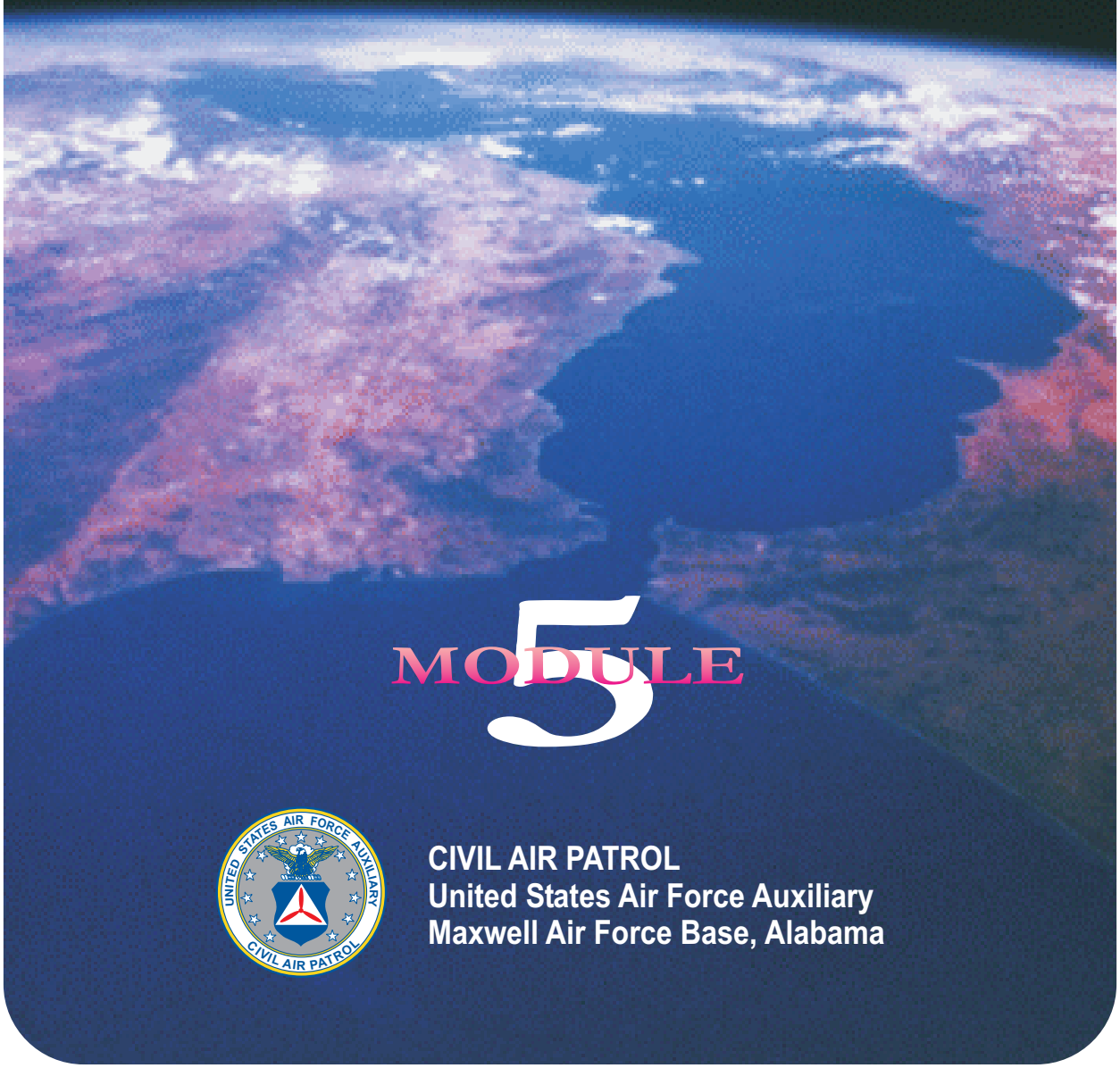
Aerospace Dimensions

# SPACE ENVIRONMENT



MODULE 5

CIVIL AIR PATROL
United States Air Force Auxiliary
Maxwell Air Force Base, Alabama

# Aerospace Dimensions

# SPACE ENVIRONMENT

## MODULE 5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I want to recognize and thank Saundra Carmichal for her creation of "Cappy", our mascot. Her creativity and variety enhanced our educational product and added some enjoyment too.

I also want to thank Civil Air Patrol's Regional Directors of Aerospace Education for their diligence and support throughout this process.

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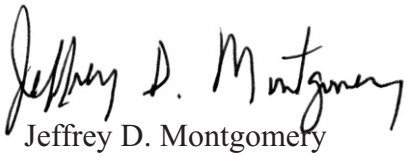
Finally, I want to thank Jim Mallett, the Director of Education and Training, Headquarters Civil Air Patrol, for making this book a reality.



Jeffrey D. Montgomery
Cadet Aerospace Education

Published 2000

# INTRODUCTION

This module, Space Environment, is the fifth of six modules, which combine, make up Phases I and II of Civil Air Patrol's Cadet Aerospace Education Program. This new aerospace program is called Aerospace Dimensions. Each module is meant to stand entirely on its own, so that each can be taught in any order. This enables new cadets coming into the program to study the same module, at the same time, with the other cadets. This builds a cohesiveness and cooperation among the cadets and encourages active group participation.

We included many activities within the text to further enhance and promote the ideas of cooperation and participation . These activities were designed as group activities, but can be done individually if desired. We provided several activities for every section, so that you can choose which ones you would like to do. We believe that these activities will not only be fun but will also reinforce the concepts that are presented in these chapters. The activities for this, and the other modules, are located in the Activity Section in the back of each chapter.


Cappy, our mascot, appears throughout the modules offering suggestions, tips and help along the way.

We provide leader guides for each of our modules. These guides offer possible ways of presenting the material to the students. However, how the lesson proceeds is up to the leader. If the leader has a different idea on how to present the lesson, that is fine as long as the learning outcomes of the lesson are met. These outcomes should be thought of as objectives of the lesson; the information the cadets should know when they finish the lesson. Leaders should study these outcomes so they will know what information the students need to learn to successfully proceed through the aerospace education portion of Phase I and II. The learning outcomes are listed after the Introduction of each module.

At the beginning of each chapter is a list of Important Terms. Please review these before you begin your lesson. They will help familiarize you with the material and give you an idea of where the chapter is headed. We also included a review section called Things to Remember. Always take a moment and review this, too.

A major emphasis of these modules is the activities. These hands-on exercises are designed to be fun and educational. We hope you will take the time and perform many of these activities. We think they are worth your time and effort and will expand your knowledge of the subjects.

So, good luck with Space Environment and all of the modules in CAP's Aerospace Dimension. program.

# CONTENTS



# LEARNING OUTCOMES

## Chapter 1 - Space

After completing this chapter, you should be able to:

- Describe microgravity.
- Identify characteristics of space.
- Describe what makes up the universe.
- Define constellation.
- Define galaxy.
- Describe a nebulae.
- Define interplanetary and interstellar space.

## Chapter 2 - Solar System

After completing this chapter, you should be able to:

- Describe our solar system.
- State basic facts about the planets in our solar system.
- Define a comet.
- Explain the differences between an asteroid, meteoroid and a meteor.
- Recall the differences between solar flares, solare prominences and sunspots.

# 1 SPACE

Important Terms

black hole - a region in space where no radiation is emitted
cislunar space - the space between the Earth and the Moon
constellation - a grouping of stars, named after mythical figures and animals
galaxy - an enormous collection of stars arranged in a particular shape
interplanetary space - measured from the center of the Sun to the orbit of its outermost planet
interstellar space - the distance from one solar system to another
microgravity - small gravity levels or low gravity
nebulae - giant cloud of dust and gas
pulsar - pulsating star that flashes electromagnetic emissions in a set pattern
space - region beyond the Earth's atmosphere where there is very little molecular activity
star - a body of hot gases
universe - everything is part of the universe; stars, planets, galaxies, animals, plants and humans
Van Allen belts - radiation belts filled with charged particles

Since the beginning of time, man has looked to the stars with awe and wonder. Our universe has always fascinated scientists and other observers. What was once unexplored territory has now become the new frontier. Many expeditions, missions, satellites and probes have traveled into this overwhelming vastness we call our universe, in search of knowledge and understanding.

When we talk about the universe several words may come to mind. Many people think of words like, space, stars, planets and solar systems. This volume on the space environment will define these terms and give you a basic understanding of our universe.

You might wonder why this is important. Well, all of our volumes have been talking about aerospace, and space is certainly a part of this overall concept. We are no longer limited, in our thinking or achieving, to the immediate area of Earth's atmosphere. For years, travel has occurred beyond that scope. The US has participated in manned satellites for years, and now our missions include stops at space stations. American astronauts have stopped at the Russian space station Mir and helped them. Missions now involve astronauts staying in space for extended periods of time. It is conceivable that some of us could indeed travel to space during our lifetime. So, let's take a brief look at some basic information that we should know in our quest for learning about our space environment and the universe.

## SPACE IS A PLACE

First, space is a place. It is the region beyond Earth. It is part of the universe beyond the immediate influence of Earth and its atmosphere. This does not happen at a particular point, but rather happens gradually. You may have heard space described as a void or a vacuum, but no place in the universe is truly empty. Eventually the molecules and atoms become so widely

spaced that there is no interaction. We call this space. The Air Force and NASA define space as beginning at an altitude of 50 miles, and anyone who reaches this height is awarded astronaut wings. However, an object orbiting the Earth has to be at an altitude of 80 or 90 miles to stay in orbit. So, many consider this to be the beginning of space.

Space is a part of the universe. The universe includes everything, stars, planets, galaxies, animals, plants and humans. Let's talk about the concept of space first and then expand into a discussion of the universe.

## Characteristics of Space

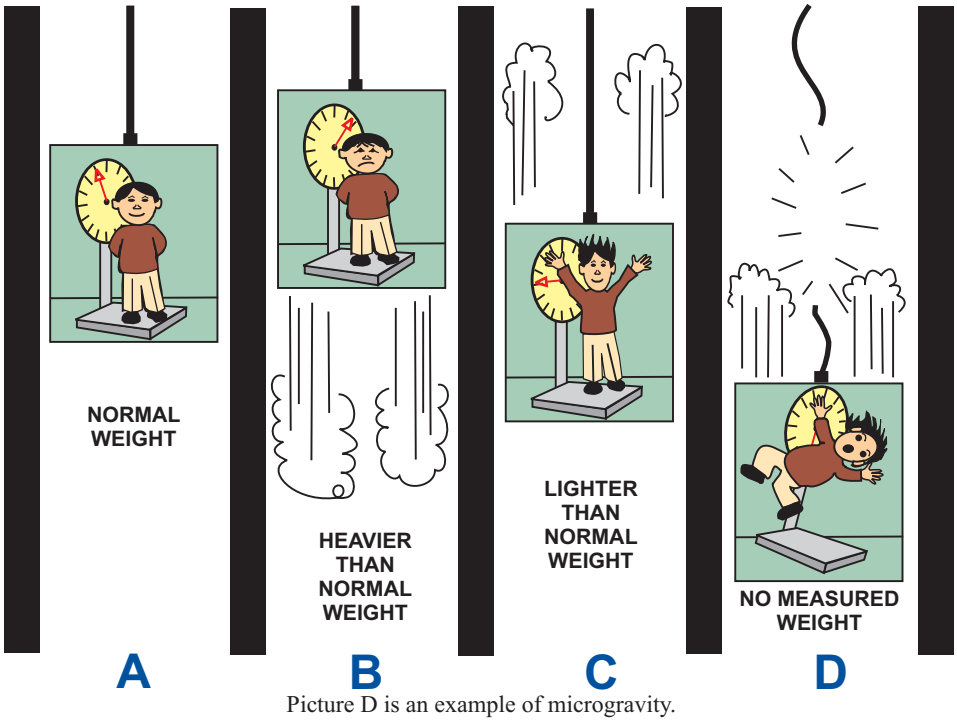
When we describe space as a physical place we must include its characteristics. What is the gravity like in space? How about the temperature and pressure? Are they like Earth's?

