, a low energy source emitting no visible light.



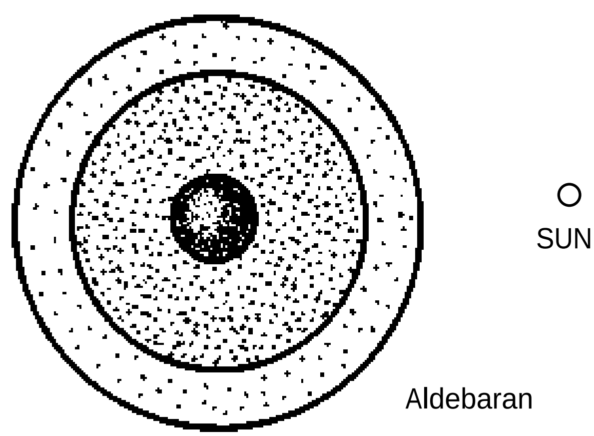
Giant Star

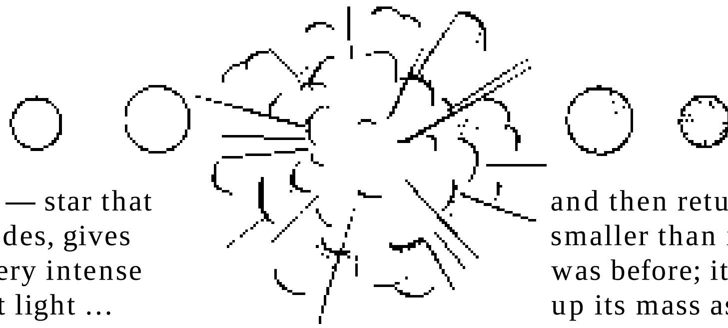
Large size and high brightness



Red Giant

Large, hundreds of times brighter than the sun, but has cooled.





Nova — star that explodes, gives out very intense bright light …

and then returns smaller than it was before; it used up its mass as it changed into light

The Life Cycle of a Star

A. Star is born

B. Star continues in average class

C. Star leaves average class

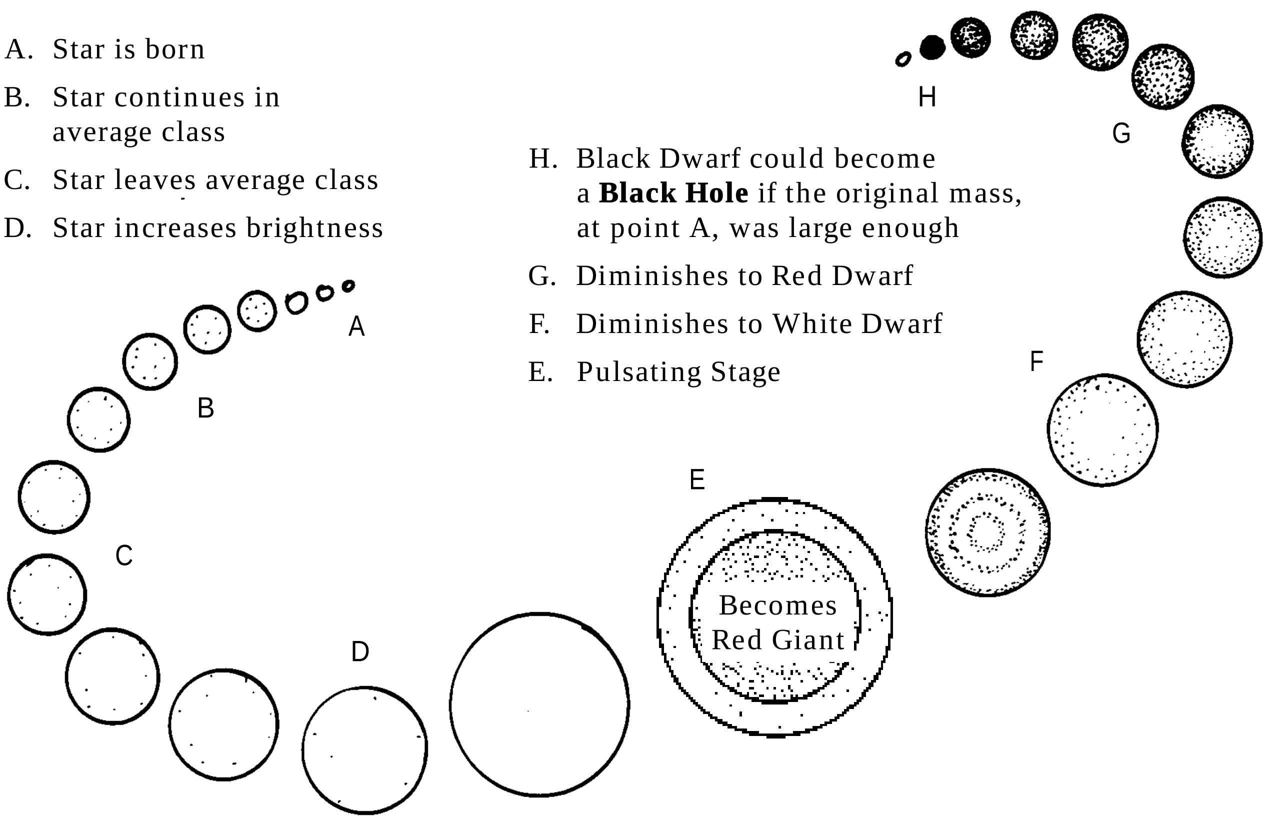
D. Star increases brightness

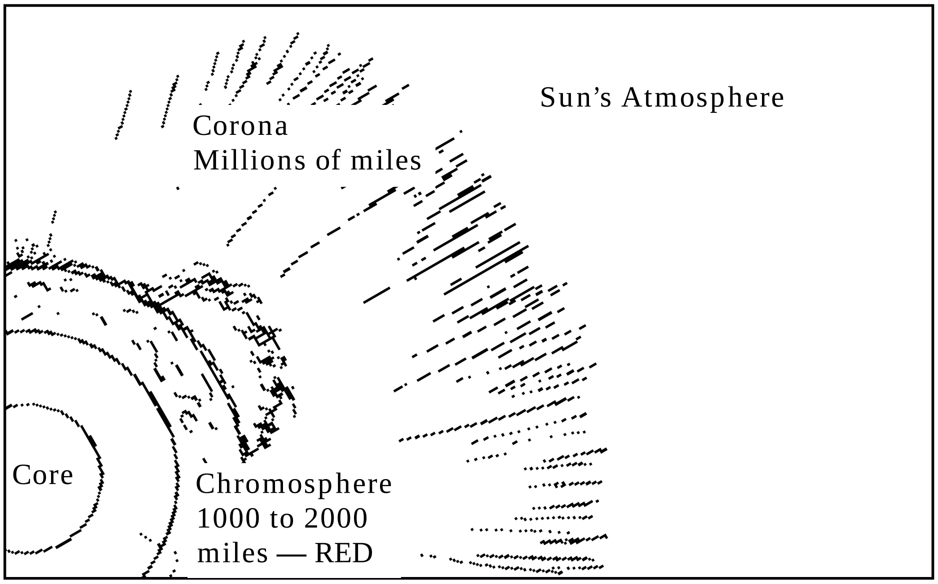
H. Black Dwarf could become a **Black Hole** if the original mass, at point A, was large enough

G. Diminishes to Red Dwarf

F. Diminishes to White Dwarf

E. Pulsating Stage





The Sun

Application

Students use the information above and read in reference books to answer the following:

1. Using a picture similar to the one above, write a paragraph describing the core, the chromosphere and the corona of the sun, or
2. Design and complete a chart to compare the sun to other stars in color, size, brightness and distance from earth, and then write a paragraph or make a drawing and label it, or
3. Describe the sun in as many ways as you can.

LESSON 5 *Our Sun's Family — The Planets and Their Satellites*

BIG IDEAS The sun in our solar system has nine planets traveling in elliptical orbits around it.

Whole Group Work

Materials

Model of the solar system that includes the earth's moon; this can be a commercially made model to demonstrate the relative motions or the model(s) made by the students during **Lesson One**

Chart for students to draw the solar system in their journals

Word tags: names of the planets, static, dynamic, elliptical, orbit, path, sphere, sidereal

Encountering the Idea

At night when we look up at the night sky, we find it difficult to distinguish many of the things we see, one from the other. We can, however, see that the points of light have different brightness and that they are different in size. The one stellar body we can see without difficulty, if there are no clouds, is the moon. Night after starry night, the sky appears very much the same. But the night star picture does change. The moon travels across the sky quickly, while other stellar bodies take months for their motion to be noticeable.

One question all ancient people have asked: How do the planets stay in their paths, or orbits, all the time? Why doesn't one planet or star just fly off into outer space. What binds the planets to each other and to the sun? In this lesson, we will study the forces that keep stellar bodies in their orbits.

Using a model of the solar system, name the planets in order of their distance from the sun. See **Activity** — Planet Data. Describe their size, their distance from earth and other details students have researched. Tell the students that in reality the planets and the sun itself are moving at very high velocities. The **awesome** thing about their movement, however, is its regularity. We know that the earth's gravity attracts the moon, and the moon's gravity affects the earth, **BUT** the moon does not fall on earth, the earth does not fall into the sun, and the sun comes up every morning. What keeps all the planets in their orbits? What kinds of orbits, or paths, do these stellar bodies follow? We will learn about the shape of the orbits and also what forces keep the stellar bodies in the universe in their place.

