SPACE EXPLORATION

Teacher Guide

including

Lesson Plans, Student Readers, and More Information

Lesson 1 - Early History of Exploration

Lesson 2 - Development of Telescopes

Lesson 3 - Telescope - Lab

Lesson 4 - Virtual Space Travel - Lab

Lesson 5 - Hubble Telescope - A Story

designed to be used as an Electronic Textbook
in class or at home

materials can be obtained from the Math/Science Nucleus

EARTH SCIENCES - SPACE EXPLORATION

Lesson 1 - Early History of Exploration

MATERIALS:
reader

Objective: Students explore the early tools used to explore space.

Teacher note

Space exploration is a frontier that has not been fully exploited. Development of tools to help see the Universe has guided its exploration. The rules of space are not the same as Earth, so you have to make predictions based on limited information. We have not traveled far in our exploration. We still have not fully explored all the planets and their moons. The stars and other galaxies is only in its infancy.

Technology, money, and the human curiosity to explore, will one day discover more and more information. Your students will be part of this exploration.

This reader is to provide an introduction to students. Either read as a class or as a homework assignment and discuss the early development. Key concept to emphasize is **the invention of the telescope was important to exploring space**. Even today the telescope is used to obtain new information. The types of telescopes have improved, but the philosophy is similar.

EARLY EXPLORATION OF SPACE

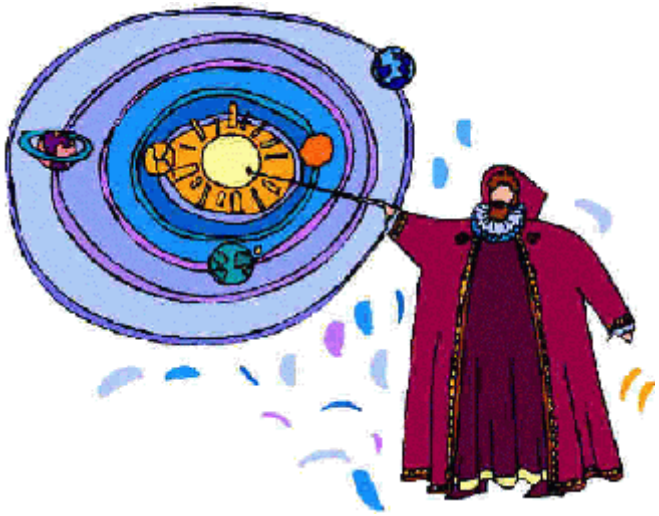
Observing the components of the Universe are dependent upon the human ability to look beyond the Earth. Prior to the invention of the telescope, people had few tools to explore space. **Egyptians** carefully watched the Sun for years and recorded the sunrises and sunsets with just their eyes as their guide. They were the first to record the position of stars in the heaven repeats after 365 sunrises and sunsets. People in Egypt, India, China, **Mesopotamia**, and the Americas also observed the stars and divided them into recognizable groups which are now called **constellations**. Most **civilizations** realized that there are 7 planetary bodies that moved, the Sun, the Moon, and 5 planets and created legends and myths of these gods. Other early cultures, from all the continents, based many beliefs on **astronomical** observations, but all these early people just used their sight as their only tool.

This planetary nebula could not be seen by ancient civilizations.

Later civilizations, like the Greeks held the heavens with great respect, based, mainly on **philosophical** thinking rather than **observational** data. **Ptolemy** (90-168) is probably the best known **Greek** astronomer who proposed a detailed **geometrical** interpretation of celestial motions known as the **Ptolemaic System**. One of his explanations included that each planet moved in a small circle (**epicycle**) in the period of its revolution around the Sun and that the entire system moved around the Earth.

During this early Greek phase of astronomy, the philosophers were not as **dogmatic** as later church "scientists." In the time when **Christianity** was experiencing an enormous growth, astronomy was considered an "evil." It wasn't until the rebirth of scientific thought around the turn of the 16th century did astronomy become a growing science. The history of astronomy on other continents is difficult to document because there is no written record. Unfortunately the only tools they had were their eyes and human logic to help guide them, which led many of these civilization to the incorrect **conclusion**.

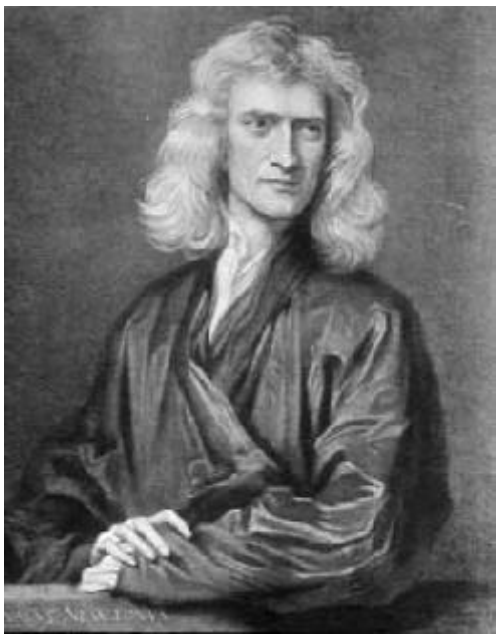
Nicholas **Copernicus** (1473-1543) disposed of the Earth as the Universe's center, by placing the Sun in the central position, with the planets (including Earth) revolving around the Sun. Although Copernicus tried to maintain some of the Ptolemaic epicycles, his work marks a new era of the **"Heliocentric" theory**. Tycho **Brahe** (1546-1601), financed by the King of Denmark, used a **wall quadrant** and **sextant** that measured star and planet locations accurately. This was modern equipment for this time. He noticed that the stars were farther than previously imagined.



Johannes **Kepler** (1571-1630) using Tycho's records, developed 3 laws of **planetary motion**. Kepler's laws outline that the orbit of planets are elliptical with the Sun as the focus point; that planets revolve around the Sun over equal areas; and there is a mathematical relationship of how far the planets are from the Sun. Eyesight was still the most important tool that humans had to explore the sky.