Space is characterized by a lack of oxygen. It would be impossible for us to travel or live in space without oxygen. We compensate for this by including an oxygen supply on all manned space flight projects. Also, in space there is much lower pressure than on Earth. The pressure inside a spacecraft is maintained at levels similar to Earth. In terms of temperature in space, generally, -273$^{O}$C (absolute zero) is used. This is because temperature is based on molecular movement and there is hardly any in space, so absolute zero is used.

When discussing the characteristics of space one of the first concepts we think of is gravity. Most of us have seen pictures of astronauts floating around in space. That happens because the gravity in space is much smaller or less than on Earth. Small or low gravity is called microgravity.

The prefix micro really means one part in a million, but we use it all of the time to simply mean something small. That is how we use it when referring to space. To actually go into space where the Earth's gravitational pull is one-millionth of that at the surface, you would have to travel 17 times farther away than the Moon. As you know, no human has traveled beyond the Moon yet.

We can create a microgravity environment here on Earth. Imagine riding in an elevator to the top of a building. When you get to the top the elevator cables break, causing the elevator and you to fall.

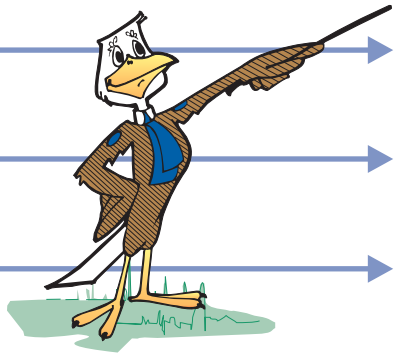



Picture D is an example of microgravity.

Since you and the elevator car are falling together, you feel like you are floating inside the car. You and the car are accelerating downward at the same rate due to gravity alone. If a scale were present, your weight would not register because the scale would be falling too. NASA calls this floating condition microgravity.

The next few activities are designed to give you a better understanding of microgravity and its effects.

See Activity One - Creating the Microgravity of Space
Refer to the Activity Section at the end of the chapter for this activity.



See Activity Two - The Can Throw
Refer to the Activity Section at the end of the chapter for this activity.

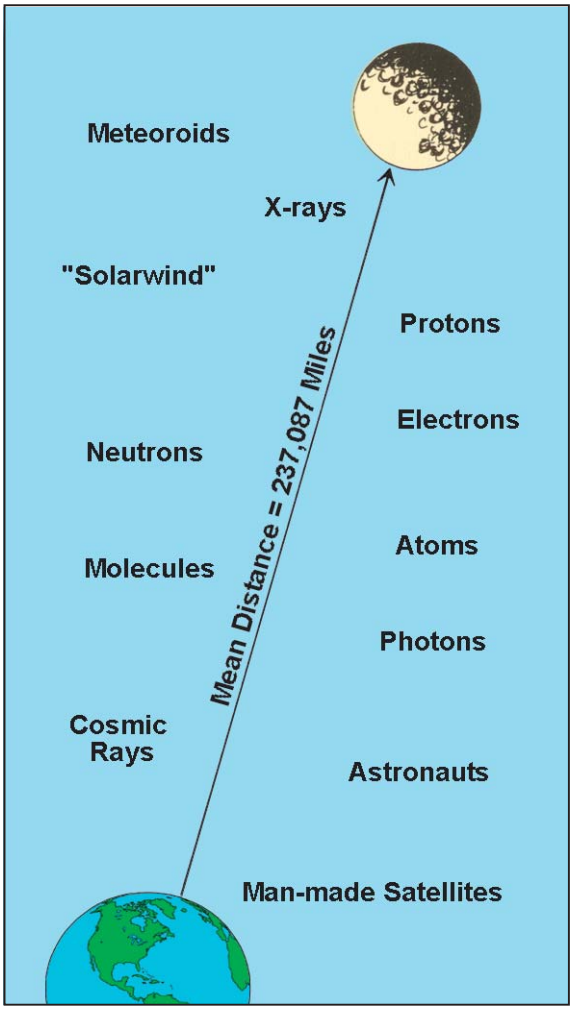
See Activity Three - Surface Tension and Microgravity
Refer to the Activity Section at the end of the chapter for this activity.

See Activity Four - Rapid Crystallization
Refer to the Activity Section at the end of the chapter for this activity.

We can further describe space as cislunar, interplanetary or interstellar space. Cislunar space is the space between the Earth and the Moon. This distance varies from month to month since the Moon's orbit around the Earth is elliptical. The average distance between the Earth and its Moon is 237,087 miles.

Cislunar space is not a void or a vacuum. Part of the Earth's magnetosphere is found in cislunar space. The magnetosphere contains protons and electrons and magnetic lines of force. Radiation storms emitting from the Sun are also located here. Cislunar space also contains meteoroids, asteroids and comets, which we will discuss in the next chapter.

So, you can see cislunar space is far from being void. However, it is not overcrowded either. According to astronauts who have been there, space looks like the void it has been called. Astronaut Anders (Apollo 8) said, "the sky is very, very stark. The sky is pitch black and the Moon is quite light. The contrast between the sky and the Moon is a vivid dark line."




Dimensions and Occupants of Cislunar Space

Interplanetary space is measured from the center of the Sun to the orbit of its outermost planet. This planet, Pluto, has an orbit that extends as far as 4,566,000,000 miles from the Sun. In addition to the Sun, this portion of space includes nine known planets. It also contains numerous

planetary satellites, a huge belt of asteriods, charged particles, magnetic fields, dust and more. This interplanetary space is often referred to as the Solar System. Then, interstellar space is the distance from one solar system to another.

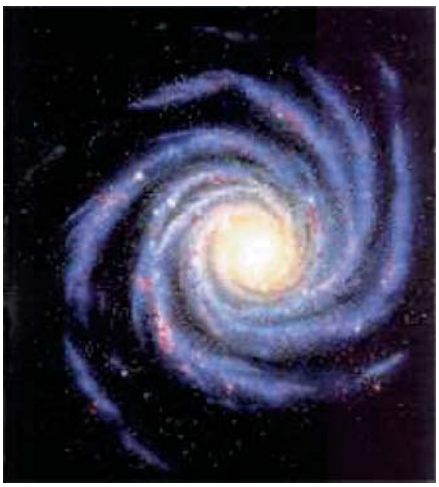
Now, we know a little about what space is like. We should remember that space is a part of the universe. The universe is the all-encompassing term that includes everything. Although the universe includes plants, animals and humans, we want to talk about the part of the universe that includes stars and galaxies.

The universe contains many galaxies. Our sun, which is the center of our solar system, is but a tiny spot in our galaxy (We will talk about the sun and the solar system in the next chapter). In fact, there are 200 billion suns in our galaxy, and our galaxy is just one of millions of galaxies. The smallest galaxies have about 100,000 stars, while the largest have about 3,000 billion stars. Our universe is huge!

One way to think about this is by using distance. Distance in space is measured in light years. A light year is about 6 trillion miles. Our galaxy is about 150,000 light years across. Again, our galaxy is only one of millions of galaxies. Our universe is so vast it is almost incomprehensible. So, let's not worry about how big it is, and instead just take a brief look at some basic information concerning galaxies and space.

So, what is a galaxy? A galaxy is an enormous collection of stars, and these stars are arranged in a particular shape. There are three main shapes of galaxies: elliptical, spiral and irregular. Elliptical is oval shaped. Spiral has arms spiraling outward from a center. Irregular has no particular shape.

Our galaxy is the Milky Way galaxy. The Milky Way is a huge collection of stars arranged in a spiral shape. This picture shows the Milky Way from above. The Milky Way has a dense central bulge with four arms spiraling outward. The center of our galaxy contains older red and yellow stars, while the arms have mostly hot, younger blue stars. Scientists estimate that the Milky Way probably contains 100 billion other solar systems and stars.



The Milky Way Galaxy

Nebulae

Horsehead Nebula

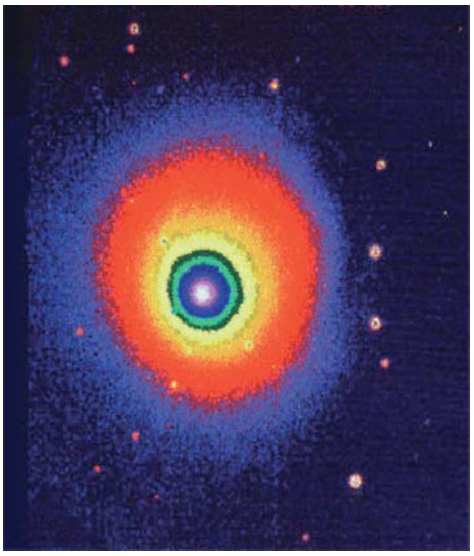
Distances between the stars and solar systems vary and involve such high numbers of miles that it is staggering. In this case, distance is thought of in light years and parsecs instead of astronomical units. A light year is the distance a photon can travel in one of Earth's calendar years. This amounts to 5 trillion 878 billion-statute miles(5,878,000,000,000 miles). When the number of light years gets very large, parsecs are used; once parsec is 3.26 light years, or 19.2 trillion miles.

Galaxies also contain giant clouds called nebulae that are spread throughout the galaxy. These nebulae are clouds of gas and dust. A nebula may be dark or bright. The dark nebulae are vast clouds of matter that have not yet formed into stars. The bright nebulae may be studded with stars

and send forth brilliant arrays of color. Some bright nebulae are the remnants of supernova, like the Crab Nebula. Nebulae spin and move and give a galaxy shape. Nebulae can also spin and move and become stars.

Stars are bodies of hot gases. Most stars are composed of hydrogen and helium in their gaseous state. Stars have their own gravity and this gravity holds the gases together. The gravity pushes inward and the pressure from the hot gases drives outward, thus creating a balance. The intense heat of a nebulae star releases energy in the form of light and heat. This is how we are able to see them.

Many stars are hard to see. This is because they come in various sizes. Some, of course, are much smaller than others. Also, stars are hard to see because they are so far from Earth. About half of all stars come in pairs with the stars sharing the same gravitational center. These are called binary stars.



Nova

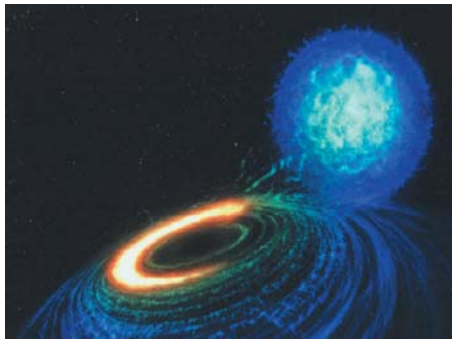
Novas are stars that are not stable; they flare, subside and flare again. This type of existence has been observed just before the star "dies." It is not known if this is part of the normal life cycle of a star. A supernova occurs when a star gives up great mass in one giant explosion of light and energy.

A **constellation** is a grouping of stars. Hundreds of years ago, early astronomers divided stars into groups and made imaginary figures out of them. Things like a lion or a scorpion, or a dog were used. This is how constellations were named. The stars in these constellations are not really related; they only appear to be as we view them from Earth. There are 88 constellations in use by astronomers today.

Pulsar

Some of the more well known ones are: Ursa Major (the Big Dipper is part of it), Orion and Cassiopeia. We included an activity to help you become more familiar with constellations.