Exploring the Idea

In order for the students to complete **Activity** — How Planets Stay in Orbit, they go into the playground or to a large space where they can swing a tennis ball and not cause damage.

At the **Science Center,** the students complete **Activity** — Stellar Bodies that Reflect Light.

At the **Mathematics Center,** the students

1. complete **Activity** — Closed Paths (this activity gives students the background they need to complete the activities on orbits)
2. complete **Activity** —Elliptical Orbits
3. complete **Activity** — Parabolic Orbits.

Getting the Idea

If the class has made the model of the suspended planets, talk to the students about the model being static — it does not move. A moving model would be called a “dynamic” model.

When planets move, they move, as we know, around the sun. The earth takes a little more than 365 days to make its journey around the sun. This is its sidereal period. But, what is the path of the earth? Is it a circle?

In the year 1500, Copernicus claimed that the earth traveled around the sun in a circle. Another astronomer and mathematician, Kepler, claimed that the orbit was an ellipse. Scientists today believe the orbits are elliptical for most of the stellar bodies. As we said, some comets travel in elliptical orbits, but others travel in parabolic paths, and we see those comets only once. Why? (Parabolic paths are not closed paths.)

Remember, we have said that the major force dominating the movements of the stellar bodies is the gravitational force the bodies exert on each other. In rotating the tennis ball, you experienced two forces at the same time — one is the velocity of the tennis ball as you make it rotate around you, and the other force is the string that is keeping the ball from flying away. Those two forces keep the stellar bodies in their place.

Next time you go to an ice skating show, or see one on television, notice what the skaters do **to stop** after they have been whirling around very fast**.** When you see this, see if you can make a guess as to what forces are acting on the ice skater.

Organizing the Idea

In your journals, describe how the tennis ball felt as it was rotating around. Describe its path when you released it. Draw the path in your journal.

Make a chart of the different geometric curves we have looked at in this lesson and write an illustrated description of each figure: ellipse, circle, parabola.

Students make a chart to compare the various stellar bodies after reading about them in reference materials.

Stellar Body	Description/Classification	Average Size	Average Temperature
Planet			
Satellite			
Meteorite			
Comet			
Asteroid			
Black Hole			

Applying the Idea

1. Think about the activity of the rotating tennis ball. If you were a rocket scientist, how would you design your rocket so that it would escape the earth's gravity? (It would have to have a very powerful engine to go fast enough to escape the pull of the earth's gravity.)
2. Make several paper cones as you did in the activity with the parabola, and try to make other figures by cutting through the cones in different ways. Try putting two cones together, peak to peak, cut through two cones at a time and see what happens.

Closure and Assessment

Students draw and/or write about

- the way planets and stars are alike or different;
- the difference between an asteroid and a comet;
- what a "shooting star" is.

Student groups select and write or dictate illustrated reports with information from any of the activities they have completed. All of the reports can become a Big Book for their class library.

After showing the charts with information on the planets, discuss the distance of the planets from earth, again in terms of large numbers. How far is the nearest planet? How do we know how far it is from earth?

List of Activities and Appendix for this Lesson

▲ Planet Data

▲ How Planets Stay in Orbit

▲ Stellar Bodies that Reflect Light

▲ **Appendix—**Partial View of the Solar System (from Saturn)

▲ Closed Paths

▲ Elliptical Orbits

▲ Parabolic Orbits

ACTIVITY
Planet Data

Students use this chart to compare the planets and to help them complete their mural.

	Mercury	**Venus**	**Earth**	**Mars**	**Jupiter**	**Saturn**	**Uranus**	**Neptune**	**Pluto**
Distance in millions of miles from sun	36	67	93	141	484	893	1767	289	3674
Diameter (Mi.)	3000	7,600	7,927	4,200	88,700	75,100	30,900	33,00	3,600
Diameter Earth=1	1/3	1	1	1/2	11	9	4	4	1/2
Mass Earth=1	1/10	1	1	1/10	317	95	15	18	?
Volume Earth=1	1/10	1	1	1/10	1,318	736	50	42	1/10
Period of Rotation	59d	243d	24h	25h	10h	11h	16h	6d	24d
Sidereal Period (around sun)	88d	225d	365d	2y	12y	29y	84y	165y	248y
Surface Gravity Earth=1	1/3	1	1	1/3	3	1	1	1	1/3
Known Moons	0	0	1	2	12	10	5	2	0
Max. Vel. Mi./Sec.	30	22	19	15	8	6	4	3	3
Maximum Surface Temp. (F)	640	800	140	50	-215	-240	-280	-300	-370

h = earth hours; d = earth days; y = earth years

ACTIVITY
How Planets Stay in Orbit

Objective

Student demonstrate with a string and a weight how the gravitational pull of the earth balances with an object's tendency to move in a straight line to stay in orbit around the sun.

Preparation

Conduct this activity outdoors to permit students to make several types of observations. Take care when releasing the ball that students are careful to stay out of its way.

Materials

Several pieces of heavy string about three to four yards each
Several tennis balls — one per student pair

Procedures

1. Tie a tennis ball securely on the string.
2. Students take turns swinging the ball in an arc over their heads. Each student is to notice how the tennis ball feels as it swings around in a circle.
3. The student holds the string securely in her/his hand as it swings and then releases **the thumb only.** They describe how the ball feels.
4. Tell the students that after they get the ball swinging, they are to release it. **Before they release the ball,** the students **predict** the trajectory of the ball from the moment they release it to the moment it lands. They check their predictions and discuss why they were correct or incorrect.
5. Students compete to see who can send the ball the farthest. Later they describe what they had to do to get it to go as far as possible.
6. Tell the students that they are now going to swing the ball **as slowly as possible.** They are to predict what will happen. Who can swing it the slowest?
7. What force keeps the tennis ball from falling? (The velocity of the ball as it goes around its orbit.)

Organizing the Idea

1. In this activity of the rotating ball, what does the string represent? (The pull of the sun's gravity.) What does the tennis ball represent? (The earth.)
2. Could the string represent the earth's gravity and the ball represent the moon?
3. Are all planets and satellites kept in their orbits in a similar way?
4. What happened when you didn't swing the ball hard enough? Yes, it fell to the ground.
5. What would happen to the moon if it began to slow down?
6. What would happen to Pluto if it started to speed up?

Remember

The two forces — the velocity of the planet and the strength of the gravitational attraction of the sun — have to be in balance for the planets to stay in orbit.

ACTIVITY
Stellar Bodies that Reflect Light

Objective
The students experiment with materials that emit, reflect and/or absorb light and categorize them correctly.

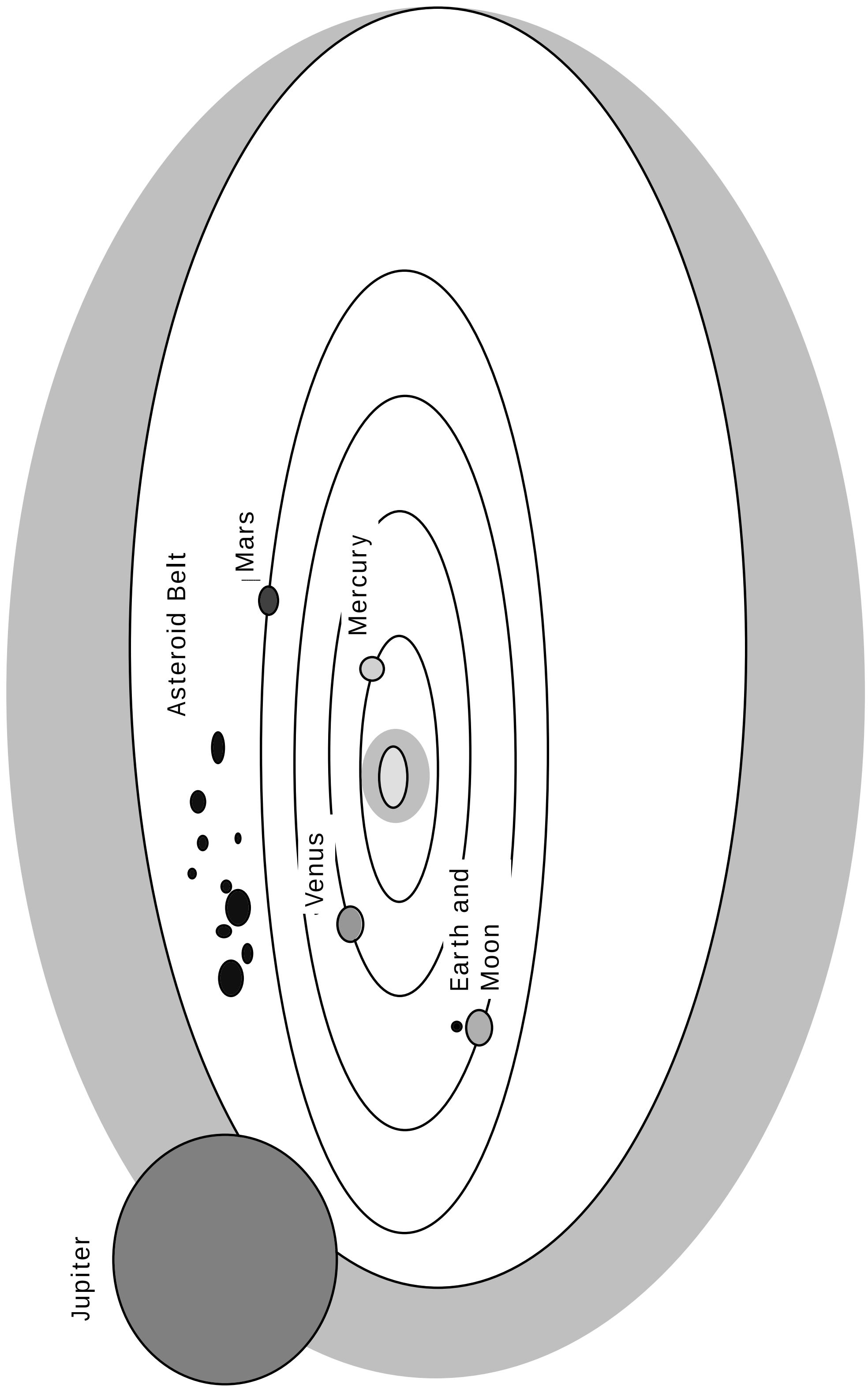
Materials
Flashlight; aluminum foil; black and white construction paper; match; candle; wax paper; mirror; ceramic tile; glass; other objects that emit light
Inflated balloon covered with aluminum foil