The 1600's became an important century for both exploring the heavens and the **microworld**. Lenses and how to use them was now being developed. The right type of lenses used for a **telescope**, were first invented in **Holland** in the early part of the 1600's. In 1609 **Galileo** Galilei (1564-1642), an **Italian**, heard of the invention of spyglasses or **refracting telescope**. He used lenses in his "optic" tube, which allowed him to see objects that were invisible to the unaided eye. Galileo was able to see stars of the Milky Way, mountains on the Moon, phases of Venus and many other important observation that would lead him to the laws of **inertia** (a body under no constraint moves in a straight line). Galileo's inquiry on motion would be used by Sir Isaac **Newton** to uncover more mysteries of the Universe. In 1632 Galileo published a book attacking the current theories of the Earth. He was tried in court and was forced to deny that the Earth moves. He was put under house arrest for his remaining years.

Newton (1642-1727) used a new type of **reflecting telescope**, as well as other instruments, to observe and calculate the **orbits** of **planets** and **satellites** that would be the basis for his laws of motion and gravity. He could now see more than any scientist before him. Newton's law of motion would take astronomy to a new **scientific** level. Newton's first law of motion may be stated simply that a body remains at rest or continues to move with **constant velocity** in a straight line unless it is acted on by an **unbalanced** outside force. The second law of motion states that the change of **speed** or direction of a body (**acceleration**) is directly **proportional** to the external force producing the change. The third law of motion is that every action has an opposite and equal **reaction**.



Sir Isaac Newton, 1689

In the 1700's Thomas **Wright** and William **Herschel** (England) using an 18 inch reflecting telescope discovered a new planet called Uranus. The data also suggested that the Milky Way might in fact be a flat **disc** of stars in which the Sun was embedded. This information was putting the significance of Earth even farther from the original Ptolemaic theory. Then in the 1920's Harlow **Shapley** and Jan **Oort** put the final indignation to the Earth centered theory, by saying that we lived in a fairly typical galaxy amongst hundreds of millions of other. Albert **Einstein** in the early 1900's developed the theory of relativity, that put the Earth in a position in space and time that would have been unthinkable to early civilizations.

Albert Einstein

Exploration of the Universe would increase when astronomers learned to use **infrared**, **microwaves**, and other components of the **electromagnetic wave spectrum**. Up until the 1920's astronomer's observation was hindered by their tools. During World War II, technology advanced on the use of radio **transmission**. Astronomers realized that they could use this technology to see the Universe, not with "eyes," but through the transmission and **reception** of microwaves, infrared, **ultraviolet**, **x-ray**, and **gamma rays**. The Universe would slowly unfold to researchers. Presently new advances in the technical ability to search the Universe, has allowed some of Einstein's mathematical theories to be proven or disproven. However, the field is still in its infancy.

EARTH SCIENCES - SPACE EXPLORATION

Lesson 2 - DEVELOPMENT OF TELESCOPES

MATERIALS:
reader

Objective: Students learn about how the telescope developed in astronomy.

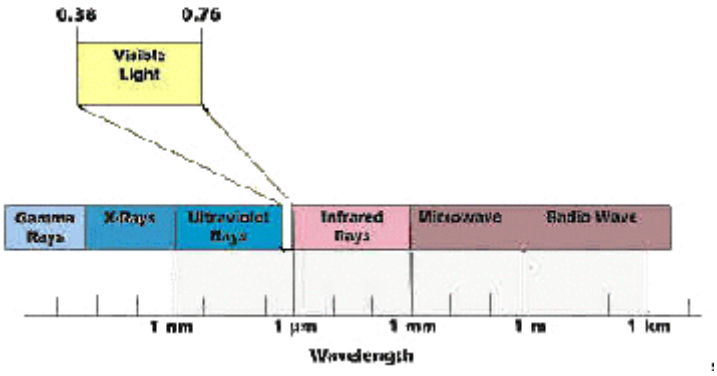
Teacher note

Telescopes are important for space exploration. Technology can open up new worlds for astronomers as new equipment is being developed. You may want to do a search on new types of telescopes to keep your information up-to-date.

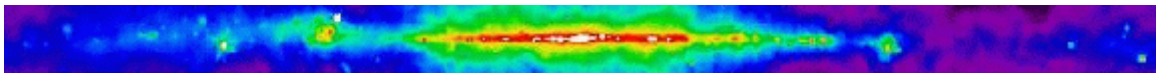
Read the story on the development of the telescope either as a class homework assignment or in class. Discuss with the students the impact on modern telescopes to our understanding of the Universe.

You may want to have students do an internet search using the key words of astronomy or telescopes to find sites that use the telescope in research or amateur astronomy. The online site for *Sky and Telescope* magazine is a good place to start (http://www.skypub.com).

Looking at the components of the Universe require different types of telescopes because of Universe seems to always change. The Universe is highly **three dimensional** in both time and space, and that creates a different world then most of us are familiar with. There are two waves to classify telescope. The type of **electromagnetic waves** used and how those electromagnetic waves move.



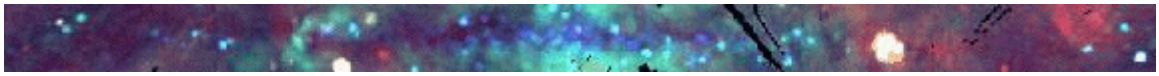
The types of electromagnetic wave telescopes include gamma rays to radio waves as shown on the electromagnetic wave spectrum on the right. The photos below show the same area of the Milky Way using the different types of waves. Each of the photographs reflect different "clues" which scientists have to predict what they mean.



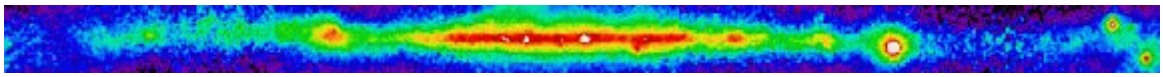
Radio waves

Infrared waves

Light waves



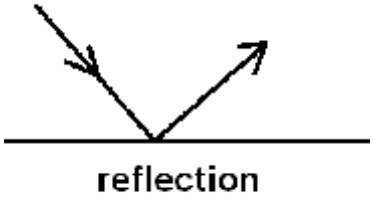
X-ray waves

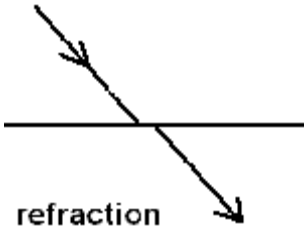


Gamma ray waves

REFRACTING AND REFLECTING

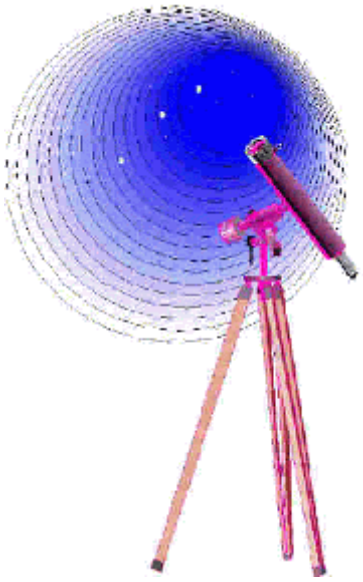
Refraction is when light goes through a lens and changes its direction. A **biconvex** lense can change the direction of the light and focus an image upside down. These basic principles are used when constructing and designing telescopes. Different lenses and different surfaces can move light and some of the other electromagnetic waves so it can enlarger or make smaller objects.