Quasars are extremely luminous bodies with a volume roughly equal to our solar system. A quasar emits up to 10,000 times the energy of the entire Milky Way galaxy. Scientists believe quasars are fueled by gases such as remnants of stars spiraling into super massive black holes at the center of galaxies.



Black Hole

A pulsar is known as a pulsating star because it flashes electromagnetic emissions in a set pattern. The astronomers who discovered a pulsar first thought Earth was being sent signals from intelligent life in another solar system.

A black hole probably began as a large star that exhausted its nuclear fuel and collapsed inward upon itself. The theory is that if gravitational force builds at the proper rate, the force itself keeps an explosion from occurring. So much matter is compressed into such small volumes that nothing is

allowed to leave because the resulting gravity is so strong. There are no x-rays, ultraviolet rays, radio waves, or visible light — nothing is coming from this dense body. If it can't emit some type of radiation, it is known as a black hole.

## Space Environment Around the Earth

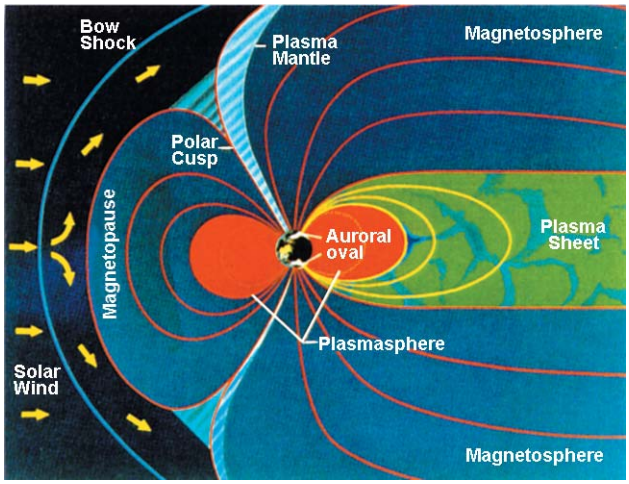
You have probably heard of the aurora borealis and the aurora australis. The aurora borealis (or northern lights) flashes brilliant colors in varying patterns across the northern skies, and the aurora australis presents a similar display in the Southern Hemisphere. Observers have determined that these displays occur at heights ranging from 60 to 600 miles above the Earth's surface. It has also recently been determined that these displays are associated with a zone of electrically charged layers in the upper atmosphere called the ionosphere.

The ionosphere is a part of the atmosphere divided by its electrical activity. It gets its name from the gas particles that are ionized or charged. The ionosphere was discovered early in the twentieth century when scientists learned that radio waves were transmitted in the atmosphere and were reflected back.

The ionosphere is filled with ions. Ions are atoms that carry a positive or negative electrical charge as a result of losing or gaining one or more electrons. These ions concentrate in certain parts of the ionosphere and reflect radio waves.

The ionosphere is caused by powerful ultraviolet radiation from the Sun and the ultra high-frequency cosmic rays from the stars. This radiation bombards the scattered atoms and molecules of nitrogen, oxygen and other gases and knocks some of the electrons out of the atoms.

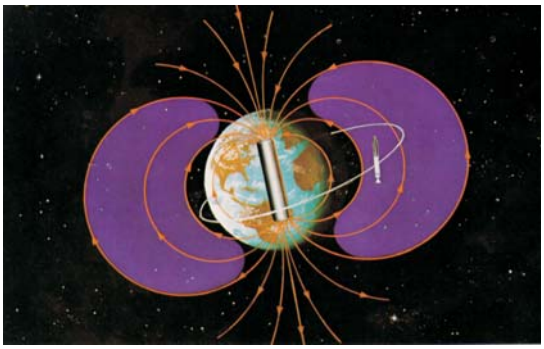
Another region where ions play an important role is in the magnetosphere. The magnetosphere begins at about 215 miles above the Earth's surface and extends into interplanetary space. The magnetosphere is characterized by its magnetic field of force, which surrounds the Earth. This force field is strongest at the poles and weakest at the equator.



Regions of the Magnetosphere

The magnetosphere's force field is effected by solar winds. Solar winds strike the magnetosphere with such force that it forms a bow shock wave. The resulting bow shock wave distorts the Earth's magnetosphere.

Like the ionosphere, the Van Allen radiation belts are filled with charged particles. Also like the ionosphere, the Van Allen belts are caused by the interaction between the Sun and the Earth. Thus, some scientists regard these belts as an extension of the ionosphere. Scientists believe the belts are crescent-shaped and composed of two shells. The belts dip toward the Earth's magnetic poles as the charged particles follow the magnetic lines of force.


Van Allen Belts

The Sun is the primary cause of the Van Allen belts. The Sun constantly emits charged particles that sweep outward in all directions and extend for

unknown distances. These particles are mainly protons and electrons traveling at a million miles per hour. This speed increases considerably when the Sun is active.

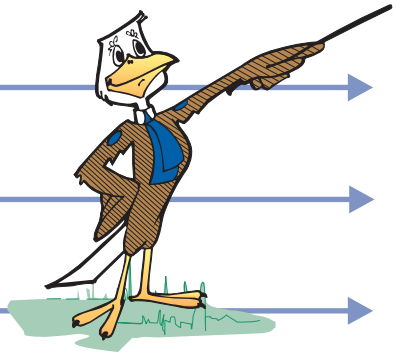
The Sun is considered to be active when solar flares and other solar disturbances are occurring. When these charged particles encounter Earth's magnetic field, many of them are trapped and bounce back and forth between the Northern and Southern Hemispheres.

Some scientists believe that the Van Allen belts are also caused by cosmic rays. Cosmic rays are energetic charged particles that originate from all over the galaxy. They continually rain down on the Earth. These atomic particles are mostly electrons and the nuclei of atoms. They travel at nearly the speed of light and can disrupt spacecraft operations.

Heavy concentrations of radiation are also found within the Van Allen belts. This radiation poses a hazard to astronauts. If astronauts spend much time in this portion of the magnetosphere they must be protected with heavy shielding. During the Apollo program, astronauts had to pass through the Van Allen radiation belts on their way out and on their return trip. However, the exposure time was very short and insignificant. Orbits of the Space Shuttle are beneath the Van Allen belts, so they don't have to worry about radiation.

The radiation associated with the Van Allen belts can be damaging even to satellites. However, many of the orbits are just on the fringe of the belts, so satellites remain functional for many years before replacement is necessary.

See Activity Five - Astronomy in a Tube
Refer to the Activity Section at the end of the chapter for this activity.



See Activity Six - Measuring the Brightness of the Stars
Refer to the Activity Section at the end of the chapter for this activity.

See Activity Seven - Analyzing Starlight
Refer to the Activity Section at the end of the chapter for this activity.

See Activity Eight - The Expanding Universe
Refer to the Activity Section at the end of the chapter for this activity.


## THINGS TO REMEMBER

Everything is part of the universe. Stars, planets, galaxies, plants, animals and humans are all part of the universe. Space is part of the universe. Space is a place without oxygen and with very little gravity. Temperature and pressure are much different than on Earth.

Our galaxy is called the Milky Way, and it is spiral shaped. It is one of the millions of galaxies in our universe. It is filled with stars and nebulae. You should remember the definitions of a star, a nebula, a galaxy and a constellation, and remember some examples of some constellations.

You should also remember some of the characteristics of the ionosphere, the magnetosphere and the Van Allen radiation belts.


## REVIEW QUESTIONS

1. An enormous collection of stars arranged in a particular shape is called a
   a. constellation.
   b. galaxy.
   c. nebula.
   d. binary.

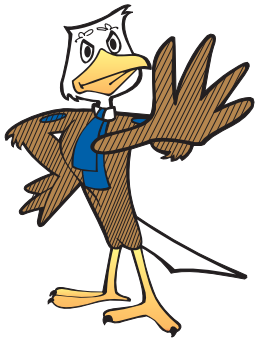
2. A grouping of stars named after mythical figures and animals is called a
   a. constellation.
   b. galaxy.
   c. nebula.
   d. binary

3. Stars are hot bodies of gases composed of
   a. oxygen and nitrogen.
   b. hydrogen and oxygen.
   c. hydrogen and helium.
   d. helium and oxygen.

4. Small amounts of gravity or low gravity are called
   a. astrogravity.
   b. microgravity.
   c. Newtonian gravity.
   d. universal gravity.

5. Which of the following characteristics of space is not accurate?
   a. Space begins around 80-90 miles outward from Earth.
   b. Space is characterized by very little oxygen.
   c. In space, molecules and atoms are closely spaced and interact frequently.
   d. Space is generally an area of low gravity.

# ACTIVITY SECTION



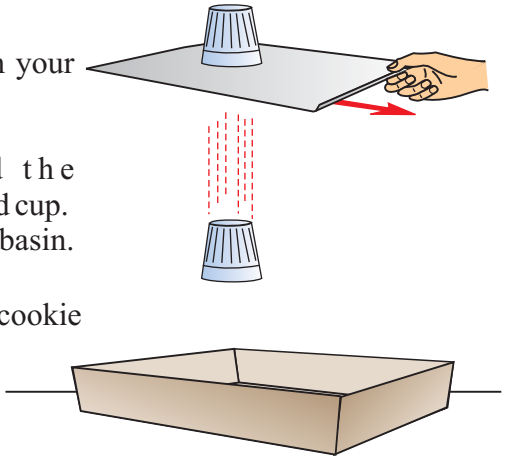
STOP!

Safety Precautions: Water on floors or tile can create a walking hazard. Also, make sure electrical cords and appliances are removed from the area before doing these activities.

## Activity One - Creating the Microgravity of Space

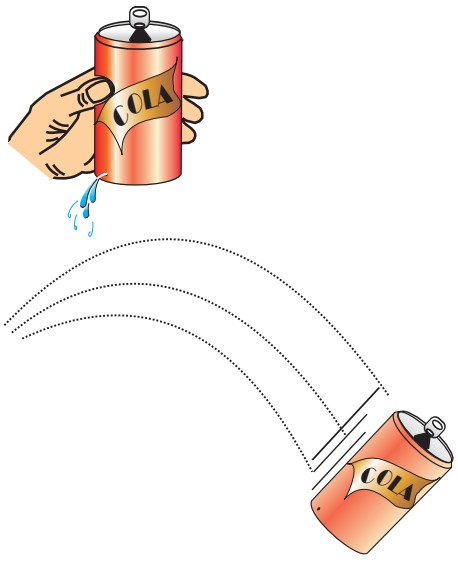
Materials: plastic-drinking cup, large cookie sheet with at least one edge that doesn't have a rim, empty soda pop can, a large pail (catch basin), towels (old bath towels for cleaning spills), a step ladder.

**Procedure:**



1. Place the catch basin in the center of an open area in your meeting room.
2. Fill the plastic cup with water.
3. Place the cookie sheet over the opening of the cup. Hold the cup tight to the cookie sheet while inverting the sheet and cup.
4. Hold the cookie sheet and cup high above the catch basin. This is where you may want to use the stepladder.
5. While holding the cookie sheet level, quickly pull the cookie sheet straight out from under the cup.
6. The cup and the water will fall together.

## Activity Two - The Can Throw

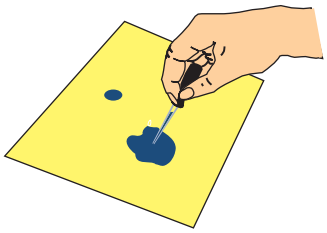



Materials: empty aluminum soft drink can, sharp nail, catch basin, water, and towels.

**Procedures:**

1. Punch a small hole with a nail near the bottom of an empty soft drink can.
2. Close the hole with your thumb and fill the can with water.
3. While holding the can over a catch basin, remove your thumb to show that the water falls out of the can.
4. Close the hole again and stand back about 2 meters (approx 6 ft) from the basin. Toss the can through the air to the basin, being careful not to rotate the can in flight.
5. Observe the can as it falls through the air.