Procedures
Students work in small groups.

1. Students categorize objects as those that emit, reflect or absorb light.
2. Students justify to each other why they classified each object as they did. When objects reflect light do they shine all over or just in some places? (They shine only where they reflect the light.)
3. When do you know that an object is absorbing light? (It gets warm, hot.)
4. Can we classify some objects in more than one category? Can an object reflect and absorb light at the same time? (Even though some objects reflect light, they also absorb it. If the students cannot give an example, ask: Have you walked barefoot in the summer on hot dirt? Have you walked on the sidewalk and on a street paved with black asphalt? Why is the dirt hot? Which was hotter — the dirt, the sidewalk or the black asphalt? Why? Does earth reflect or absorb sunlight?)
5. Can any of these objects make their own energy?
6. Darken the room as much as possible. Using a flashlight and the aluminum covered balloon held at a distance, the students shine the light on the balloon. Is the balloon emitting its own light? (It is just reflecting it.)
7. Some of the students stand behind the balloon as the sun is shining on one side of it. Is the balloon reflecting light from the other side? Why? (It's getting light from only one direction.)
8. If the balloon is the earth and the flashlight is the sun, why can astronauts see the earth from the moon?
9. Take the batteries out of the flashlight. Does it turn on? What gave it its energy (the batteries).
10. Place a sheet of black construction paper and a white sheet in a sunny place. After several hours the students touch each sheet and report. Does paper reflect or absorb light? (Both; the black sheet, however, gets hotter — it absorbed more heat.)

APPENDIX

Partial View of the Solar System (from Saturn)



ACTIVITY
Closed Paths

Objective

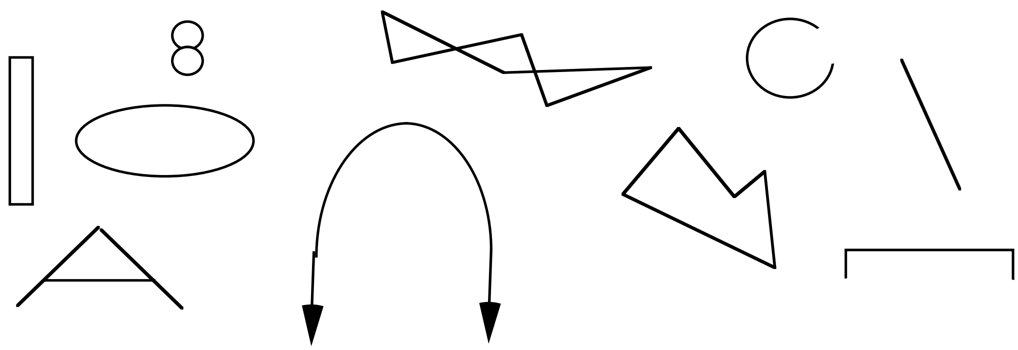
The student names at least two geometric figures that form closed paths and describes a geometric figure that is not a closed path.

Materials

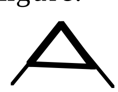
Copies of the figures shown below

Procedure

1. Show students the following geometric figures and ask them to categorize them in any way they wish:



2. After the students have mentioned several ways to categorize the figures, if they have not suggested it, point out that some of the figures are **closed.**
3. What do they think a closed figure is? Yes, the rectangle is closed and also the ellipse. The figure that looks like part of an arrow is also closed.
4. The part-rectangle is not closed, nor is the figure that looks like the letter C or like an open circle. The horseshoe figure is not closed. The arrows show that the figure continues indefinitely in those two directions and will not come together again.
5. The figure that looks like the number “8" is also closed, because you can trace it with your pencil — start at one point and go all around it and get back to the beginning without lifting the pencil.
6. A line segment is not closed.
7. The figure with the zig-zags is also closed. The figure that looks like the letter “A" has one part that is a closed figure.

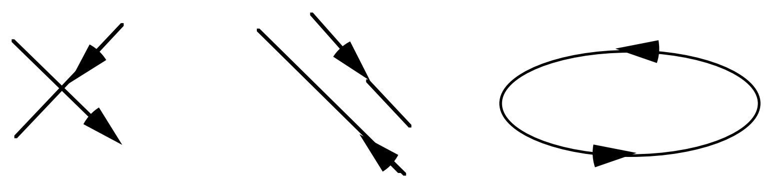


Application

1. Which of the letters of the alphabet (use capital, printed letters) do you think are closed? Which ones are not closed? Which have a part that is closed? Make a list and see.
2. Are there more letters that are closed or are there more letters that are not closed?
3. Which of the numerals zero through nine are closed? Not closed? How many more?

Remember
If you can trace a figure with the tip of your pencil beginning at one point all the way around and get back to the beginning without lifting your pencil, then the figure is closed.

Problem
A dog and a cat are walking on the paths shown in these three pictures. If the dog and the cat meet, they will fight. Where do you think there will be a fight? Explain your reasons. Remember, the arrows **points in the direction in which the dog and cat can walk,** the arrows show where they are, and they can't walk backwards.



Discussion
The only path where there can be a fight is in the last figure. If one of them stops or one goes faster than the other they will meet. The dog and cat will not meet in the first figure because one of them has passed the only point where they could meet. In the middle figure, they can never meet because there are no common points.

ACTIVITY
Elliptical Orbits

Objective
The student draws a circle, an ellipse as an elongated circle and an ellipse using two focal points.

Materials
Large sheet of paper; large piece of cardboard placed under the paper
One seven-inch piece of string and one 24-inch piece of string, tied end-to-end to form a loop
styrofoam cup; pencil; thumbtacks

Procedures
Part 1

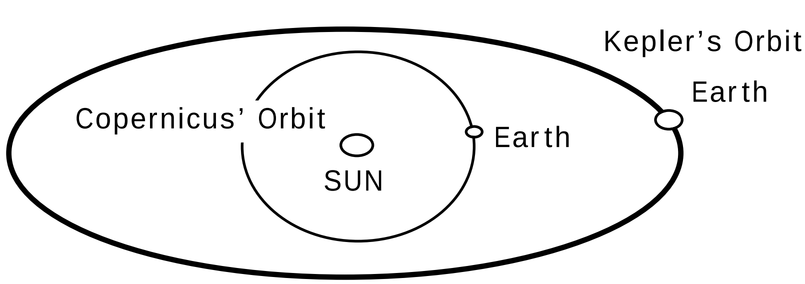
Drawing a circle and an ellipse with a cup.
1. Trace the mouth of a styrofoam cup on a piece of paper.
2. Using the same styrofoam cup, gently squeeze it into an elongated circle. Trace the mouth of the cup in its elongated form.

Part 2

Drawing a circle with a piece of string.
1. Place the large sheet of paper on the cardboard. Draw a picture of the sun (measuring about one inch in diameter) in the center of the paper.
2. Tie the seven-inch piece of string securely to the pencil in a position slightly above the point. Secure the other end of the piece of string to the center of the sun.
3. With the point of the pencil, draw a circle around the sun using the thumbtack as a pivot point.

Part 3

Drawing an ellipse with a piece of string.
1. Press two thumbtacks about eight inches apart into the paper and cardboard on the same line across the picture of the sun.
2. Place the loop of string around the thumbtacks.
3. Place the pencil, tip down, inside the loop of the string and, keeping the string taut against the pencil, draw an arc as before.
4. Make other ellipses by changing the distance of the thumbtacks from each other. An astronomer and mathematician, Kepler, claimed that the orbit of the earth around the sun was an ellipse.



Discussion
In the year 150 A.D., Ptolemy proposed that the earth was the center of the universe and the sun, planets and moon moved around the earth. In the year 1500 A.D., Copernicus claimed that the earth traveled around the sun in a circle.