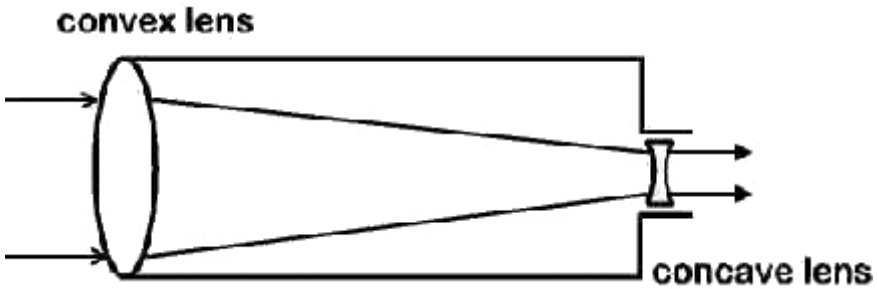




REFRACTING TELESCOPES

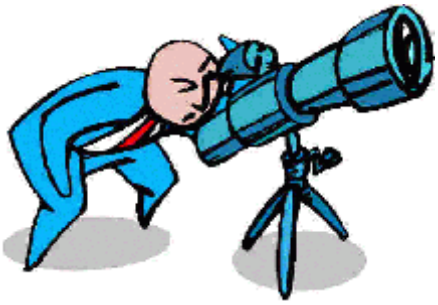
The design of the first optical telescopes in the 1570's was a simple design. There was one **concave** and one biconvex lens fitted inside a tube. The lenses bend the light as it passed through the glass and made the image 3 to 4 times larger. Galileo in 1609 made a telescope with 20-power refracting telescope. It created quite an international commotion because he discovered the valleys and mountains of the moon and discovered 4 moons of Jupiter. This design could make an image larger, but the tube had to be larger and the lense larger. Astronomers were creating monster telescopes up to 150 feet long with a lens of 1 meter (3.28 ft). That was just too large!



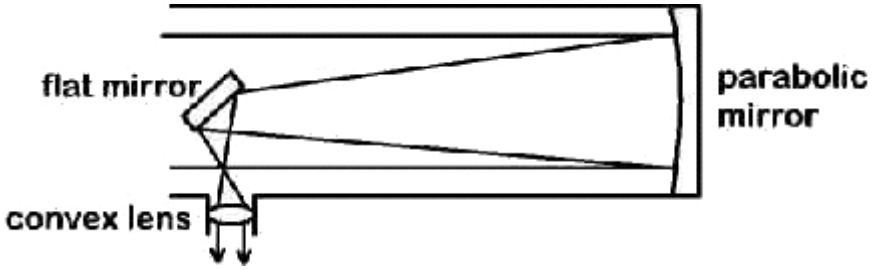


Refracting telescope

REFLECTING TELESCOPES

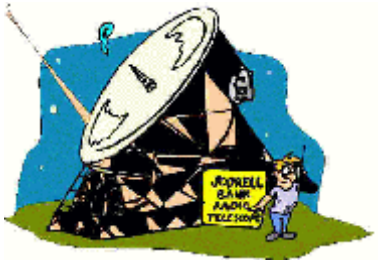


Sir Isaac Newton was searching for a way to reduce the length of a telescope and still enlarge an image. He used a curved **mirror** to reflect and focus the light inside the tube, and invented the reflecting telescope. Unfortunately the image has a **rainbow effect** on the outside of the image, that requires other lenses to correct. Ultraviolet and infrared wavelengths can be used with reflecting telescopes.

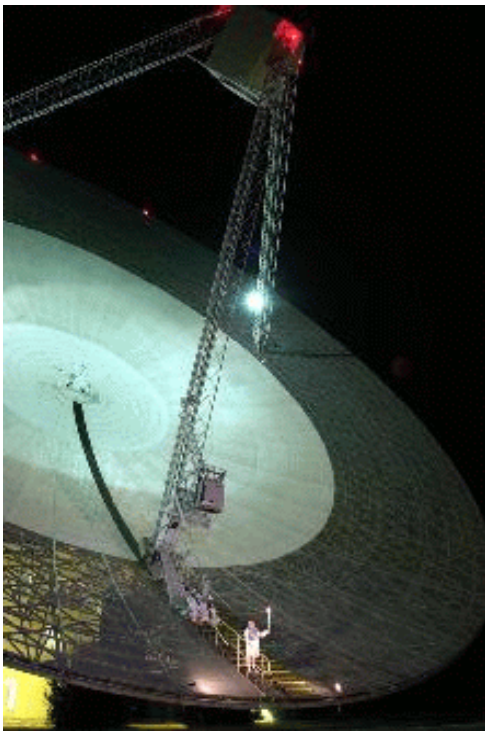


Reflecting telescope

TELESCOPES WITHOUT LIGHT



Karl **Jansky** in the 1930's discovered that galaxies emitted radio waves, and with a radio telescope you can see new worlds. He was actually looking for radio interference in Trans-Atlantic communication, and discovered the reason for that but also that radio telescopes could be useful in exploring space.



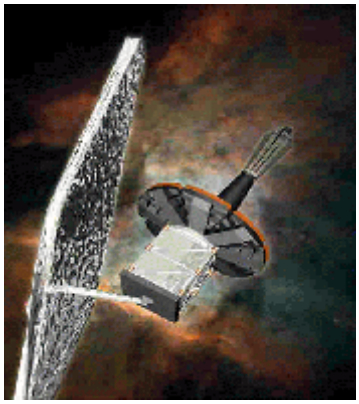
Radio telescopes have reflectors and receivers and need to be large. An example of a modern radio telescope is The Very Large Array in New Mexico, composed of 27 antennas over 36 kilometers (22 miles) or the Parkes Radio Telescope in Australia (right).