## Activity Three - Surface Tension and Micrograv ity

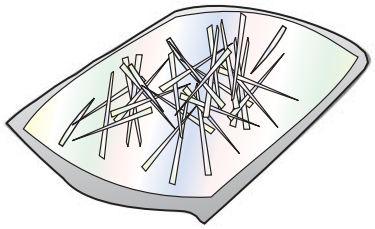


**Materials:** water, liquid dish detergent, toothpicks, eyedroppers, wax paper squares (20 x 20 cm).

**Procedures:**

1. Fill an eyedropper with water.
2. Carefully squeeze the bulb of the dropper to form a drop at the end.
3. As the water drops, sketch the shape of the water drop. Sketch several and observe.Compare the shapes and the sizes.
4. Place a small drop of water on a square of wax paper. Sketch the shape. Measure the diameter and height as best you can. Add a second drop of water, sketch and measure.
5. Continue adding water to the first drop. What happens to the shape? With the dropper, try to pull the drop over the wax paper. At some point, friction overcomes the surface tension and the drop breaks up. How large of a drop can you pull in one piece?
6. Add a small amount of liquid detergent to the drop. What happens?

## Activity Four - Rapid Crystallization



**Materials:** heat pack hand warmer (1 per group, sold at camping and hunting stores), water boiler (an electric kitchen hot pot can be used), styrofoam food tray (1 per group), metric thermometer (1 per group), tongs, observation and data table (1 per group), cooler and clock.

**Procedures: Be careful with boiling water!**

1. Prepare the heat packs by boiling each until all crystals have dissolved. Using tongs, remove the pouches and place them on towels so that the remaining hot water can be dried off.
2. Each group should place a pouch on a styrofoam food tray and slide the bulb of a thermometer under the pack. When the pouch temperature is below 54$^{o}$ C, the internal metal disk can be snapped to trigger crystal growth.
3. Use the data sheet and observe the crystal growth in the pouch.
4. Repeat the activity several times, but cool the pouch to different temperatures. To cool more rapidly, place the pouch on a hard surface. Return it to the styrofoam to measure the temperature and trigger the crystallization.

Is there any relationship between the initial temperature of the pouch and the temperature of the pouch during crystallization?

## Activity Five - Astronomy In A Tube

**Materials:** an empty Pringles potato chip can with its opaque plastic lid, a 9"x12" sheet of black construction paper, some tape (Scotch brand), hammer, nail, straight pin and pair of scissors.

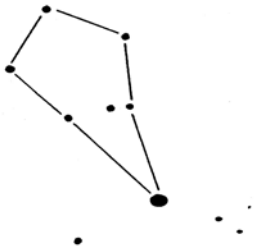
Procedures:

1. Tape the constellation pattern page to the piece of black construction paper.
2. Lay the construction paper and pattern down on a piece of cardboard.
3. Using a straight pin, poke holes through the pattern sheet and black construction paper at each dot.
4. Using the hammer, put a nail through the center of the Pringles can cover.
5. The object is to view the constellation patterns by looking through the Pringles can cover hole, and holding the star patterns at the open end.

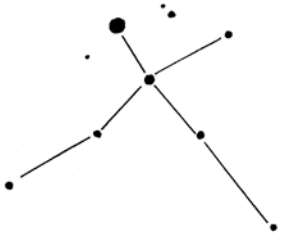
**CONSTELLATION PATTERNS**

**Cassiopeia**

**Bootes**

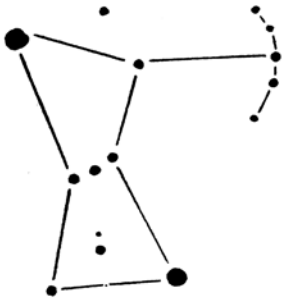


**Cygnus**

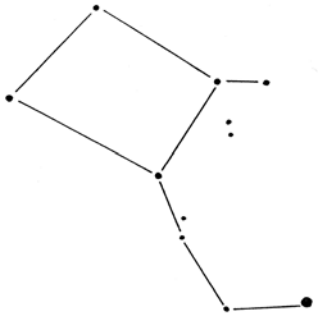


**Corona Borealis**

**Orion**



**Pegasus**



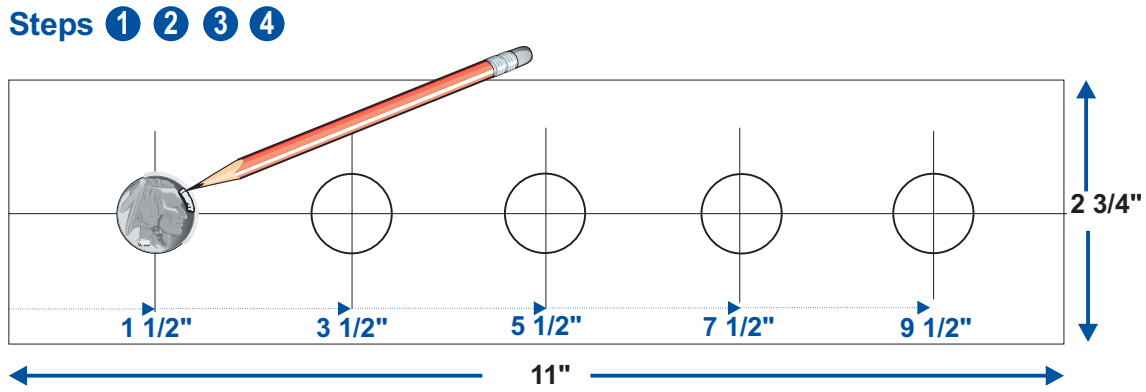
## Activity Six - Measuring the Brightness of the Stars

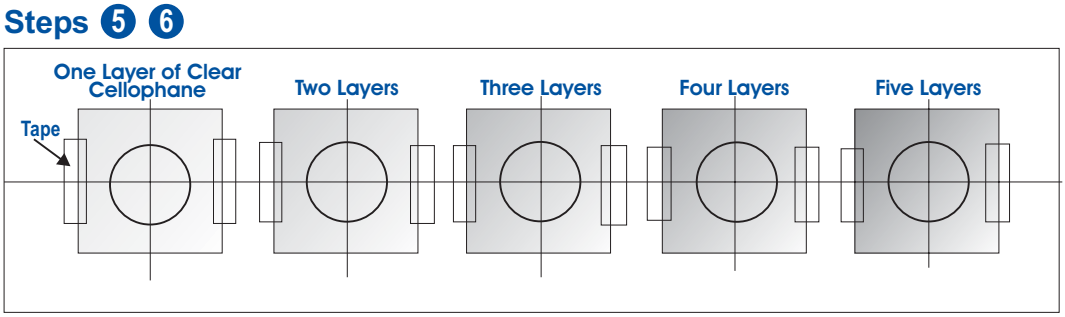
Materials: each participant needs a piece of cardboard (or a file folder), and a strip of clear cellophane.

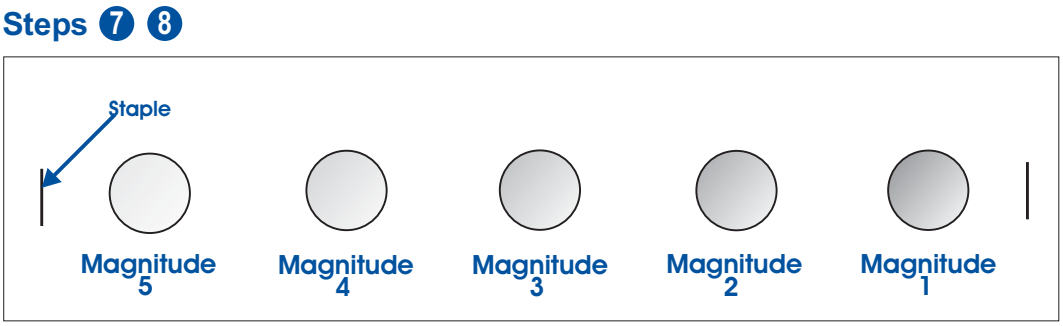
Procedures:

1. Cut two pieces of cardboard, 11 inches long by 2-3/4 inches wide.
2. Use a ruler to mark one cardboard at five equidistant points: 1-1/2", 3-1/2", 5-1/2", 7-1/2" and 9-1/2".
3. Use a nickel to trace a circle over each of the marks, centering the circles between the top and the bottom edges of the cardboard strip.
4. Carefully cut out the five circles. Trace the cutouts onto the second piece of cardboard; carefully cut out the five circles.

5. Cut 15 squares of cellophane, each 1-1/2"x1-1/2".
6. Working with one strip of cardboard: cover the first hole with one square of cellophane; cover the second hole with two squares of cellophane. Cover the third hole with three squares of cellophane, the fourth hole with four squares of cellophane, and the fifth hole with five squares of cellophane. Use small pieces of tape to secure the squares as necessary.
7. Carefully place the second piece of cardboard on top of the secured cellophane squares, being certain to line up the holes in the two pieces of cardboard. Staple the cardboard strips together.
8. Label the hole covered with five squares of cellophane as number 1; label the others in order, with the hole having only one piece of cellophane over it being labeled "5".
9. To use the magnitude strip: Look at a star using only your unaided eye. Then look at the star through the magnitude strip, looking through the hole numbered "1". If you can see the star through hole number 1, the star is a first magnitude (or brighter) star. If you cannot see it, try looking through the hole labeled "2". Keep moving down the magnitude strip until you can see the star. Stars that are seen through the 4th hole are fourth magnitude stars; stars that can not be seen through the fifth hole, but can be seen with the unaided eye, are sixth magnitude stars.



## Activity Seven - Analyzing Starlight

Materials: You must plan ahead. To do this activity you must purchase diffraction grating. (Edmund Scientific, 101 East Glouchester Pike, Barrington, New Jersey 08007-1830 sells it) Their phone number is (609) 573-6250. Two sheets of diffraction grating measuring 6"x12" costs less than $10. These sheets will need to be cut; one sheet will make 18 two-inch squares. Twenty-five diffraction gratings mounted in 2"x2" cardboard slide mounts can be purchased for $21.95. These can be used straight from the package to build the spectroscopes for the cadets. You also need cardboard tubes (paper towels, toilet tissue, or gift wrapping tubes), scissors or hobby knives, cellophane tape, colored markers or pencils, typing or computer paper, flashlights.

Procedures:

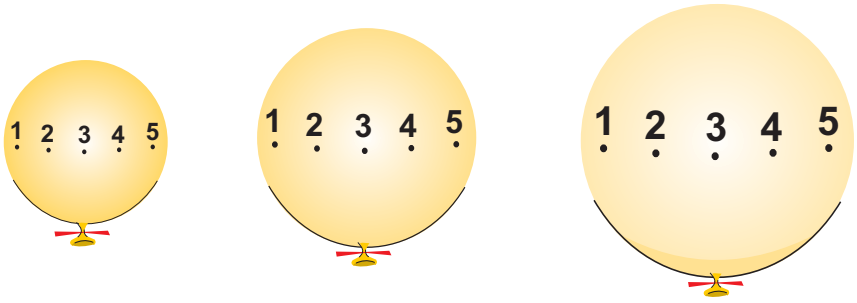
1. Cover both ends of a cardboard tube with paper and fasten with tape.
2. Make a thin slit in the paper at one end of the tube. (Only a narrow band of light should show through this slit.)
3. Make a small hole (1/8") in the paper at the other end of the tube.
4. Put the diffraction grating over the small hole and fasten it with tape.
5. Point the slit toward the available light source. (Do not look at the sun)
6. Move the tube slowly to the right or left so as to make an image appear.
7. Using a sheet of paper, sketch the light pattern observed.
8. Observe two other light sources, if possible, and sketch the light patterns observed.