ACTIVITY
Parabolic Orbits

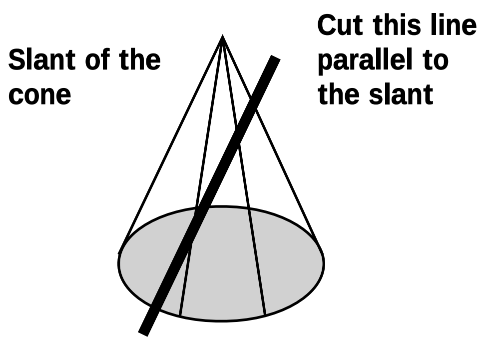
Is an ellipse a closed curve? How do you know?

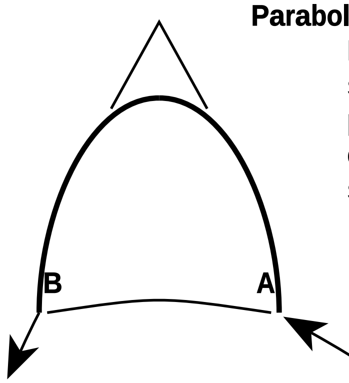
Objective
The student sketches a parabolic shape and says that some stellar bodies, such as comets, travel in parabolic paths; once those bodies come by earth's orbit, they leave and never return, because the parabola is not a closed curve.

Materials
Any cone-shaped object, such as a paper cone made from a piece of paper cut into a semicircle and taped

Scissors; transparent tape

Procedures
1. Using the paper cut into a semicircle, form a cone by bringing the two edges of the semicircle together; fasten with tape.
2. Flatten the cone only enough to get a slant side of the cone.
3. Cut the cone along a line that is **parallel** to the slant edge of the cone.
4. The cut edge of the cone will show a **parabolic** shape.





Parabolic Shape

Entry and exit paths of comets that are seen only once from earth. Since the parabola is not a closed curve like a circle or an ellipse, if a comet comes close to our solar system at point A and leaves at point B, it will not come on this path again.

LESSON 6 *The Moon Is Our Nearest Neighbor*

BIG IDEAS As the earth's follower, the moon affects the earth in many important ways. We know the distance from Earth to the moon because humans have calculated the distance and traveled there.

Whole Group Work

Materials

Book: **Eclipse: Darkness in Daytime** by F.M. Branley
NASA pictures showing astronauts walking on the moon.
Pictures of the moon's craters
Word tags: eclipse, lunar, tide

Encountering the Idea

Let's start our lesson on the moon by looking at the data, or information, we have collected and recorded on our charts. What can you tell about the moon from the charts? Describe it as you have recorded it on your charts. (Pause for students, working in small groups or pairs, to prepare responses.) First, we can see that every day it has a different shape, and every day it rises in a different part of the sky. Sometimes we can even see it during the daytime — it may be very faint, but we can still see it. Why do you suppose the moon has a different shape every day? Does the moon ever have the same shape again? If we keep records of the moon's shape for a long enough period of time, we will see that its different shapes have a pattern. What is that pattern? In our activities, we will learn about the moon's shapes and what causes them. We will also learn other things.

Have any of you heard about an **eclipse of the moon**? Do you know what it is? Have you seen one? That's one of the things we are going to study today — about the eclipse of the moon and what causes it.

Exploring the Idea

At the **Science Center,** the students

1. continue working on the chart on **Star-** and **Moon-Gazing,** adding as many new observations as possible and discussing them within their student groups and with the class.
2. complete **Activity** — Moon Phases
3. complete **Activity** — The Moon Affects the Tides
4. complete **Activity** — Eclipse of the Moon.

At the **Mathematics Center,** the students complete **Activity** — My Weight on the Moon.

Getting the Idea

1. The students make a paper-mache model of the moon. After researching the surface features of the moon, students form its features and color the surface as described by the astronauts. The students discuss how many “times” larger the earth is than the moon!!
2. A stellar body’s gravity depends on the body’s mass — the greater the mass, the greater the gravitational attraction of a stellar body; our earth weight is different from our moon weight because the moon has 1/6th the mass of the earth.
3. Students discuss the cause of a lunar eclipse.

Organizing the Idea

Brainstorm on: WHAT WE KNOW ABOUT THE MOON

Write sentences on strips of tag board as students provide information on the moon. Then the students organize the information into a report to take home to read to the family.

Students make a list of questions: WHAT WE WANT TO KNOW.

Write questions that students suggest on tag board strips also. Then the students work in pairs or small groups to find the answers. They report to the class, justifying their answers with references and/or observations.

Applying the Idea

Problem Solving

1. Suppose you are an astronaut on the moon. You want to step out of your spaceship to walk around to explore. How much more weight do you have to have on your space suit to equal your weight on earth so that you won’t go sailing off into the air?
2. Using pictures of the astronauts and pictures, if possible, of recent departures of new space vehicles, ask students if they would like to travel to the moon. Why was it important for humans to go to the moon?

Closure and Assessment

As an activity to bring closure to this phase of the unit, the students make a lunar chart with information on the moon:

Distance from Earth is 252,710 miles
Its orbit size
The moon’s brightness (the sun is 465,000 times brighter than the moon)
Orbits the earth in 29 1/2 days.
Diameter — 2,200 miles
Water — none on the moon
Air — none on the moon
Surface features — craters (dark areas) and smooth areas

The moon always faces the earth in the same position; humans can see only one side of the moon. The students can show how this is possible by using objects to represent the earth and the moon and a light source to represent the sun.

Students discuss their observations of the moon. See **Activity** — Moon Phases and, from Lesson One, **Activity** — Star- and Moon-Gazing.

List of Activities for this Lesson

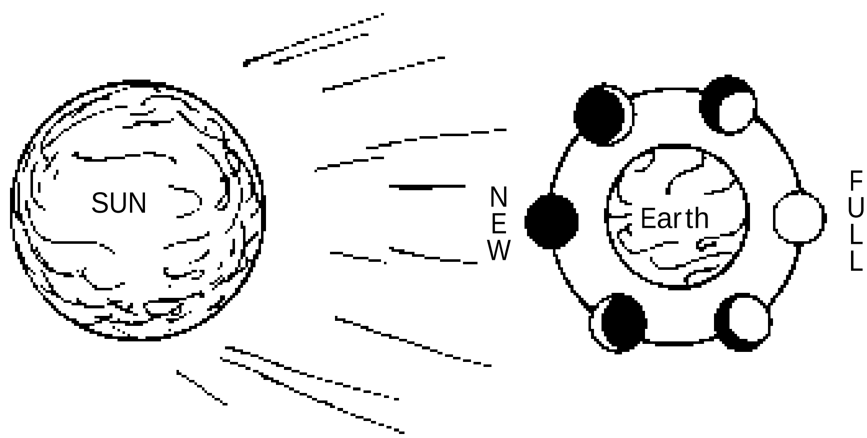
- ▲ Moon Phases
- ▲ The Moon Affects the Tides
- ▲ Eclipse of the Moon
- ▲ My Weight on the Moon

ACTIVITY
Moon Phases

Objective
The students demonstrate, using a source of light and models of the earth and moon, how the relative positions of the earth and moon produce the various phases of the moon.

Materials
Two spheres of different diameters, such as two inflated balloons, to represent earth and moon; the smaller balloon has one half covered with aluminum foil
Flashlight or other source of light, such as a lamp, to represent the sun
Copy of a lunar calendar (or transparency)

Procedures
1. The students pantomime the rotation of the moon on its axis and its revolution around the earth. One student holds the flashlight.
2. A second student holds the earth (the larger balloon) between the sun and the moon (the smaller balloon) in the positions shown in the diagram.

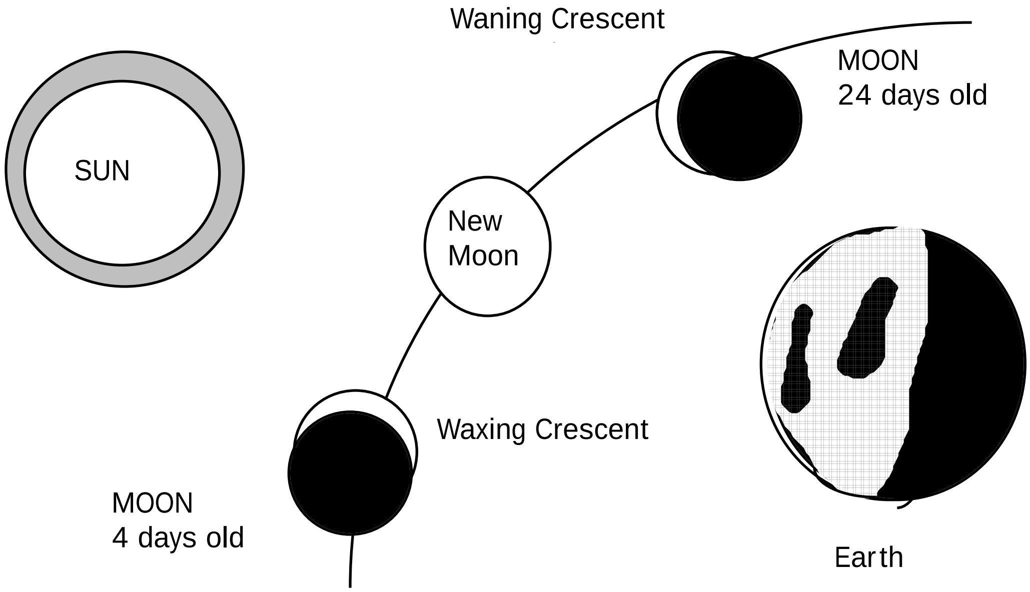


3. The moon revolves around the earth and keeps only one side (the aluminum side) facing the earth.
4. The moon rotates on its axis so that as it revolves around the earth, it keeps the same side always facing the earth.