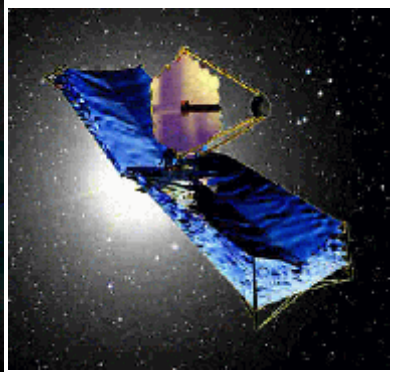
Other telescopes from infrared and ultraviolet can also be used especially when placed on mountaintops or on orbiting satellites. Gamma and X-ray telescopes have also been used since the 1970's. Telescopes will keep advancing as astronomers search the Universe.

FUTURE OF SPACE TELESCOPES

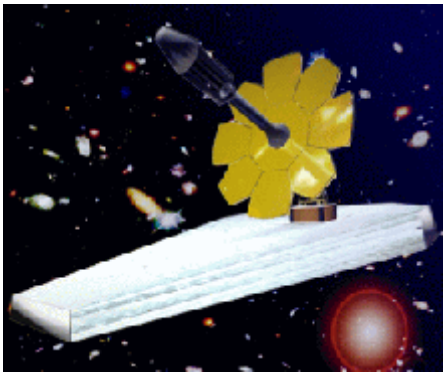
The European Space Agency is working on new **generation** of **space telescopes**. They have a project that will use Infrared technology to explore space and The `Far InfraRed and Submillimetre Telescope' (FIRST) will perform photometry and spectroscopy in the 60-670 :m range. The design of this space telescope is shown on the right.

NASA (National Aeronautics and Space Agency) has a new generation space telescope. They want to have several different types of space telescopes on the satellite. NASA has asked several companies to design a space telescope. These companies will submit a design and then NASA scientists and engineers will choose the company with the best design. Below are some of the designs they are working on. To learn more about which design is chosen check NASA's website (http://www.nasa.gov).





Lockheed Martin



GSFC

EARTH SCIENCES - SPACE EXPLORATION

Lesson 3 - TELESCOPES - LAB

MATERIALS:

reader
6 types of lenses
mini telescope
telescope
Telescope Kit (optional)

Objective: Students learn how optics are used in the telescopes.

Teacher note

Learning how a telescope works requires an understanding of the two ways in which light or any other electromagnetic waves can be moved. Reflection is when waves, bounce from a surface back toward the source. A mirror reflects the image of the observer. Refraction is when waves are deflected when the waves go through a substance. The wave generally changes the angle of its general direction.

This lab has students experimenting with different types of lenses to try and determine which combination can make something far away look magnified.The lenses you have in the kit are like the ones in the figure on student's lab sheet and include: a. biconvex (double convex); b. plano convex; c. convex concave; d. plano concave; e. meniscus; f. biconcave (double concave) . Have the students experiment with shining light through the lenses and seeing what lense concentrates the different light. Record all the information on the sheet. Remember the lenses are difficult to tell apart except when you shine light through them. You may want to color code or identify the lenses in some way. The key to this lab is for students to see how lenses are important in a telescope.

If you have a telescope we suggest you have the students use it. If you have binoculars this would also help them get the idea of how a telescope works.

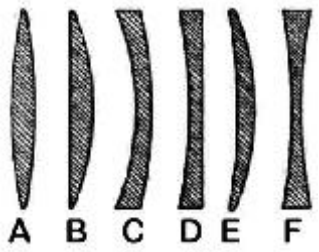
Telescopes help people to see far objects closer or in more detail. **Binoculars** magnify distant objects and consist of two similar telescope, one for each eye to make viewing easy. They contain two prisms which make the image right side up. You will understand why you need to do this when you complete the lab. You will also be asked to determine if the image is just larger (**magnification**) or if the lenses create a better, more detailed picture (**resolution**). When you look through the **lenses** make sure that the image is in focus. You may have to move the lense back and forth to find the place of best **focus**. On the pictures below, which one is out of focus?

A

B

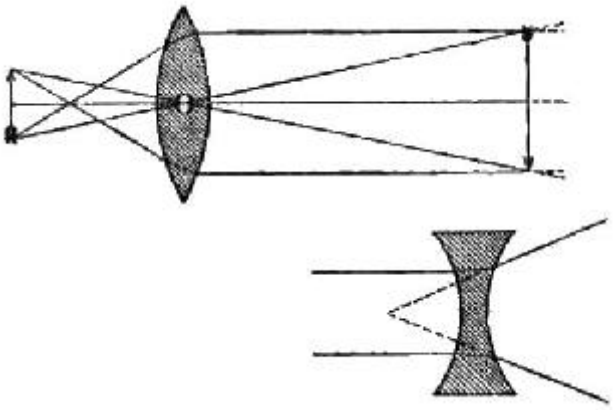
TELESCOPES
LAB

1. You have six labeled lenses in your kit. Draw each one of them in the space below and label what each one is. Use the diagram below to help. If light passes through the lense what would it look like? Consider the light source always on the left.



2. How does each lense refract light?

Look at each different lense. Shine light both ways and then ...and record what happens to the image. Can you project the imagine onto a piece of paper and is it larger or smaller when the image is in focus. Use the pictures on the right to help you decide how to experiment.



lense	describe path of light in words or pictures

3a. Look through the mini-telescope at your station. Describe how you can make it work.

b. Use a small biconvex lens and try to duplicate this telescope. Experiment with the six lenses you have and determine which combination works. Hint: Look through the small lense onto the large lense. Draw what you see and describe what you see with each lense.

4. Look through a telescope or binocular and try and determine the path of light. Make sure you determine if the telescope is a reflecting or refracting telescope. Draw the path below.

EARTH SCIENCES - SPACE EXPLORATION

Lesson 4 - VIRTUAL SPACE TRAVEL - LAB

MATERIALS:

reader
ruler
pencil
lab sheets

Objective: Students design a helmet for Pluto and Saturn.