## Activity Eight - The Expanding Universe

Materials: balloon, marker, twist tie or paper clip, measuring tape, paper, pencil

Procedures:

1. Partially inflate the balloon. Fasten the neck of the balloon with the twist tie or clip.
2. Make several dots around the balloon and label each dot with numbers ("1", "2", "3", and so on.).
3. Measure and record the distance between each of the dots.
4. Remove the twist or clip, blow more air into the balloon and re-fasten the twist around the neck of the balloon.
5. Measure and record the distance between each of the dots again.
6. Remove the twist, fully inflate the balloon, and re-fasten the twist around the neck of the balloon.
7. Measure and record the distance between each of the dots a third time.
8. Discuss what happened to the dots as more air was put into the balloon. How is this like the expanding universe?

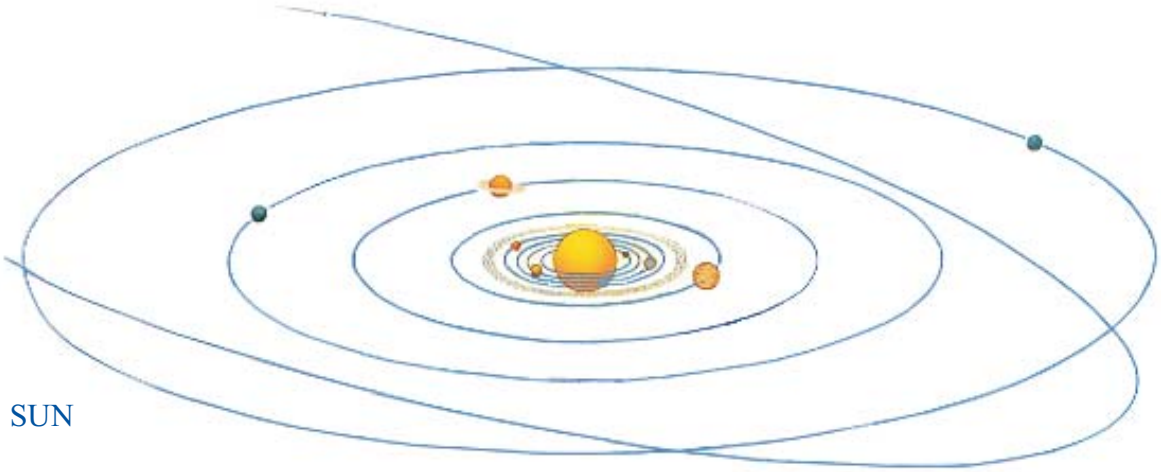


# 2 SOLAR SYSTEM

***I***mportant Terms

solar system - the sun and the bodies that orbit around it
comet - a small icy body orbiting the sun
asteroid - a small rocky body orbiting the sun; usually found in the asteroid belt
meteoroid - clump of dust or rock orbiting the sun
meteor - a small streak of light; when a meteoroid enters the Earth's atmosphere it becomes a meteor
solar flares - short-lived high energy discharges
solar prominences - larger energy discharges that can be thousands of miles high and last for months
sunspots - darker, cooler areas of the sun

When you hear "solar system" what do you think of? Most of us probably think of the planets within our solar system. Some of us might think about the Sun. These are good responses because they are part of our solar system. What is our solar system? Our solar system is the Sun, the planets and their satellites, asteroids, comets and any celestial body that comes under the gravitational influence of the Sun. This gravitational influence means that these bodies orbit the Sun. All of these parts are collectively known as our solar system. The word solar means anything pertaining to or proceeding from the Sun. So, the Sun is the key feature of our solar system. Let's take a moment of talk about the Sun.



## THE SUN

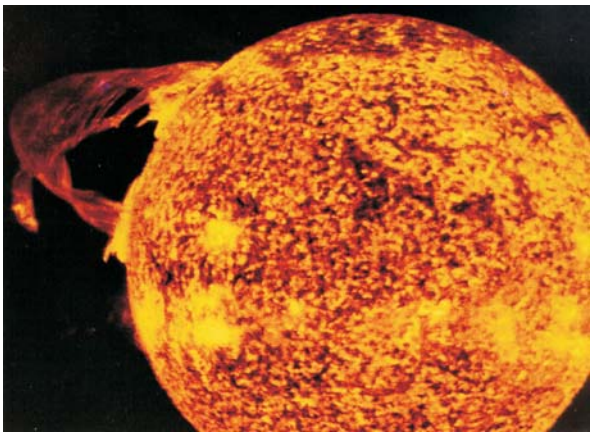
The Sun is the most important element of our solar system. Without its heat and light the Earth would be a lifeless, ice covered planet. On Earth, the Sun sustains our lives, and it gives energy which provides food and oxygen. It stirs our atmosphere and initiates our weather.

The Sun is a star. It is the central star of our solar system. All other bodies of the solar system revolve around it. Because of this, the Sun is the point of reference for most facts about our solar system. When people talk about distances in our solar system, they tell how far something is from the Sun. For instance, the Earth is 93 million miles from the Sun. When talking about the size of planets, one often compares them to the size of the Sun. The Sun is 300,000 times as massive as the Earth. Our solar system, our world, could not exist without the Sun.

The Sun is a medium sized star, a ball of gas, composed of about 90% hydrogen, 9% helium and minor amounts of several other elements. Its diameter is 864,000 miles. The Sun's diameter is more than 100 times the diameter of the Earth. The temperature of the Sun ranges from 4,200$^{O}$ C in its coolest regions to over 15 million$^{O}$ C at its center.

As just mentioned, the Sun consists mostly of hydrogen and helium. The hydrogen is converted into helium by nuclear fusion. This process generates and releases the Sun's energy in all directions, all of the time. It is generally accepted that the Sun is a giant thermonuclear reactor, releasing a tremendous amount of energy.

The core of the Sun is so hot that no solid or liquid molecules can exist. Virtually, all atoms remain in a plasma state. The energy released within the core has to make its way to the surface, atom by atom. It's theorized if the Sun's fusion reaction were to suddenly halt, it would take more than 100,000 years before any effect would show on the surface of the Sun.



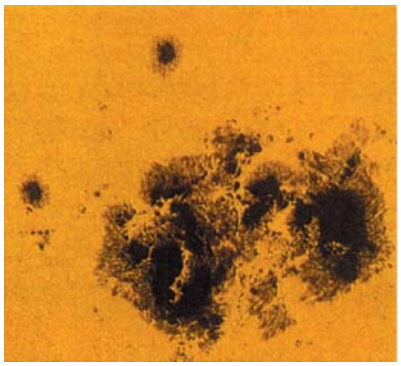
The Sun Showing Solar Prominences

The very thin shell of the Sun's outer layer is called the photosphere. This is the part of the Sun that gives off light. It is also the visible surface that we see. This shell is composed mostly of hydrogen and helium, and is very hot. Its temperature is more than 10,000F.

The outer layers of the Sun indicate constant motion and violent activity. Solar disturbances occur all of the time. Sometimes they last for less than a second, and other times they last for years. These solar disturbances are usually associated with sunspots. Sunspots are darker, cooler areas of the Sun. From these sunspots, solar flares and solar prominences occur.

**Solar flares** are short-lived high-energy discharges, that are potentially dangerous. They can harm satellites, ground systems, spacecraft and astronauts. We monitor the Sun's activity closely so we can react quickly when flares occur. The less dangerous electromagnetic radiation from a flare will reach Earth in less than 9 minutes. The more dangerous high-energy particles may take 15 minutes to 3 days to get here. Space operators must be prepared to act quickly.

**Solar prominences** are larger and longer lasting high-energy discharges. Prominences can reach thousands of miles and last for months.



Sunspots

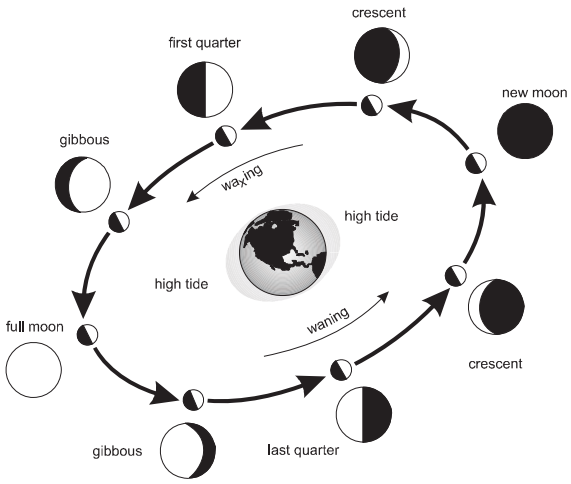
See Activity One - Build a Solar Cooker
Refer to the activity section at the end of the chapter for this activity.

## THE MOON

The Earth has one Moon and it is situated in an elliptical orbit around the Earth. Because it is elliptical and not circular, the Moon's distance from the Earth changes slightly. The distance varies from approximately 252,000 miles at its farthest point to 221,000 miles at its nearest point. The Earth's Moon has a diameter of about 2,155 miles, which is about ¼ of the Earth's diameter.

The Moon also rotates on its axis in the same amount of time it takes to orbit the Earth (27 days). Therefore, the same side of the Moon (near side) always faces the Earth. However, the amount of surface we see, the phase of the Moon, depends on how much of the near side of the Moon is in the sunlight. One-half of the surface of the Moon is illuminated by the sun, and the other half is in shadow. As the Moon rotates around the Earth, its position relative to the sun changes. As seen from

The Earth's Moon




Phases of the Moon

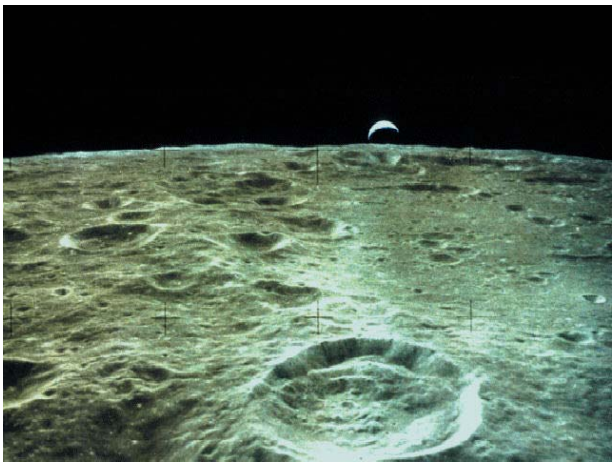
the Earth, this means that a part of the surface of the Moon that is in shadow is facing the Earth. When the Moon is on the side of the Earth nearer the sun, the Moon is new. When it is on the opposite side of the Earth the Moon is full.

See Activity Two - Seeing the Moon
Refer to the activity section at the end of the chapter for this activity.

**See Activity Three - Earth -Moon Distance**
**Refer to the activity section at the end of the chapter for this activity.**

The Moon is a dry and barren place with no atmosphere or water. It consists mainly of solid rock covered with dust.

This fine dust covers the entire surface of the Moon. There are two theories on how the dust got there. Some think the impact of meteoroids striking the surface pulverized lunar matter into dust, which settled to the surface slowly and evenly. Others think the dust is cosmic dust from space that the Moon's gravitational pull brought to the surface.



The Surface of the Earth's Moon

The Moon has many different kinds of rocks. We learned this from the lunar landings. Moon basalt is a dark gray rock with tiny holes from which gas has escaped. It closely resembles Earth basalt but contains different mineral combinations. On the Moon, basaltic lava makes up the dark, smooth surfaces of the lunar plains, which cover about half of the visible side of the Moon.