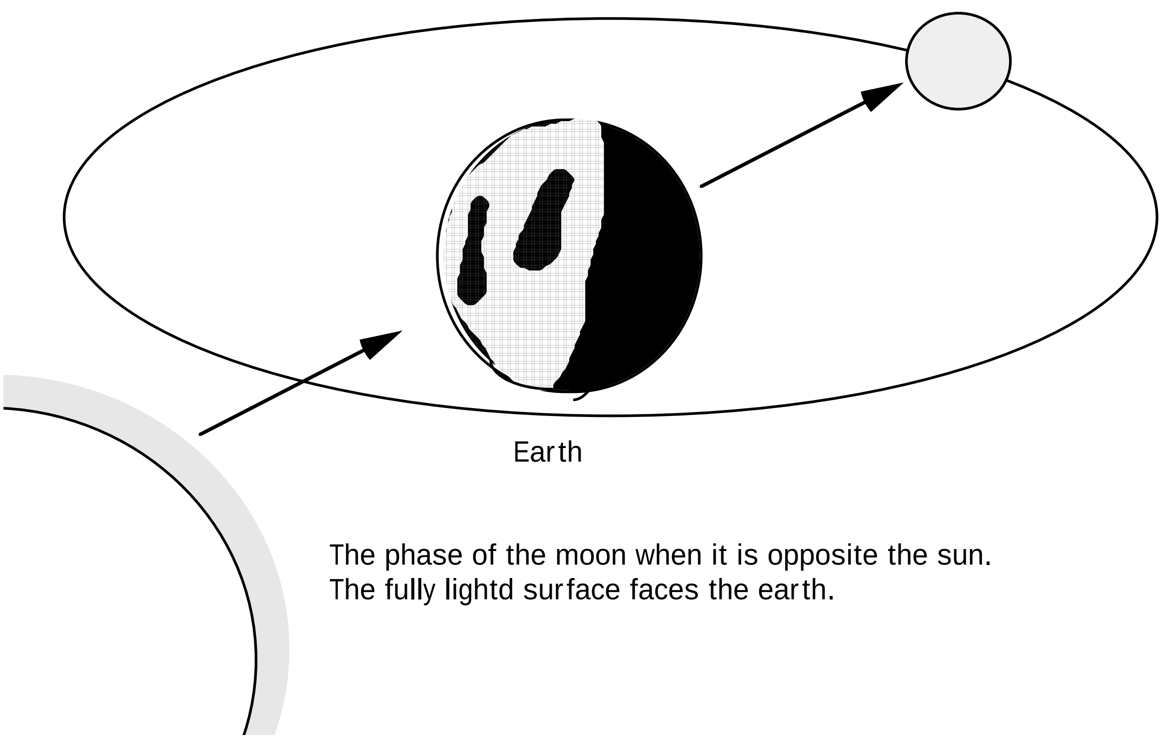
Discussion
Show students a copy of the lunar calendar. Ask the students to make observations about the chart and about the number of days in the lunar calendar. When does the lunar month begin?

When is the moon full? When is the next full moon? The next new moon? When is the moon in the various positions shown on the lunar calendar?

The New Moon



The Full Moon



The phase of the moon when it is opposite the sun.
The fully lightd surface faces the earth.

ACTIVITY
The Moon Affects the Tides

Objective

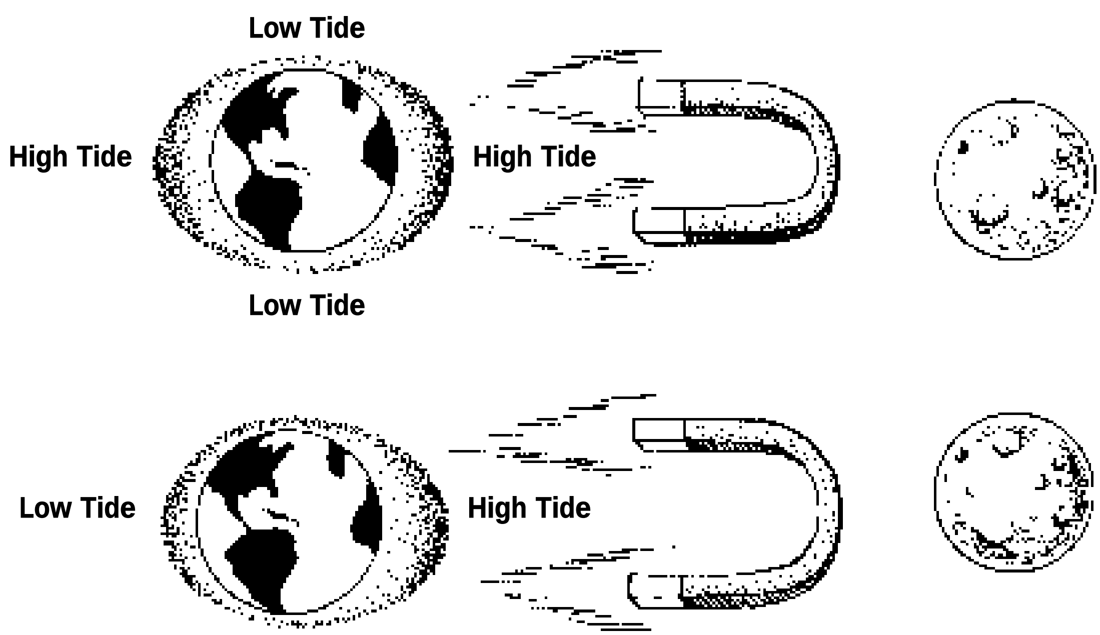
The student demonstrates by using a small dish and a strong horseshoe magnet the way the moon affects the tides on earth.

Materials

Small, round dish containing iron filings
Strong horseshoe magnet

Procedures

1. Review with students the action of a magnet on iron filings. Move the magnet back and forth among the filings to demonstrate how the filings respond to the movement of the magnet.
2. Tell students that the iron filings stand for the water in the ocean on earth, and the magnet represents the moon. Since the moon is a stellar object it effects an attraction on everything on earth, the same way that the earth effects an attraction on other stellar bodies in space.
3. Put iron filings in a small, round dish. Bring the magnet close to the dish, keeping the dish in the center of the horseshoe area of the magnet.
4. The students describe the effect of the magnet on the iron filings.



Discussion

The sun effects an attraction on earth also. Which picture above shows the effect of the sun on the tide? (When the sun is opposite the moon, the sun attracts the water, causing a high tide on its side. When the sun is on the same side as the moon, the high tide reaches its highest point.)

ACTIVITY
Eclipse of the Moon

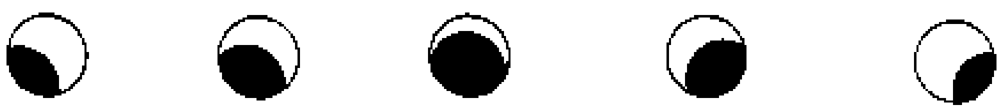
Objective
The students demonstrate, using a source of light and models of the earth and moon, how the relative positions of the earth and moon produce a partial and total eclipse of the moon.

Materials
Two spheres of different diameters, such as two inflated balloons, to represent earth and moon; smaller balloon has one half covered with aluminum foil—this is the side that faces earth at all times

Flashlight or other source of light, such as a lamp, to represent the sun.

Procedures
1. Darken the room as much as possible.
2. The students pantomime the rotation of the moon on its axis and its revolution around the earth. One student holds the flashlight.
3. A second student holds the earth (the larger balloon) between the sun and the moon (the smaller balloon) in the positions shown in the diagrams.

Partial Eclipse



Total Eclipse

4. The students describe the position of the earth in relation to the moon when the earth's shadow can fall on the moon. (Note: The moon is much closer to earth than earth is to the sun.)

ACTIVITY
My Weight on the Moon

Objective
The student says that a person's body weight depends on where he/she weighs himself/ herself and gives his/her body weight on earth and on the moon.

Materials
Surface Gravity chart (from **Activity** — Planet Data, Lesson 5)
Scale

Procedures
1. Students take turns weighing themselves on earth's surface.
2. They calculate how much they would weigh on the moon, given that the moon's surface gravity is only _______ of the earth's.

For example, a person weighing 100 pounds on earth would only weigh ______ pounds on the moon.

	Stellar Body's Surface Gravity
Earth	1
Pluto	1/3 (still in doubt)
Mercury	1/3
Mars	2/5
Venus	1
Neptune	1
Uranus	1
Saturn	1 1/5
Jupiter	2 3/5
Earth's moon	3/5

Discussion
Stellar bodies have different masses that affect the strength of their gravitational attraction. But the mass is not always evenly distributed throughout the body, thus the strength of the gravitational attraction is not the same everywhere. What this means is that your weight will not always be the same everywhere you weigh yourself. Your **mass,** however, remains the same.