Teacher note

Spacesuits that are designed for space travel is important for humans to explore space. The environments are different in different sectors of planetary travel. For instance, if you traveled to Jupiter you could not really touch the surface, as it is composed of liquid gases. If you traveled to Mars the surface would be like a rock. Humans need a protective shell to explore while remaining flexible and protecting against hazards, such as high-speed particle impacts, encountered there. These requirements meant that engineers and technicians had to spend long hours investigating and selecting appropriate materials, finding ways of fabricating and joining suit parts together, and providing operating pressure, power, and communications while assembling a garment that was tough but flexible.

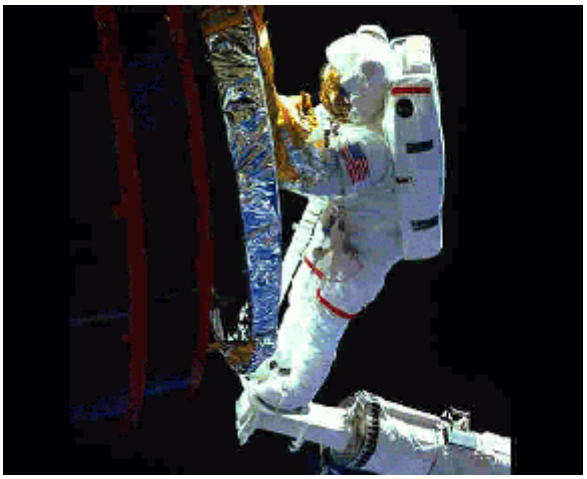
For more information please check out the NASA website on SpaceSuits. It is a complete package of information including history. The website is: http://quest.arc.nasa.gov/space/teachers/suited.

This activity is adapted from this information. Students are asked to design several helmets. One would be on a terrestrial planet (Mars), a gas planet (Saturn), and the outermost planet (Pluto). Each will have different requirements. Review the information on each of the planet from earlier lessons. Important for them to determine is temperature, darkness, vision (i.e. Saturn would be like in a fog-like atmosphere). Use the design sheets adapted from NASA.

VIRTUAL SPACE TRAVEL

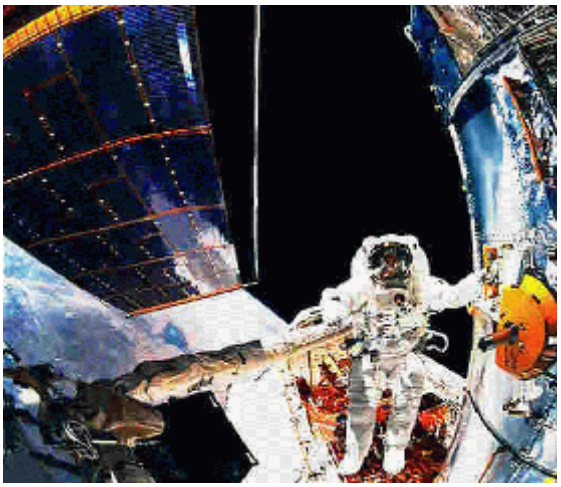
Space is not easy to live in. Objects float away if you don't secure them. If you drink milk the liquid will float away unless it is in a container and you use a straw to get the liquid. Even going to the bathroom can be a difficult experience. **Micro gravity** is tough on a person's body. If an astronaut stays in space too long, their bones start to break down. In this exercise, you are to design a space helmet for Pluto, Mars, and Saturn.

VIRTUAL SPACE TRAVEL
LAB



A

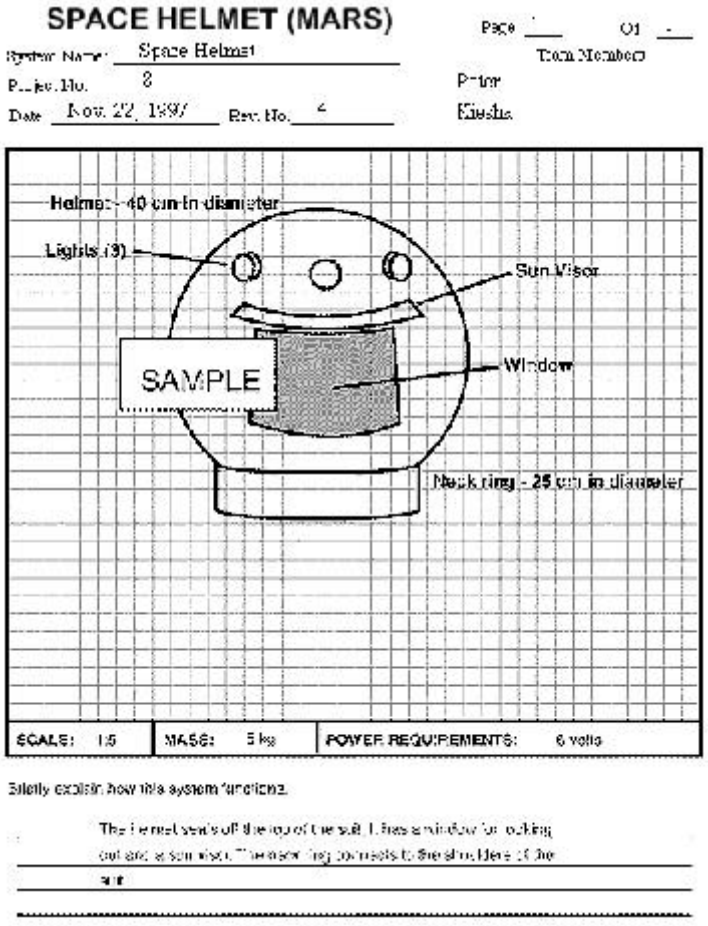
B



C

1. Explain why in photo B the astronauts do not have a space suit on. In figures A and C what protections do the spacesuits have to keep the human alive.

2. Design a space helmet for Pluto and Saturn. Make sure you think of the conditions on the surface of the planet before you design the different helmets. Use the example provided if the helmet was used for Mars (from NASA, Quest). Would the requirements be the same for Pluto and Saturn? Explain the difference and similarities.