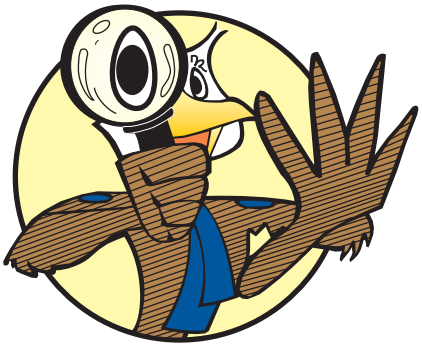
Probably the most common rock on the Moon is known as anorthosite. This rock is composed almost entirely of one mineral, feldspar. Anorthosite is found in the highlands of the Moon and shows up from Earth as the light areas of the Moon. Anorthosite is rare on Earth, but is found in Greenland and is believed to be an ancient rock.

` Primarily, the Moon has two types of terrain, highlands and lowlands. The highlands are filled with craters surrounded by mountains, and the lowlands are filled with craters that have been flooded with molten lava and appear as dark areas called maria (Latin for sea).

A Moon day lasts 27 Earth days, so daytime on the Moon lasts about 13-14 Earth days. Temperatures can rise above 250$^{O}$ F during the day. Nighttime also lasts 13-14 Earth days, and the temperatures can go below -250$^{O}$ F.

See Activity Four - Lost on the Moon - Survival

**Refer to the activity section at the end of the chapter for this activity.**



## THE PLANETS

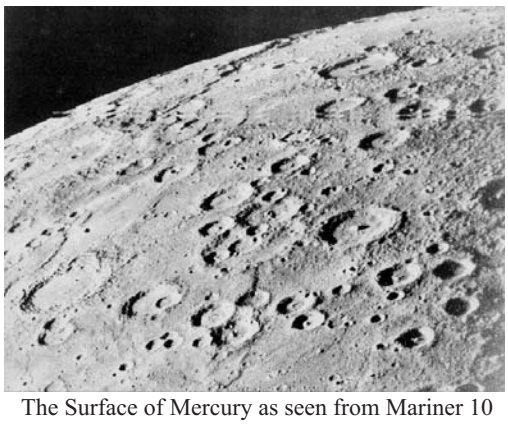
Our solar system contains nine planets. Most of us can probably name them, and are somewhat familiar with them. Let's take a few moments and look at some interesting facts about each planet. They are listed in order of their distance from the sun, beginning with the closest.

### Mercury

Mercury is the closest planet to the Sun, yet it is the most difficult to see because of the Sun's glare on it (Don't look for Mercury while the Sun is in the sky. It could damage your eyes). Mercury is slightly larger than the Earth's Moon and is the second smallest of the nine planets.

Mercury is only 36 million miles from the Sun and revolves around the Sun every 88 days. It has a very elliptical orbit, and it moves about 30 miles every second. Mercury rotates very slowly, taking 59 Earth days to rotate on its axis.

Mercury



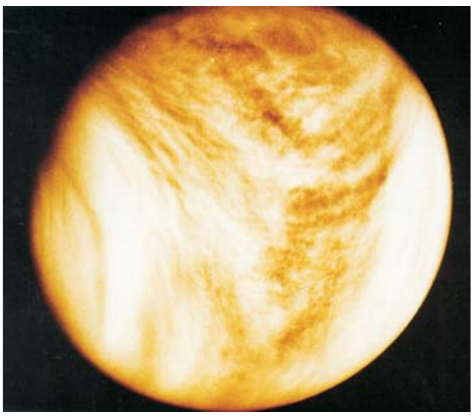
The Surface of Mercury as seen from Mariner 10

Mercury has a rocky, crusty surface with many craters resembling the craters of the Earth's Moon. Many of these craters were formed when rocks crashed into the planet. Mercury also has many lava flows and quake faults on its surface. These craters, flows and faults have shaped the surface of the planet.

Except for small amounts of helium and hydrogen, Mercury has no atmosphere. Scientists believe that Mercury has an iron core that extends through most of the planet. Mercury has significant temperature differences. Its daytime temperature reaches 800F, while its nighttime temperatures reach -300F.

Pictures of Mercury's surface were taken from the Mariner 10 spacecraft that made flybys in 1974 and 1975. Mariner 10 was the only spacecraft to visit Mercury. The pictures displayed Mercury's many craters and loose, porous soil.

## Venus



Venus

Next, is Venus. It is the closest planet to Earth in both distance and size and is often referred to as Earth's sister. Venus is 67 million miles from the sun. It takes 225 days to revolve around the sun. It is a very hot planet with temperatures in excess of 850$^{O}$ F. In fact, Venus is the hottest planet in the solar system.

Even with the heat, Venus is covered with clouds. These clouds are made of water vapor and sulfuric acid, and they rotate at a different rate than the planet. These clouds rotate every four days; much faster than the 243 Earth days it takes for Venus to rotate on its axis. By the way, Venus is the only known planet to rotate in a clockwise manner.

The atmosphere is 96% carbon dioxide and 4% nitrogen. There are also small amounts of water, oxygen and sulfur. Scientists believe volcanic activity is responsible for the sulfur found in the atmosphere. Because of this thick layer of carbon dioxide and the clouds, the heat cannot escape. Therefore, there is very little temperature change on Venus.

The surface of Venus is a relatively smooth, hot desert. It does have some highlands and craters too. Venus is the easiest planet to see at night and is the brightest of all. You can even see it in the daytime if you know where to look. Since it is the brightest planet that can be seen from Earth, Venus is referred to as the Evening Star.

Since Venus is the closest planet to Earth, it is also the most visited by our spacecraft. Mariner 2, 5 and 10 visited Venus, as did Pioneer 1 and 2. The USSR's Venera 9 and 10 also visited Venus.

The Magellan spacecraft orbited Venus in 1990. It collected radar images of 84 percent of the planet's surface. As a result of the mission, it was verified that volcanic materials cover most of Venus.

## Earth

Earth

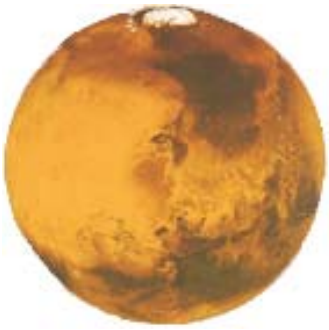
As far as we know, Earth is the only planet that sustains life. Therefore, it is a unique planet. Our atmosphere contains 78% nitrogen and 21% oxygen, with small amounts of argon, carbon dioxide, neon, helium, ozone and hydrogen. This atmosphere provides the oxygen that we breathe and keeps the temperature of water liquid, so that life is possible.

Our atmosphere also acts like a protective blanket. It contains clouds, and these clouds, along with the chemical composition of the atmosphere, help absorb some of the sun's radiation.

The surface of our planet is covered with over 67% water, with the Pacific Ocean accounting for over 50% all by itself. Also, we have anywhere from smooth pastures, to plateaus and small hills, to

tremendous mountains. We have lush forests and barren deserts. Our planet sustains not only human life, but plant life and animal life too. We revolve around the sun in 365 days, and we rotate on our axis every 24 hours.

## Mars



Mars

Of all of the planets, Mars probably fascinates us the most. Over the years, it has been the most publicized in books and movies, and just about everyone knows it as the Red Planet. This is due to its red color which can be seen even with the naked eye. This color is due to the rock and dust covering the surface of Mars. It has been analyzed and found to have a high iron content, so it has a rusty look.

The surface of Mars is dry and rocky and is covered with this reddish dust. Even the deserts of Mars have a red tint to them. The atmosphere is very thin and is composed mainly of carbon dioxide. Mars has about half of the gravity of Earth, so when the wind blows, the dust from the surface rises and gives the atmosphere a reddish pink appearance.

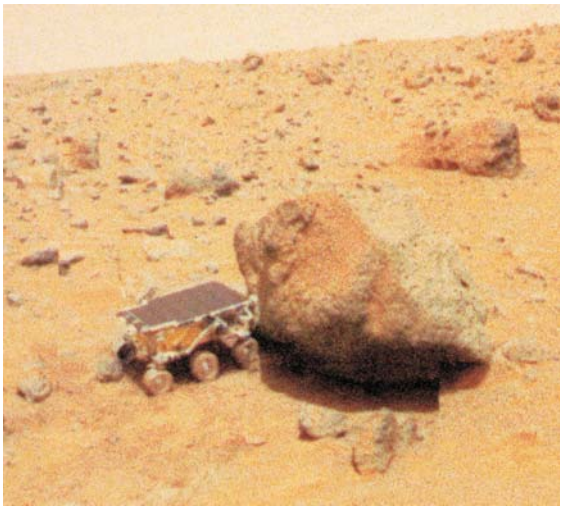
The surface of Mars is covered with deserts, high mountains, deep craters and huge volcanoes. One of Mars' volcanoes is the highest known mountain in our solar system. It is over 400 miles across and 17 miles high. (that is about 90,000 feet high)

The atmosphere of Mars consists of 95% carbon dioxide, 3% nitrogen and traces of oxygen, carbon monoxide and water. Daytime temperatures on Mars reach 65$^{O}$ F, while nighttime temperatures can dip to -130$^{O}$F. These temperatures were recorded from Mars' surface.

One day on Mars lasts slightly longer than it does on Earth, at 24 hours 37 minutes. A Martian year is almost twice as long as an Earth year about 687 Earth days.

In the mid to late 1960s, the Mariner spacecraft made flybys of Mars and took lots of photos. Pictures revealed Mars' surface to be like the Earth's Moon. Then in the mid 1970s another probe, Viking I, touched down on Mars. The primary mission of Viking I and Viking 2 was to determine if life ever existed on Mars. Unfortunately, the experiments were inconclusive even though more

In July 1997, the space probe called the Mars Pathfinder landed on Mars. The next day the Pathfinder's rover, Sojourner Truth, began its exploration of the planet. The Sojourner was two feet long and one foot tall. It studied the surface, analyzed the soil and rocks and conducted scientific experiments on Mars.



Sojourner Truth

Some people believe that Mars may have the right ingredients for life. Next to Earth, it certainly has the most favorable conditions of any of the other planets in our solar system. However, it has less than 1% of Earth's pressure and water content. There is much evidence of water on Mars, but it is frozen. Scientists believe that there are indications that at some point, long ago, liquid water flowed on Mars. Again, according to evidence from Sojourner, now all of the water on Mars is frozen. Obviously, that becomes a critical point for any further exploration or even colonization of Mars.

Jupiter

## Jupiter

Jupiter is the largest planet in our solar system. It has three times the mass of all of the other eight planets put together. This equates to Jupiter being about 11 times larger than Earth. Even though Jupiter is huge, it rotates very quickly, about every ten hours. This causes a flattening effect at the poles and a bulging effect at the equator. This fast rotation also enhances the weather patterns on Jupiter. It creates high winds and giant storms.

Jupiter is a gas giant. Hydrogen is the most prominent gas (about 90%), followed by helium, methane and ammonia. The outer core of Jupiter is composed of liquid hydrogen and helium, and these mix with the gaseous atmosphere to form belts of clouds. These belts are very colorful, but change rapidly due to the high winds associated with the quick rotation of the planet. These belts make Jupiter look like a striped ball with a giant red spot in the lower half. The Giant Red Spot is a distinguishing feature of Jupiter. This spot is a giant storm that is 30,000 miles long and 10,000 miles wide.

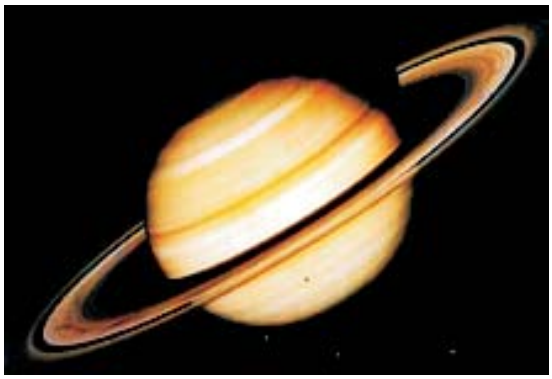
Another feature of Jupiter is the moons. There are 16 known moons, with four that are much larger than the rest. These four are called the Galilean moons, named after their discoverer, Galileo. One of these moons has active volcanoes.