We use earth as the standard unit on the chart. With the exception of earth — because its surface gravity is used as the standard unit — all of these other factors are approximations. We can still develop the notion, however, that weight is a property of matter that depends on location — where the weight is measured. Mass is constant — the amount of "stuff" in a piece of matter does not change even though its weight depends on where the "stuff" is weighed.

[1]Note that although the mass of the earth is 6 times greater than the mass of the moon, the moon's **surface gravity** is 3/5th the surface gravity of the earth.
[2]Earth's surface gravity is the standard unit of surface gravity for the other planets in our solar system.
[3]A unit is usually assigned the number 1; that unit is used then as the standard by which to make comparisons.

LESSON 7 *Constellations*

BIG IDEAS We see light from faraway stars as reliable patterns called "constellations". These patterns in the sky guide travelers on earth at night and tell astronauts where they are in space.

Whole Group Work

Materials

Books: **The Big Dipper and You** by E.C. Krupp, **Her Seven Brothers** by P. Goble, **Follow the Drinking Gourd** by J. Winter, and **Exploring the Night Sky** by T. Dickinson

Collection of pictures of the constellations; set of dot pictures of the constellations, for example, The Big Dipper: See **Activity** — Major Constellations

Word tags: constellation, zodiac, Greeks, circumpolar, seasonal, gourd

Encountering the Idea

Read the story **The Big Dipper and You** or one of the other stories to the class. As you show pictures of the constellations to the students, discuss the story with them. In their observations of the night sky, have they detected any patterns such as the ones described by the authors in the books? In this lesson, they will study the patterns that appear in the night sky and learn how the patterns have become useful guides for travelers on earth and in space.

Exploring the Idea

At the **Mathematics Center,** the students complete **Activity** — Star Find.

At the **Science Center,** the students

1. complete **Activity** — Finding Our Way
2. complete **Activity** — The Night Sky
3. complete **Activity** — Major Constellations
4. complete **Activity** — Zodiac Data.

Do **Activity —** Use Your Umbrella, as below.

Materials

Large black umbrella; soft white chalk

Procedures

Students open a large black umbrella and draw several of the constellations on the black underside around the shaft of the umbrella, identifying **Polaris** first, then locating various other stars and constellations. They label what they can identify in the constellation.

Getting the Idea

Ask the students if they know what the word "constellation" means. If they break it down into syllables, they may be able to guess. "Con" in Spanish means "with", or "together with." What does the word "stella" suggest? Yes, star. What would the word mean? With other stars, or a grouping of stars. In the activities you have completed, you have learned that there are some consistent patterns in the night sky that we can identify because they suggest familiar objects.

Constellations visible in any part of the sky appear to move easterly each hour because of the earth's rotation. Constellations visible in any part of the sky also appear to move in a westerly direction each month, but this is because of the earth's revolution about the sun. Thus, over a period of a year, each constellation is visible for a period of six months when we observe it, at the same time of the night, moving from an easterly direction to west. These are the **seasonal** constellations.

On the other hand, **circumpolar** constellations are constellations that do not rise or set — in other words, do not appear to move as the others do. These constellations appear to move in a series of circles around **Polaris, the North Star,** thereby termed "circumpolar".

We have learned that the Greeks gave constellations names because if a constellation suggested the figure of a familiar object, it would be easier to find it regularly in the night sky. But does **each of the stars** in a particular constellation have a name? In current times, astronomers throughout the world need a common communication system to talk about stars and constellations. There are so many stars that there has to be a way of identifying them without making a mistake. One common characteristic stars have is their brightness. So, the Greeks ordered the stars by apparent brightness and gave them a prefix of a Greek letter and then the name of the constellation where the star could be found. For example, B, beta, meant the *second brightest* star in a constellation. Look at your **Star Data** chart. You will find some stars labeled alpha (first letter in the Greek alphabet, like A) and others labeled beta (second letter in the Greek alphabet, like B), and so on.

The Greeks not only named the constellations after the figures they imagined they could see in the patterns but also gave the constellations names to commemorate important events. They used letters of the Greek alphabet to name the individual stars within the constellations.

The Greeks designed another stellar coding system called the **Zodiac.** See **Activity** — Zodiac Data. They developed this system on the basis of the position of the sun, rather than the stars. The Greeks believed that the planets had great influence on the lives of people. The Greeks used the word "Zodiac" to name this system, because when they looked for familiar figures in the night sky they were reminded of a **zoo** — a place where we find many animals.

After discussing the ideas presented in the activities, the students may want to consider the following interesting questions.

1. What did you think of the game of finding a star using an ordered pair of numbers? Of course, in space you would have to use additional numbers to actually find a star because, for one, space is three-dimensional.
2. Are there other calendars that other people have developed? For example, the Chinese have their own calendar, as do the Mayans and the Hebrews. Look in your reference books for one or more of these systems and report to your class.

Organizing the Idea

Read or tell stories about the constellations; make and label a zodiac belt around the model solar system. Walk the earth's orbit and make a chart indicating the months when we can view each constellation. Put the charts in the class library.

At the **Writing Center:**

1. Write a class **Newsletter** to include student-authored stories and pictures of planets and constellations, and planet games (Write the rules for the games you make up so that other students can play the games.) Read your newsletter to your family at home.
2. Find your own zodiac sign and those of your friends; follow horoscope predictions that usually appear in the daily newspaper. See and describe in your journal how the predictions relate to the events of the day.

At the **Language Center:**

1. Find other stars on your **Star Chart** that have Greek letters added to them. You may also want to find in your reference book other Greek letters that are similar to English letters, for example, the last letter of the Greek alphabet.

ALPHA	BETA	GAMMA	DELTA	EPSILON
α	β	γ	Δ	ε

2. Look up the word "alphabet" in the dictionary and identify and describe the relation of that word to the Greek letters "alpha" and "beta".
3. Look for the definitions of "astronomer" and "astrologer". How are these two methods of studying stellar bodies the same, and how are they different?

Applying the Idea

1. Do you think the Greeks had a good idea when they decided to group the constellations into specific patterns and give them names of familiar objects or persons? Explain why you think it was a good idea or not. Give your reasons.
2. Would you like to design your own scheme for keeping track of the stars? If so, how would you go about it?
3. Extend the game "Star Find" to a third dimension, or third number, if you would like. You can get one of your friends to help you design the game and then teach it to the other members of the class.

Closure and Assessment

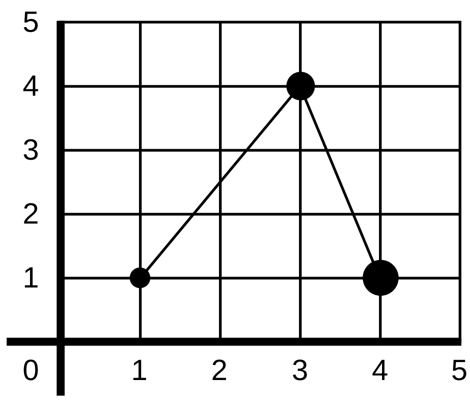
At the end of the lesson, reconvene the children to ask the following questions about **The Big Dipper and You** and **Exploring the Night Sky.**

1. What objects can you see in the night sky?
2. Can you name the planets in our solar system? Which is the largest? Smallest?
3. How are Earth and Venus alike/different?
4. What are black holes/quasars/red dwarfs?
5. What is a constellation?
6. How can the stars in the Big Dipper help guide you?
7. Which star can you see only in the daytime?
8. What are some other names for the North Star? What is the "drinking gourd"?

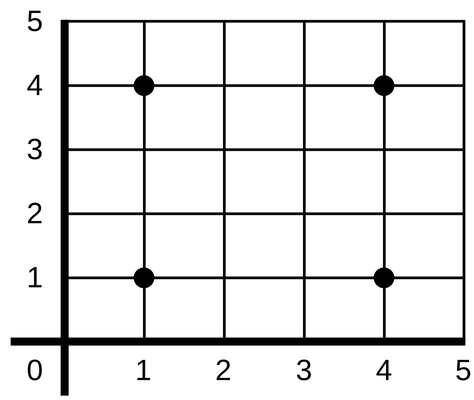
9. Why do the stars seem to move across the night sky?
10. Why is the Big Dipper called by other names in different countries?
11. Do people living at the tip of South America see the same constellations as we see here in the United States?

Finding some Stars

1. Write the coordinates (ordered pairs) of the vertices (corners) forming the triangle on the first grid showing the constellation “Tristellis”.
2. Draw a square on the second grid and write the ordered pairs forming the vertices (corners) of the square showing the constellation “Quadristellis”.



Tristellis



Quadristellis

3. If you had been a Greek naming the constellations and the stars, how would you have named the stars in the “Constellation Tristellis”? ((4,1) is alpha Tristellis; (3,4) is beta Tristellis; (1,1) is gamma Tristellis; the brightest is alpha, and so on.) In “Constellation Quadristellis”?

List of Activities for this Lesson

▲ Star Find

▲ Finding Our Way

▲ The Night Sky

▲ Major Constellations

▲ Zodiac Data

ACTIVITY
Star Find

Objective
Students use the concept of an ordered pair of whole numbers on a coordinate plane so that
1. given an ordered pair of a "star location," they can circle the intersection of the ordered pair
2. shown a "star" on a coordinate plane, they can give its location using an ordered pair.