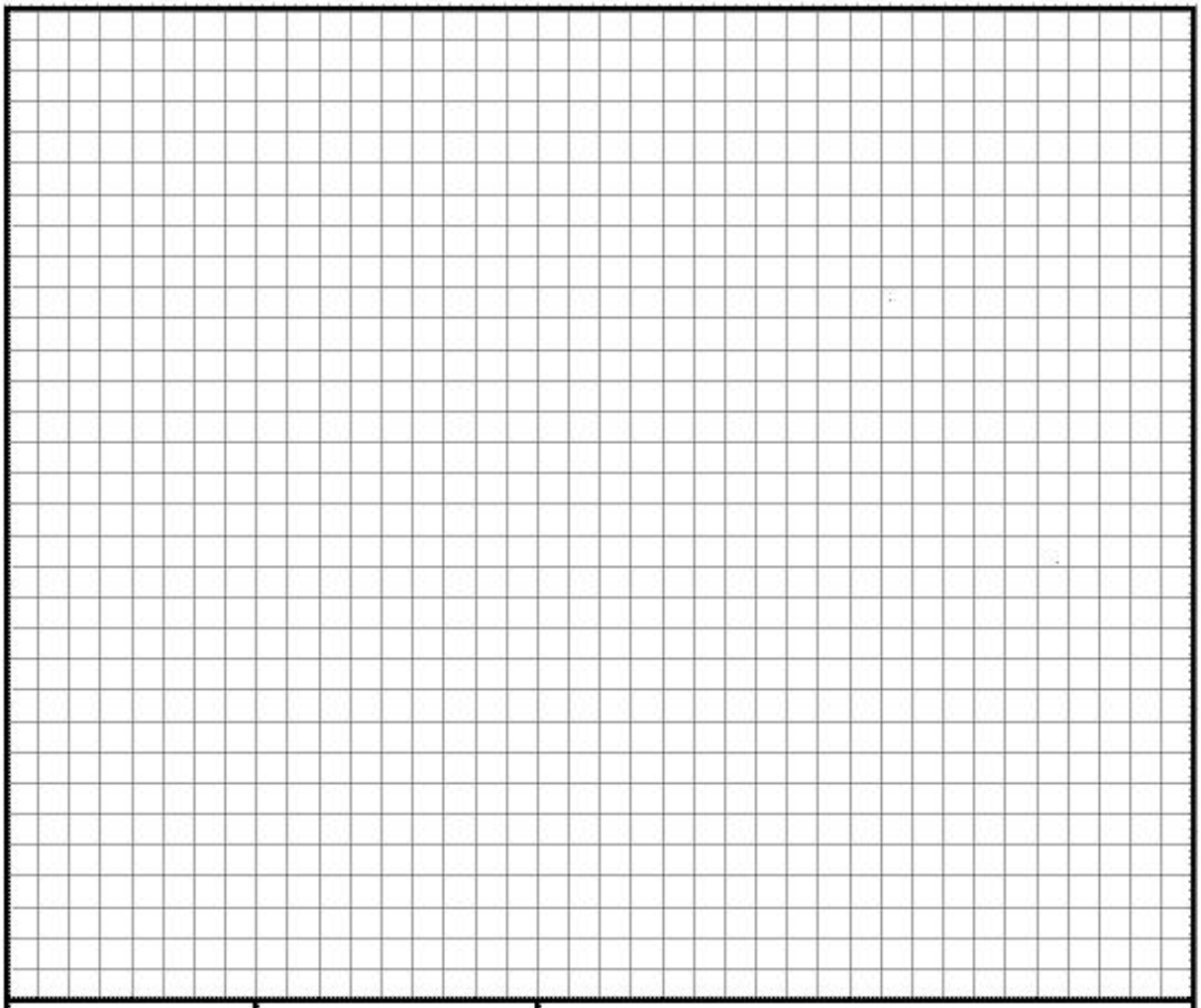
Design for Pluto

HELMET DESIGN (_____) Page ____ Of ____

System Name: _____ Team Members

Project No. _____ _____

Date _____ Rev. No._____ _____



SCALE:	MASS:	POWER REQUIREMENTS:

Briefly explain how this system functions

_____

_____

_____

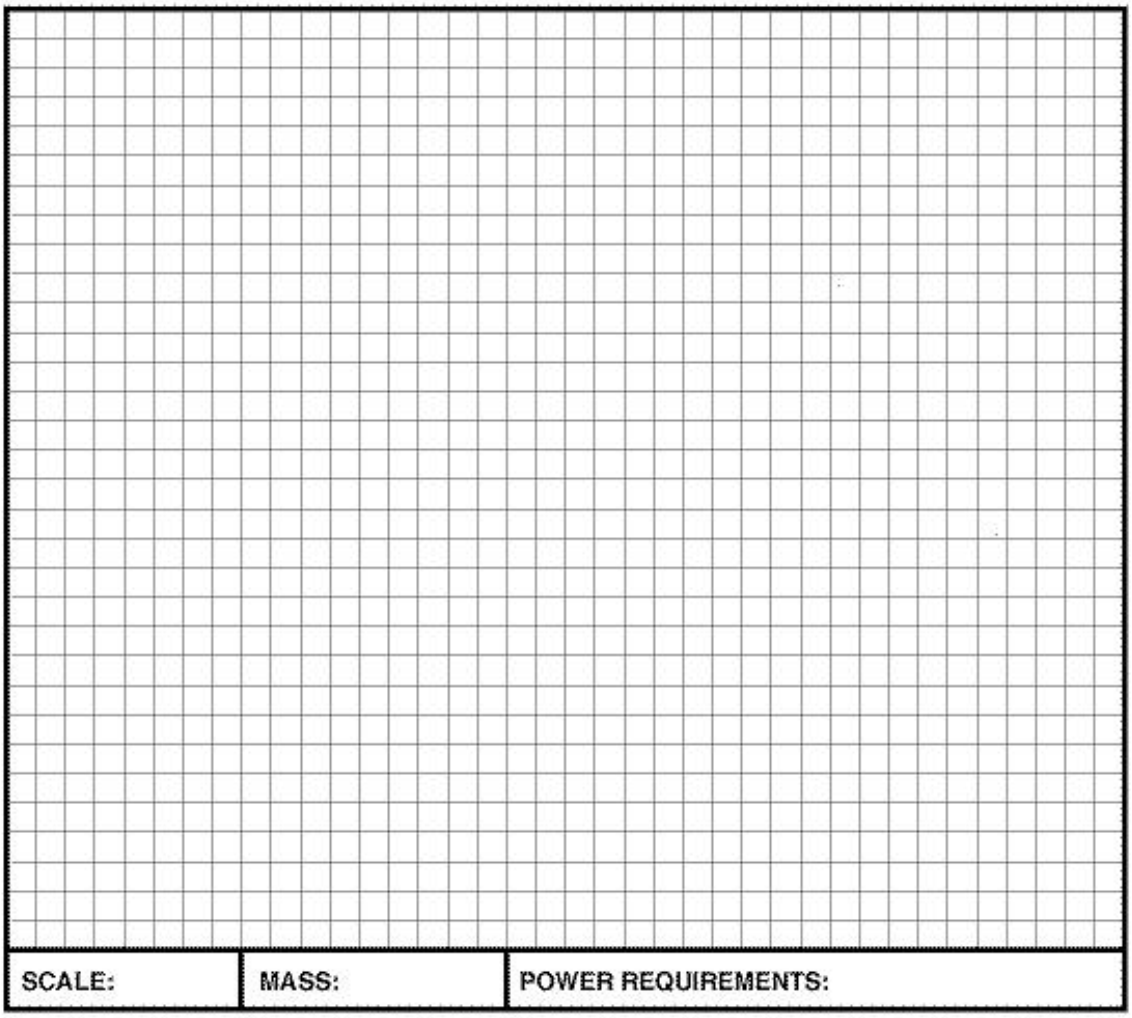
Design for Saturn

HELMET DESIGN (_____) Page ____ Of ____

System Name: _____ Team Members

Project No. _____ _____

Date _____ Rev. No._____ _____



SCALE:	MASS:	POWER REQUIREMENTS:

Briefly explain how this system functions

_____

_____

_____

EARTH SCIENCES - SPACE EXPLORATION

Lesson 5 - The Hubble Space Telescope

MATERIALS:
reader

Objective: Students learn about the Hubble Space Telescope and its influence on modern astronomy.

Teacher note

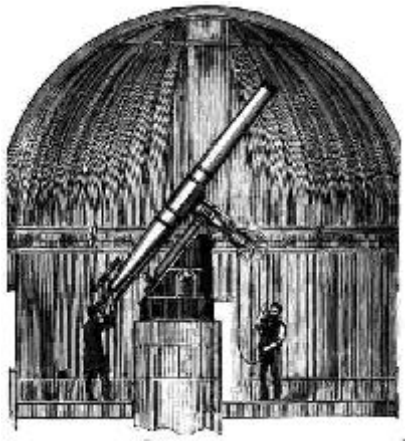
The Hubble Space Telescope can help us explore the Universe continuously. It has provided scientists with clearer pictures of some components of the Universe that a land telescope could not resolve. Students will sometimes hear on the news that a new discovery was made from the Hubble Space Telescope, so they should be aware of this great tool.

This instrument will continue to bring us new information for generations to come.

Introduction

For as long as people have looked up into the night sky, they have tried to understand the heavens. The earliest human civilizations interpreted the movements of the planets and stars, the occurrence of **shooting stars**, **supernovas**, and **comets**, and other astronomical events as the activities of **supernatural** beings. By several thousand years ago, people figured out that planets and stars moved in regular patterns, the beginning of the science of **astronomy**. The modern science of astronomy got a real boost with the development of **optics** and telescopes in Europe in the 18th century. Rather than relying on their eyes alone, people were able to examine objects in the sky in more detail.

Problems with Earth Telescopes



Telescopes on the Earth's surface all have one problem. They must look at the heavens through the Earth's **atmosphere**. This causes **distortion** of the telescope images. Air currents make the images seem to move. Atmospheric gasses **scatter** light and make the images fuzzy. Both of these problems limit the amount of detail that can be seen through Earth-based telescopes. This limits how much astronomers can learn about the heavens. The distortion problem can be partially solved by building telescopes on the tops of mountains. Here the atmosphere is thinner, so distortion is not as bad, but still exists.

Astronomers have long known the only real way to fully solve the distortion problem: putting a telescope in orbit around the Earth. This dream came true in April of 1990, when the Hubble Space Telescope was put in orbit around the Earth. The telescope is named after the American scientist Edwin P. Hubble, who made many important astronomical discoveries. The Hubble travels at an altitude of 380 miles, well above the atmosphere.

The Hubble Space Telescope

The Hubble Space Telescope is a large machine. It is about 44 feet (13.1 meters) in length, roughly the same size as a school bus. The Hubble is heavy; it weighs 12 tons (11,600 kilograms). The Hubble looks like a fat silver tube, almost like a number of cans stacked on top of each other. Forty foot long **solar power panels** sprout form each side of the telescope. These provide all the power the Hubble needs to operate.

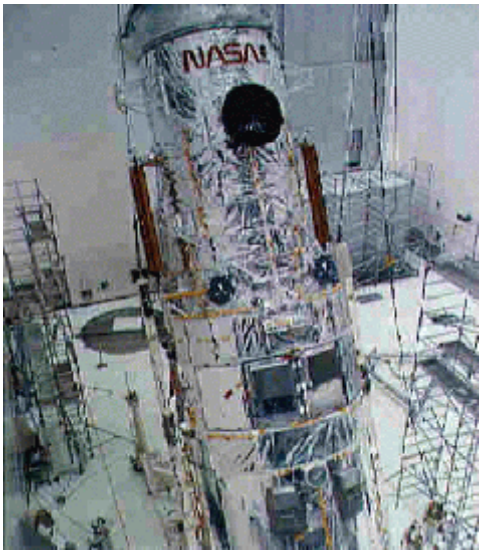
Hubble Space Telescope preassembly.

Inside, the Hubble contains one large mirror which 8 feet (2.4 meters) in diameter. When the Hubble is aimed at an astronomical object, such as a galaxy, radiation from the galaxy shine into the telescope and onto the mirror. From here the radiation is analyzed by several scientific instruments.

None of these instruments take pictures like the photographic cameras we are used to. Instead, they take digital images, which are stored as files in a computer and then transmitted to Earth. No person ever really "looks through" the Hubble Space Telescope.

How the Hubble Space Telescope Works

The Hubble is a **satellite**. It orbits the Earth very quickly, completing one **revolution** every 97 minutes. This means the Hubble moves a speed of about 5 miles per second, or 18,000 miles per hour! When the Hubble observes distant stars and galaxies, it must stay pointed in the same direction for hours at a time. In addition, it must remain stable while fighting the effects of the Earth's gravity and the solar wind.