A couple of other facts about Jupiter involve its revolution around the sun and its temperatures. Jupiter revolves in about 11 Earth years, and the temperature ranges from over 60,000$^{O}$F at its center, to -220$^{O}$F at the upper cloud layers.

The Pioneer probes, launched in the 1970s, were the first to visit Jupiter. They discovered that the banded structure of the atmosphere was not present near the poles. The poles had a thick blue-sky atmosphere. Detailed studies showed rapid motions among the clouds and changes in the wind speeds.

A great deal of atmospheric activity on Jupiter is similar to that of Earth. However, Jupiter's storms seem to be powered by the planet itself rather than by the Sun as they are on Earth. Jupiter's highly compressed hydrogen at its center causes the planet to emit almost 70 percent more heat than it absorbs from the Sun. This leads scientists to speculate that the source of Jupiter's stormy turbulence is the planet itself.

Beginning in 1979, Voyager probes were launched to study the outer planets. Additional moons of Jupiter were discovered, raising the total of moons orbiting Jupiter to 16. Four of these moons are large enough to see with high-powered binoculars. One of these moons, Io, was found to have volcanic activity. This was the first evidence of volcanic activity outside of Earth.



Saturn

## Saturn

When we think of Saturn we think of its rings. The rings are easily the most recognizable features of Saturn. Through a telescope, the rings are spectacular! They are made of icy chunks of rock ranging from tiny particles to large boulders. The main rings are made up of hundreds of narrow ringlets. The entire ring system is about one mile thick and extends about 250,000 miles from the planet. There are seven distinct rings around

Saturn. The first five were discovered by Galileo in 1610, and the final two were discovered by the Pioneer spacecraft.

The planet itself has an icy rock core surrounded by metallic hydrogen with an outer layer of hydrogen and helium. The hydrogen and helium are mainly liquid and turn to gas as they get to the outer surface.

Saturn is a large planet, though not nearly as large as Jupiter. Like Jupiter, Saturn rotates at a very fast 10 hours. However, it takes over 29 years to revolve around the Sun. Also like Jupiter, the combination of fast rotation and gaseous and liquid atmosphere create very strong winds, clouds and storms. The winds of Saturn have been known to reach 1,100 miles per hour.

The temperatures of Saturn do not vary as much as many of the other planets. During the day it gets up to 130$^{O}$ F and at night, down to -330$^{O}$ F. These numbers translate into 73$^{O}$ C and -200$^{O}$ C, which is approaching absolute zero. Saturn is about 900 million miles from the Sun.

Saturn has 18 known moons, 17 of which are covered with craters and icy surfaces. The one exception is Titan, which has an atmosphere of nitrogen and methane. It is the only moon in our solar system to have its own atmosphere.

Pioneer and Voyager passed by Saturn in the late 1970s and early 1980s and produced much information about the planet. For instance, in was found that Saturn's outermost region contained its atmosphere and cloud layers. Saturn's three main cloud layers are thought to consist of (from top down) ammonia ice, ammonia hydrosulfide ice, and water ice.

## Uranus

Uranus

Uranus is the third largest planet in our solar system, and like Jupiter and Saturn, it is a gas giant. Uranus has a rocky core surrounded by water, ammonia and methane, in both ice and liquid form. The outer layer consists of hydrogen and helium gases. There is also methane in the upper atmosphere, and this gives Uranus a bluish greenish color.

Uranus is about 1.7 billion miles from the Sun, about twice as far as Saturn. It has only been since the mid 1980s that we have been able to increase our knowledge of Uranus. This of course was due to the US unmanned space flight to Uranus.

It takes Uranus 84 years to revolve around the Sun, and it rotates in about 18 hours. Because Uranus is tilted 60$^{O}$ on its axis, daylight lasts 42 years followed by 42 years of night. This means that even though the planet is rotating on its axis every 18 hours, it continues to face the sun light for 42 years because of the 60$^{O}$ tilt.

Like Saturn, Uranus has rings around it. It actually has 11 very narrow and black rings. They are made of chunks of rock and are very dark and hard to see. Additionally, Uranus has 15 moons. These moons are made of rocks and ice.

The temperature is about -340$^{O}$ F on Uranus. Its environment is super cold because hardly any solar radiation reaches Uranus.

## Neptune

Neptune is the outermost of the gas planets and is the fourth largest planet in our solar system. It was discovered in 1846 when scientists determined that something was affecting the orbit of Uranus. Neptune and Uranus are so similar they are sometimes called twins.

Neptune

Neptune is about 3 billion miles from the Sun and it takes 165 Earth years to complete an orbit. A Neptune day lasts about 19 hours. The planet has a rocky core surrounded by water, ammonia and methane. The atmosphere consists of hydrogen, helium and methane. The methane gives Neptune a bluish color.

Pictures of the planet show bright clouds of methane ice crystals are present. Pictures also indicate that Neptune has a very thin, faint ring system, which is hard to detect.

Neptune is a windy planet, the most windy in our solar system. It has recorded winds of 1,500 miles per hour. Storms similar to those on Jupiter were found during Voyager missions. Several large dark spots were found during the missions. The largest of the storms, the Great Dark Spot, is about the size of the Earth.

The ring system around Neptune is narrow and very faint. The rings are composed of dust

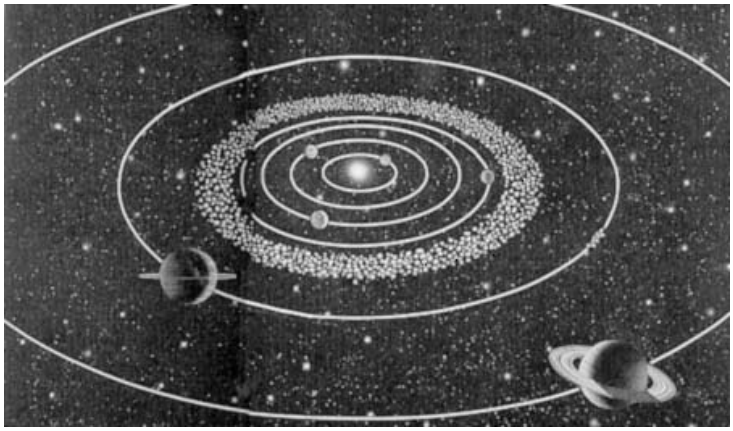
tell the two apart. Charon's rotation period is the same as Pluto's, so they travel in synchronous orbit together. However, they spin in opposite directions.

A distinctive fact about Pluto is its strange orbit. It is more elongated than any of the other planets, and sometimes is actually closer to the Sun than Neptune.

Pluto

## Other Bodies

Asteroids, comets and meteoroids are part of our solar system and therefore orbit around the Sun. Collectively, they are thought of as debris orbiting in space. You might wonder why they are important to us. Well, one reason is safety. Space planners and space travelers need to consider these phenomena as they prepare to go deeper into space. Let's take a quick look at each of these individually and learn a little more about them.



Asteroids

Asteroids are chunks of rock that range in size from particles of dust to some that are a few hundred miles across. Most asteroids travel in an orbit between Mars and Jupiter. This area is known as the asteroid belt.

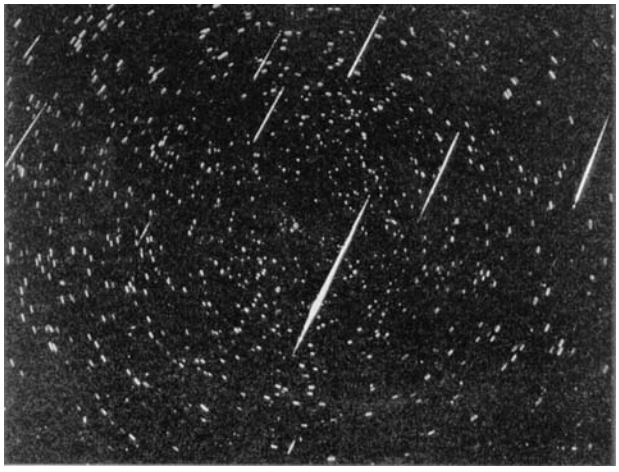
The first asteroid was discovered an Italian astronomer, Guiseppe Piazi, in 1801. Since that time, more than 15,000 asteroids have been

found and catalogued. Scientists speculate that there are probably millions more of them in our solar system. Scientists know of more than 200 asteroids whose orbits come close to our Earth and are capable of hitting us. However, the closest any have come is about 100,000 miles. Scientists know of more than 200 asteroids whose orbits come close to our Earth and are capable of hitting us. However, the closest any have come is about 100,000 miles.

Spacecraft have flown through the asteroid belt and found that large distances separate asteroids. In October 1991, Gaspra was visited by the Galileo spacecraft and became the first asteroid to have high-resolution images taken of it. Gaspra is composed of metal-rich silicates and looks like a lumpy potato-shaped rock.

In 1997, the spacecraft Near Earth Asteroid Rendezvous (NEAR) made a high-speed, close encounter with the asteroid Mathilde. Scientists found Mathilde to be a carbon-rich asteroid. NEAR went on to encounter the asteroid Eros in 1999-2000. Eros had numerous boulders protruding above the surrounding surface.

Comet



Meteor Shower

Earth-based observations of asteroids continue too. In May 2000, scientists observed Kleopatra with the 1,000 foot telescope of the Arecibo Observatory. Kleopatra was a metallic, dog bone-shaped rock the size of the state of New Jersey.

A comet is described as a giant dirty snowball. It is irregularly shaped with a tiny nucleus composed of frozen gases, water, dust and icy lumps. Comets are usually a few miles across. Comets generally travel around the outer regions of our solar system, but sometimes they are bumped off their orbit and head toward the sun. As they approach the Sun, comets usually grow in size and brightness. As the comet moves closer to the Sun, the comet's ice parts begin melting into a gaseous and dusty tail that can extend for millions of miles.

Sometimes, comets remain in their new orbits and repeat their journey. Thence, scientists can sometimes predict future comet's travel paths. For instance, Halley's Comet reappears every 76 years.

English astronomer Sir Edmund Halley first suggested that comets were members of our solar system. After studying bright objects in the sky, he predicted the appearance of a comet in 1758. When it appeared the comet was named after him. Halley's comet continues to make regular appearances in our skies. It last approached the Sun in 1996.

Very small, dust-particle size bits of matter are called micrometeorites. From this size upward, these tiny particles of dust and sand are called meteoroids. Meteoroids are usually leftover from a comet. If a meteoroid enters the Earth's atmosphere it is called a meteor. If the meteor is large enough to penetrate our atmosphere and actually hit the surface of the Earth it is called a meteorite.

Meteorites are not that common, but they have occurred. However, meteors are very common. Friction causes a meteor to heat and glow and begin to disintegrate leaving a trail of luminous matter.

When there are many meteors seen in the sky within a period of an hour, it is called a meteor shower. Meteor showers are also referred to as shooting stars. They can be seen on just about any night if you get out in the country away from the city lights.

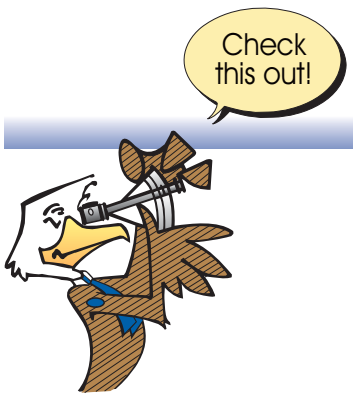
Meteorites are the pieces of matter that remains when debris does not burn up completely as it passes through the atmosphere and lands on the surface of the planet. Scientists believe many meteorites hit the Earth each year, but it is rare to actually see it happen. Most meteorites are basketball-size or smaller, but larger pieces can and do impact the surface of the Earth. Some meteorites are small pieces of an asteroid; others have proved to be material blasted off the surface of the Moon following an impact on its surface. Other meteorites have been determined to originate on Mars.