Materials
Coordinate plane drawn on heavy paper and laminated
Erasable markers

Rules
1. The person who gives an ordered pair gives two numbers less than or equal to five, for example, three and one, written (3,1).
2. The first number is the horizontal coordinate to the right, 3 spaces.
3. The second number is the vertical coordinate, up one space. (See the black dot on Fig. 1.)
4. If a student says (1,3), then that is the square on Fig. 1 and it is incorrect.
5. The point (0,0) is the origin.

Procedures
1. Students work in groups of three, taking turns.
2. One is scorekeeper and determines correctness of responses.
3. The second gives the ordered pair.
4. The third locates the star and puts a circle on its location. (Fig. 1.)
5. After students have mastered locating points on the coordinate plane using whole numbers, they suggest ways to locate a star that is **not** on a corner. (Fig. 2.)

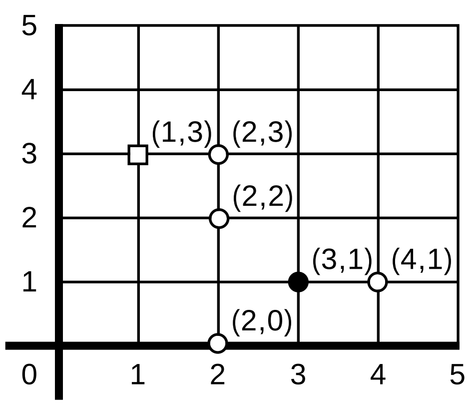


Fig. 1

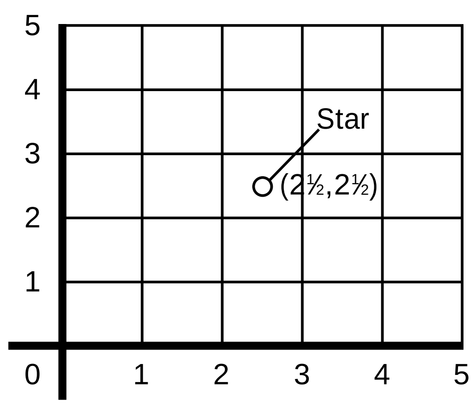


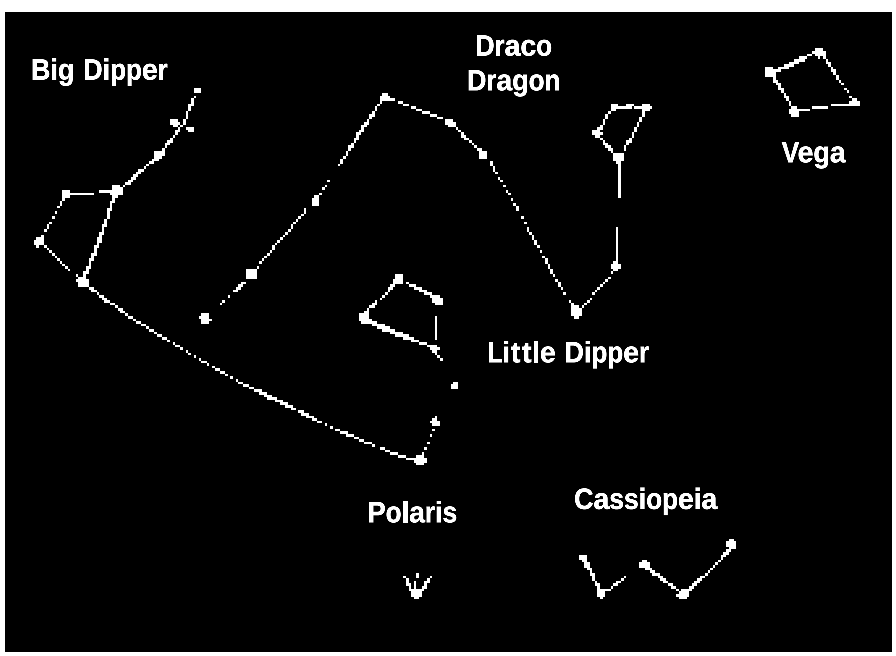
Fig. 2

ACTIVITY
Finding Our Way

Objective
The student finds in the night sky the North Star and at least three constellations, using a star chart and the North Star as guides.

Materials
Copy of the charts below for each student; world globe

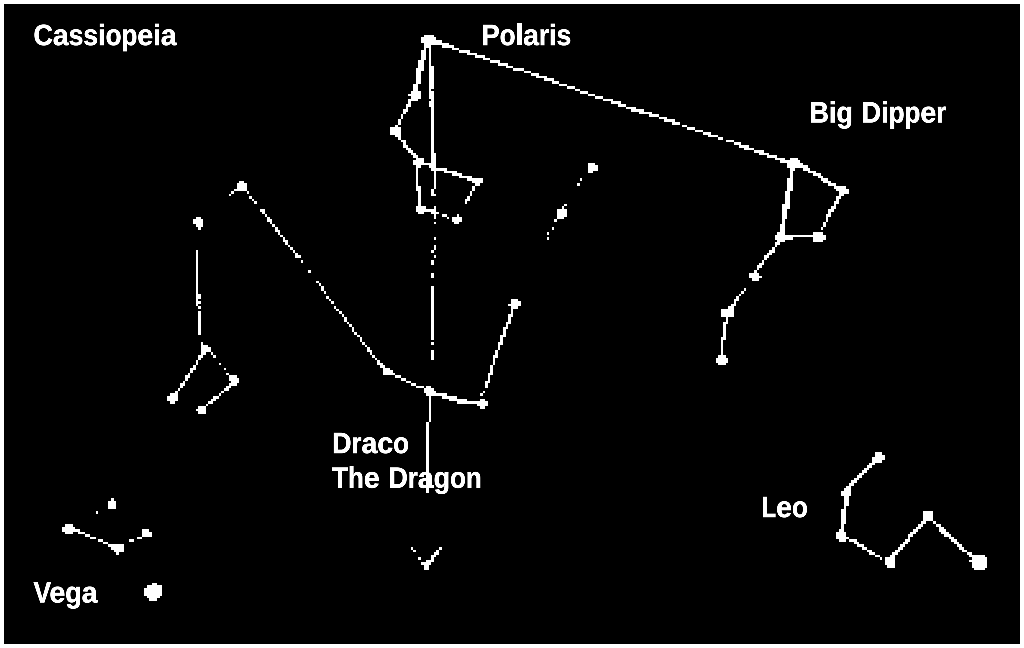
Procedures
1. The first step in orienting yourself on a clear night is to find the North Star, also called Polaris because it is the "North Pole" star.
2. Since Polaris is in the constellation we call the "Big Dipper," you start by looking for the Big Dipper. If you have an idea where north is, you look in a northerly direction.
3. Look for four stars that make a bowl, and three stars that make the handle.
4. The two stars farthest from the handle are the "pointers" to the North Star. Notice that the North Star is at the end of the handle on the Little Dipper.
5. If you draw a perpendicular line from the North Star down to the horizon, true north (for you) is the point where the imaginary line from the North Star intersects with the horizon.
6. The second star in the handle of the Big Dipper (arrow) is not one star, but two stars that appear to be very close. If you have especially good eyesight, you will be able to see the two.
7. Compare the two charts of the stars. How are they alike and how are they different?



Summer Sky

8. Are the constellations shown on the charts **seasonal** or are they **circumpolar?** Explain.

9. To find the star Vega in the summer sky, draw a line from the Big Dipper to Cassiopeia, the constellation that looks like a W, then draw a line perpendicular to the first line but make it go through Polaris. That line will point in the direction of Vega, which is the brightest star in the constellation Lyra.
10. Give directions on how to find Vega in the winter sky.



Winter Sky

Getting the Idea

1. Will Polaris change its position during the year as some of the other stars move from east to west? (No, because this is a star that is **circumpolar.** It goes "around the pole" and stays in the same place throughout the year. That is why the North Star is our reference point, or the point that we begin from, to find our way.)
2. If you were a sailor on a ship out in the middle of the ocean, no sign of land, would you need a compass to help you find north? If not, how would you find north?
3. If you were in a spaceship in outer space, do you think you could find the direction the spaceship was traveling without a compass? How? Would you still look for Polaris to help you find your direction? Why, or why not?
4. Suppose you are millions and millions of miles away from earth in outer space on a very distant star. What would earth look like to you? Where would north be? Would you even care about north out there? (The earth, if it were visible from the distance, would be a mere speck. "North" is a notion that is valuable on earth only and becomes meaningless in outer space. The spaceship navigators use different methods for finding their way, but **they still use the stars!**)
5. Suppose you live in South America, Australia or South Africa (at least 1000 miles below the equator). Would you be able to find Polaris? Use a world globe and explain why. If you were an explorer would you look for north or for south? How would you find south? Would you try to use the stars? **First, you would have to find a point of reference in the south night sky!**

ACTIVITY
The Night Sky

Objective
The student finds at least three constellations in a simulated night sky.