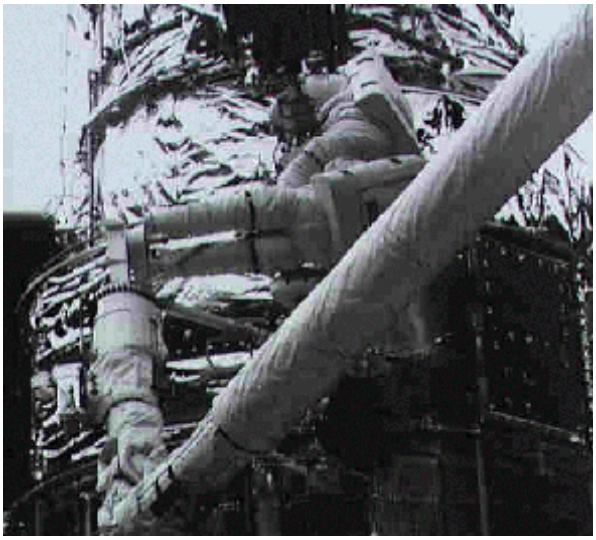
Hubble Space Telescope preassembly.

How does the Hubble remain stable? While the telescope is making observations, computer-controlled machines called **gyroscopes** keep it stable and pointed in the right direction. The Hubble requires very precise pointing to take good pictures.

The operation of the Hubble is controlled by scientists and engineers at the Space Telescope Science Institute, located near Baltimore, Maryland. The scientists, who are from all over the world, decide where they want the telescope to look, and what kind of information they want to collect. The engineers are responsible for giving commands to the satellite and making sure it stays in working order.

Repairing the Hubble Space Telescope

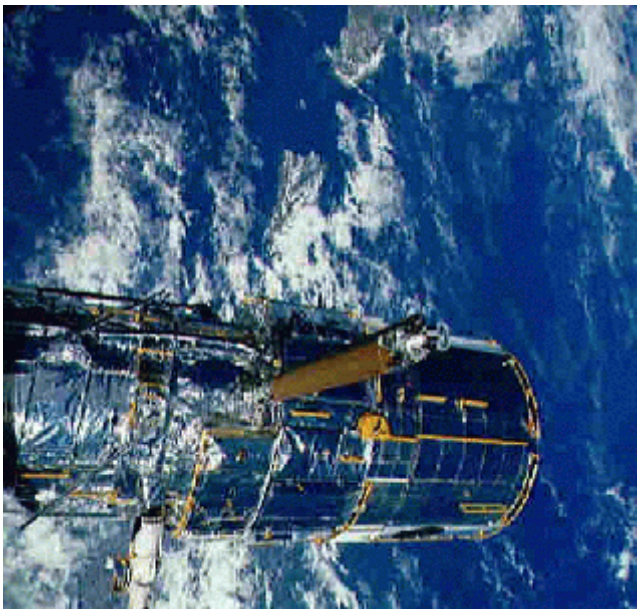
Just like any other machine, the Hubble needs occasional repairs. The first mission, in 1993, fixed the Hubble's mirror. After the Hubble was put in orbit, scientists discovered the mirror was faulty; it produced fuzzy pictures. The 1993 mission added devices to correct the Hubble's vision. The second mission, in 1997, added new instruments to Hubble's scientific package. Later repairs replaced parts of the Hubble's **guidance system**. Many more missions are planned to upgrade or repair the Hubble. These will allow the telescope to operate with new and better scientific instruments for at least ten more years.


Repairing the Hubble Space Telescope

What We Have Learned from the Hubble Space Telescope

The Hubble Space Telescope has made many very important scientific discoveries. Three of the most exciting findings are:

1) *The Birth of Stars*. The Hubble has seen areas of condensing gas and dust, indicating the formation of new stars



2) *The Evolution of Galaxies*. The great sensitivity of the Hubble's cameras have allowed scientists to discover and study galaxies that are extremely far from Earth.

3) *Looking at Pluto*. The Hubble has also studied the Solar System, and had provided the first close-up look at the surface of the planet Pluto.

The Hubble Space Telescope and its discoveries will continue to fascinate us for many years.

Earth Science - SPACE EXPLORATION - Unit Test

Part 1. Definitions Match the number of the term or concept in Column 1 with the letter of the correct definition in Column 2.

Column 1	Column 2
1. Epicycle	a. Nicholas Copernicus
2.Tycho Brahe	b. elliptical orbits of planets around the Sun
3. Very Large Array	c. theory of relativity
4. Hubble Space Telescope	d. reflective and refractive types
5. Heliocentric theory	e. weightlessness in space
6. micro gravity	f. galaxies emit radio waves
7. Types of optical telescopes	g. Ptolemaic System of celestial movements
8. Johannes Kepler	h. radio telescope
9. Karl Jansky	i. Recorded through photographs the birth of stars
10. Albert Einstein	j. measured star and planet locations

Part 2. Multiple Choice Choose the best answer to complete each statement.

1. Stars repeat themselves at the same time in the sky every
    a. 365 days
    b. 240 days
    c. 30 days
    d. 120 days

2. Telescopes were invented by
    a. Sir Isaac Newton
    b. Galileo
    c. Albert Einstein
    d. Copernicus

3. Which is not one of Newton's Law of Motion
    a. body in motion stays in motion unless acted by outside force
    b. change of speed can be measured
    c. every action there is a reaction
    d. wheels produce micro gravity

4. Which is not used in the study of the far reaches of the Universe
    a. microwaves
    b. physical waves
    c. infrared
    d. radio waves

5. Space telescopes observe the Universe from
    a. Mars
    b. satellites in space
    c. Moon
    d. Earth

6. If an astronaut remains in space too long
    a. their bones start to break down
    b. they get earth sickness
    c they lose their hair
    d. their skin gets loose

7. Hubble space telescope:
    a. is as large as a school bus
    b. weighs 12 tons
    c. uses solar panels
    d. all of the above

8. Advances in space exploration will probably be using
    a. weapons
    b. lasers
    c. electromagnetic waves
    d. aliens

9. Telescopes are based on moving electromagnetic waves by
    a. movement
    b. photons
    c. reflection and refraction
    d. gas

10. Early exploration of the Universe was based on
    a. star movement and position
    b. clouds
    c. myths
    d. aliens

ANSWERS:

PART I.

1. G
2. J
3. H
4. I
5. A
6. E
7. D
8. B
9. F
10. C

PART II.

1. A
2. B
3. D
4. B
5. B
6. A
7. A
8. C
9. C
10. A