The recent recovery of a carbonaceous chondrite meteorite from the Yukon has excited scientists who say that its very primitive composition and pristine condition may tell us what the initial materials were like that went into making up the Earth, Moon and Sun. Only about two percent of meterorites are carbonaceous chondrites containing many forms of carbon and organics, the basic building blocks of life. This type of meterorite is easily broken down during entry into the Earth's atmosphere, so recovery is quite rare.

See Activity Five - Solar System Model
Refer to the activity section at the end of the chapter for this activity.

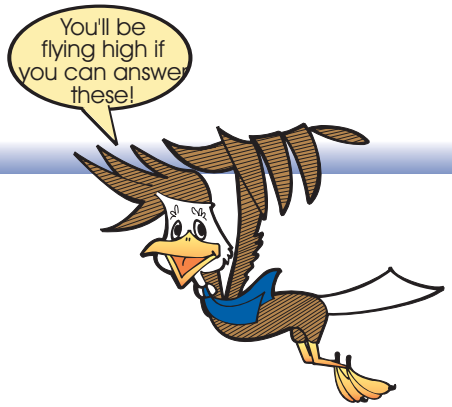
See Activity Six - How Old Are You?
Refer to the activity section at the end of the chapter for this activity.

See Activity Seven - Meteoroids and Space Debris
Refer to the activity section at the end of the chapter for this activity.




## THINGS TO REMEMBER

This chapter was about the solar system. Its a good idea to know how to define a solar system and to know the key members of our solar system. This includes our nine planets and the other bodies that orbit our Sun. Additionally, it is worthwhile to know a few of the facts about each of the planets in our solar system.




## REVIEW QUESTIONS

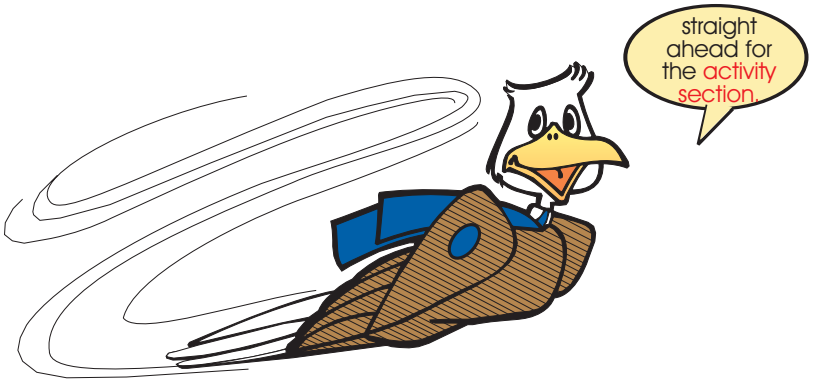
1. A solar system is defined as
   a. a small icy body orbiting the Sun.
   b. the Sun and the bodies that orbit around it.
   c. darker, cooler areas of the Sun.
   d. short-lived, high energy discharges.

2. When a meteoroid enters into the Earth's atmosphere it is called
   a. a meteor.
   b. a meteorite.
   c. an asteroid.
   d. a solar flare.

3. Which of the following statements about Venus is true?
   a. Venus rotates in a clockwise manner.
   b. Venus is composed of 78% nitrogen.
   c. Venus is known for its giant red spot.
   d. Venus is about 3 billion miles from the Sun.

4. Which planet is a dark and frozen planet 4 billion miles from the Sun?
   a. Mercury.
   b. Pluto.
   c. Saturn.
   d. Venus.

5. Which planet is known as the windiest planet in the solar system?
   a. Earth.
   b. Mars.
   c. Neptune.
   d. Uranus.



# ACTIVITY SECTION

## Activity One - Build a Solar Cooker

Materials: shoe box, aluminum foil, and plastic wrap, a skewer and some hot dogs.

Procedure:

1. Line the shoe box with the foil.
2. Insert a skewer through one of the short sides.
3. Insert the skewer through a hot dog (lengthwise) and then stick the skewer into the other short side of the box.
4. Cover with the plastic wrap.
5. Place the solar cooker in the sun and let the sun cook your lunch.
   You could try baking cookies from refrigerated cookie dough.

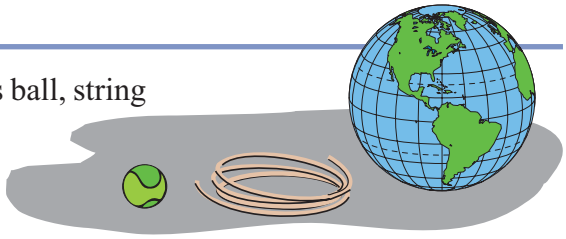
## Activity Two - Seeing the Moon

Materials: a dark room, a bright light source (a table lamp), a small ball (baseball), and the experimenter.

Procedure:

1. Hold the ball at arm's length toward the bright lamp.
2. With the lamp representing the sun, the head of the experimenter (your head) becomes the Earth, and the ball is the Moon.
3. Stand in place; slowly turn to the left so that the ball in your outstretched hand moves in a complete circle. Ensure the room is dark except for the table lamp. You will be able to see the changing phases of the Moon.

## Activity Three - Earth -Moon Distance



Materials: world globe (12 inches in diameter), tennis ball, string (about 20 feet long)

Procedure:

1. With the tennis ball representing the Moon, ask students to place the tennis ball at a distance from the globe that represents how far the Moon is from the Earth.
2. Ask students to determine the circumference of the Earth and the distance between the Earth and the Moon by consulting a reference book.
3. Ask the students to divide the distance to the Moon by the circumference.
4. Compare the earlier estimate of the distance between the Earth and the Moon with measured distance based on the Earth's circumference. Wrap the string around the globe 9.5 times. Hold one end of the string at the surface of the Earth and stretch the measured string across the classroom. The other end of the string represents the distance of the Earth to the Moon.

## Activity Four - Lost on the Moon - Survival

Background: Your spaceship has just crash-landed on the dark side of the Moon. You were scheduled to rendezvous with your mother ship 200 miles away, on the lighted surface of the Moon, but the rough landing has destroyed your ship and ruined all but the 15 items listed in this problem.

Since you are the commander, and your crew's survival depends upon reaching the mother ship, you must choose the most critical items available for the 200 mile trek across the Moon's surface. You must determine the "priority" of survival items and list them. Back on Earth, NASA would have given you their priority, but no contact can be made. The decision is yours. How would your leadership skills compare to those of the NASA"home team". This activity can be done individually or in small groups. Its fun to compare your answers with both NASA and other individuals or teams.

Materials: checklist of items provided, a pencil or pen.

Procedure:

1. Hand out a copy of the problem or read it to them.
2. Have cadets rank the 15 items in their order of priority.
3. After the cadets are done, have cadets discuss and justify their rankings.
4. Show the cadets the NASA rankings.
5. Calculate the error points for individuals and teams.
6. If you didn't have teams, calculate the error points for the group as a whole.

| | ITEMS | NASA RANKING | YOUR RANKING | ERROR POINTS | GROUP RANKING | ERROR POINTS |
|---|---|---|---|---|---|---|
| 1 | Box of matches | | | | | |
| 2 | Food concentrate | | | | | |
| 3 | 50' of nylon rope | | | | | |
| 4 | Parachute silk | | | | | |
| 5 | Solar powered heating unit | | | | | |
| 6 | Two 45 caliber pistols | | | | | |
| 7 | One case of Pet milk | | | | | |
| 8 | Stellar map | | | | | |
| 9 | Two 100-pound oxygen tanks | | | | | |
| 10 | Self-inflating life rafts | | | | | |
| 11 | Magnetic compass | | | | | |
| 12 | Five gallons of water | | | | | |
| 13 | Signal Flares | | | | | |
| 14 | First aid kit containing injection needles | | | | | |
| 15 | Solar powered FM transceiver | | | | | |
| | TOTALS | | | | | |

Calculate error points for the absolute difference between the NASA ranking and the individual or group ranking. Scoring: 0-26 = Excellent
26-32 = Good
33-45 = Fair
56-112 = Still lost on the Moon.

* The answers to this activity are in the Leader Guide.

## Activity Five - Solar System Model

Materials: 33 yards of twine or rope, 4 sheets of tagboard, pencil, black marker, drawing compass, measuring tape, cellophane tape, calculator, scissors and the chart below.

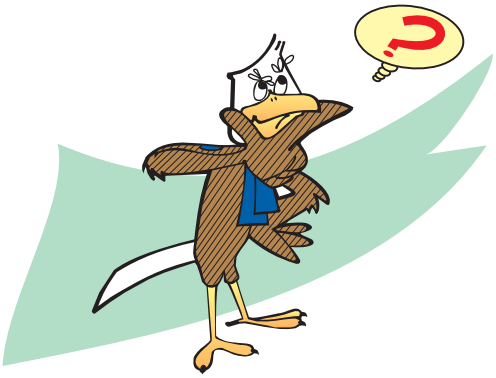
Background: If you can't obtain any rope or twine you can just step off the distances. Also, because we are using two different scales, the planet sizes and distances are not proportionate. The focus is on having a model in a fairly compact area.

### Procedures:

1. Calculate and record the scaled diameters for each of the planets.
2. Make and cut out tagboard circles to represent each of the planets.
3. Calculate and record the distance from the sun for each of the planets.
4. Using the 33 yard rope as the distance from the sun to the farthest planet in the solar system, measure and mark the location for each of the planets. Tape each planet in place.

DIAMETER OF THE SUN AND PLANETS

| | Diameter (km) times $10^3$ | Diameter (km) $1.39 \times 10^4$ km/cm |
|---|---|---|
| Sun | 1,390. | |
| Mercury | 4.9 | |
| Venus | 12.1 | |
| Earth | 12.8 | |
| Mars | 6. | |
| Jupiter | 142.8 | |
| Saturn | 120. | |
| Uranus | 51.2 | |
| Neptune | 48.6 | |
| Pluto | 2.2 | |



DISTANCE FROM THE SUN

| | Distance (km) times $10^6$ | Distance (km) $5.92 \times 10^6$ km/cm |
|---|---|---|
| Sun | | |
| Mercury | 58 | |
| Venus | 108 | |
| Earth | 150 | |
| Mars | 228 | |
| Jupiter | 780 | |
| Saturn | 1,430 | |
| Uranus | 2,880 | |
| Neptune | 4,510 | |
| Pluto | 5,920 | |

## Activity Six - How Old Are You?

Materials: chart provided.

### Procedures:

1. Calculate your age in Earth days. One year = 365 days.
2. Calculate your age in Earth days for the other planets in the solar system.
3. Then convert the Earth days into Earth years.

| | |
|---|---|
| Mercury | one year = 88 Earth days |
| Venus | one year = 243 Earth days |
| Mars | one year = 687 Earth days |
| Jupiter | one year = 11.5 Earth years |
| Saturn | one year = 29.5 Earth years |
| Uranus | one year = 84 Earth years |
| Neptune | one year = 165 Earth years |

## Activity Seven - Meteoroids and Space Debris

Materials: two or three raw potatoes (depending on group size), several large diameter plastic straws. Each cadet should get a chance to participate.

Procedure:

1. Hold the raw potato in one hand.
2. While grasping the straw with the other hand, stab the potato with a quick sharp motion. The straw should completely penetrate the potato.
   CAUTION - Don't strike your other hand.
3. Again, hold the potato and now stab it with the straw using a slow push. The straw should bend instead of penetrate the potato