Materials
Copy of the two charts shown in **Activity** — Finding Our Way.
Black construction paper
Hole punch for larger holes, and pencil and pen points for smaller holes

Prior Preparation
1. The teacher makes a copy of the summer and winter sky maps. Using this as an overlay, punch holes on each of the dots indicating a star.
2. Lay a copy of the summer sky chart on a black sheet of construction paper.
3. Place the chart outlined in black construction paper over an overhead projector.
4. Project the images onto the ceiling.
5. If the ceiling is made of acoustical tile that will interfere with the view of the dots of projected light, so you may want to cover a portion of the ceiling with paper.

Procedures
1. Darken the room as much as possible.
2. Project the chart of the summer sky onto the ceiling with an overhead projector.
3. Ask students to locate the various constellations using the directions from **Activity** — Finding Our Way.
4. Slowly rotate the chart around on the top of the overhead projector, keeping Polaris in a relatively fixed position.
5. The students describe the position of the constellations as the chart rotates.
6. The student hypothesize as to why the constellations appear to rotate in a circle. (These are the circumpolar constellations.)
7. Students practice finding the constellations and Polaris so that at night they will be able to locate them when they go out to make their observations.
8. Working in pairs, the students check each other on finding the constellations.

ACTIVITY
Major Constellations

Objective
The student names and describes at least three major constellations.

Materials
Chart of major constellations and their common names. **Note:** Indicate to students that the lines drawn on the constellations are imaginary, like the equator, and we use them only to show the pattern; these lines are not in the sky.

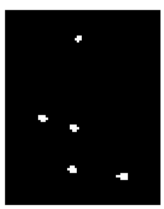
Procedures
Working in small groups to compare, communicate and share information, the students continue to observe the night sky as often as possible and report on the major constellations they have been able to identify.

1. The students identify **Polaris, The North Star,** as one of their first assignments. This star will help them identify their first constellation (Ursa Minor — the Little Bear) and others, such as the ones shown on the chart as circumpolar.
2. As soon as students identify a constellation, they report to the class, describe and illustrate it in their journals.

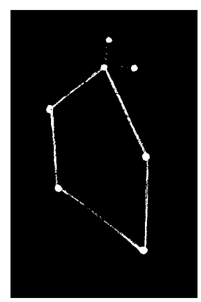
MAJOR CONSTELLATIONS

CIRCUMPOLAR

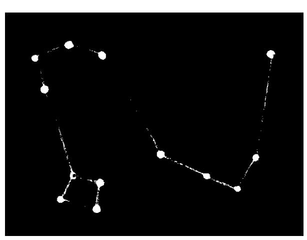
Name
Cassiopeia —
Lady in the Chair



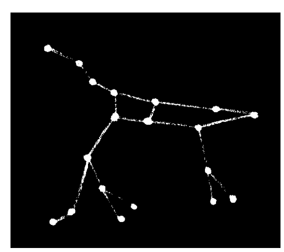
Name
Cepheus —
The King



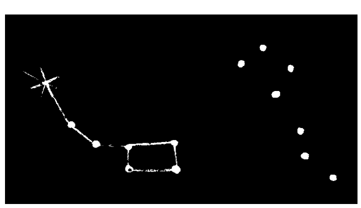
Draco —
The Dragon



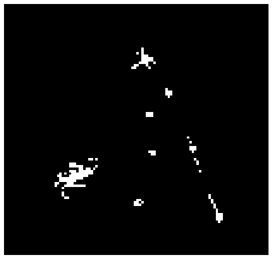
Ursa Major —
The Great Bear



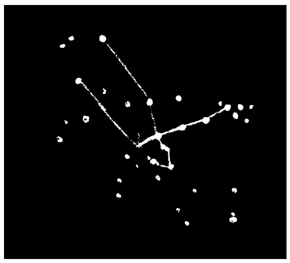
Ursa Minor —
The Little Bear



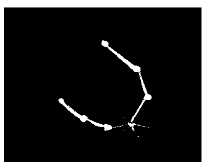
Andromeda —
The Chained Maiden



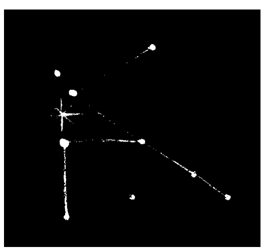
Taurus —
The Bull



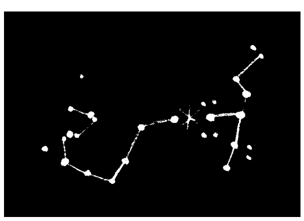
Corona Borealis —
The Northern Crown



Aguila —
The Eagle

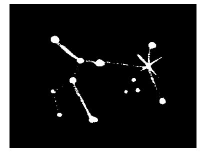


Scorpius —
The Scorpion

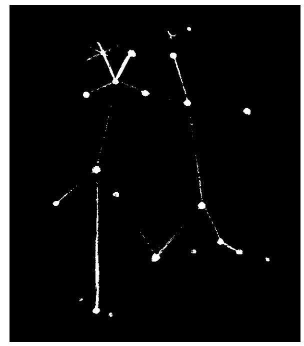


SEASONAL

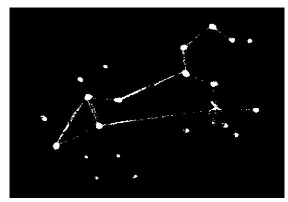
Canis Major —
The Big Dog



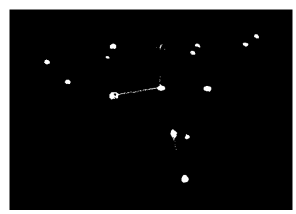
Gemini —
The Twins



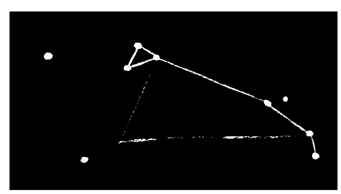
Leo —
The Lion



Cygnus —
The Swan



Aries —
The Ram



Organizing the Idea

Students record and illustrate at least three major constellations.

I saw constellation	Date Time	Description — Number of Stars; Brightest	Location — I had to look: East, West, North, South

ACTIVITY

Zodiac Data

Objective
The student identifies his/her own Zodiac sign by consulting the zodiac chart.

Materials
Copy of the Zodiac chart for each student group; reference books; students who have the same sign work as a small group

Procedures
Students find their zodiac sign on the chart, read about it and report to the class and/or collaborate to make a Big Book on the Zodiac.

ZODIAC CHART

Sign	*Name*	*Dates related to the Sign*	*Symbol*
ARIES	Ram	March 21- April 20	♈
TAURUS	Bull	April 21 - May 21	♉
GEMINI	Twins	May 22 - June 21	♊
CANCER	Crab	June 22 - July 23	♋
LEO	Lion	July 24 - August 23	♌
VIRGO	Virgin	August 24 - September 23	♍
LIBRA	Balance	September 24 - October 23	♎
SCORPIO	Scorpion	October 24 - November 22	♏
SAGITTARIUS	Archer	November 23 - December 21	♐
CAPRICORN	Horned Goat	December 22 - January 20	♑
AQUARIUS	Water Jug	January 21 - February 19	♒
PISCES	Fish	February 20 - March 20	♓

Discussion
The ancient Greeks were great students of the night sky and developed a system of naming the stars and the constellations in which the stars were grouped. The Greeks divided an imaginary belt in the sky into 12 equal segments and assigned 12 constellations or signs to each section.

Because many ancient people throughout the world assigned great importance to the influence of the stellar bodies on the lives of humans, many of these people were students of what is called **astrology,** or the study of the influence of the “astros”, or planets, on the lives of humans. Astrologers also **believed** they could foretell the future by depending on the relative positions of the constellations. Although there is no **scientific data** to support these beliefs, to this modern age many people begin their day by reading their “horoscope”, which is a guide to their lives that depends on the influence of the planets on that particular day.

UNIT ASSESSMENT

Designer Planets

For group and / or individual assessment

Design a planet to meet the conditions that the students set. **The Sky is the Limit!**

Alternative 1

Working individually, in pairs or in small groups, students select a planet they would like to visit. They write in their journals about why they would like to visit that planet and what they would expect to find there. They illustrate their report with drawings and/or three-dimensional objects (even using the pop-up kind) and include living organisms, or extraterrestrials, they would expect to find.

Alternative 2

Working individually, in pairs or in small groups, students design a planet in our solar system. Using paper mache or balloons/masking tape, they develop a model of the planet. They select a distance from the sun, size of the planet, its surface features, life and plant forms and other features and characteristics. They show their planet and give an oral report to the class and/or teacher. They write a newsletter to their parents describing their planet.

Oral Assessment

1. Name at least two ways that stars are different from each other.
2. How do we know that there are millions of stars in the universe?
3. Do you think we should continue to explore outer space?
4. Do you think scientists will discover other life forms on other planets in the universe? Explain.
5. Would you like to become an astronaut? Why? Do you know what you have to do to become an astronaut?
6. Would you like to be a moon explorer and live on the moon to investigate it?

Performance Assessment

1. Show how planets reflect light.
2. Draw our solar system and label it.
3. Draw and name five constellations.
4. Describe and/or illustrate how the sun’s energy affects the earth.
5. Name and/or illustrate as many different stellar bodies as you can.

Written Assessment

1. How do stars produce light?
2. How do we know how far it is to the moon?
3. How do we know how far it is to Mars? To a faraway star?
4. How many days does it take the moon to orbit the earth?
5. Describe one way in which the moon affects the earth.

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