Introduction

As early as 500 B.C., **astronomy**—the science or study of celestial bodies and their properties—was practiced by scholars. Pythagoras (500 B.C.), a Greek philosopher and mathematician, was observing Earth's shadow on the moon when he concluded that the Earth must be a sphere. Around 200 B.C., Eratosthenes, a Greek **astronomer**, (276-195 B.C.) used geometry to estimate the *circumference*, or distance around the Earth. Eratosthenes also measured the tilt of the Earth's axis, 23.5 degrees, which causes the *seasons*.

Eratosthenes (276- 195 B.C.) used geometry to estimate the circumference of the Earth.

These scholars used crude instrumentation to seek the answers about the Earth and beyond. The invention of the **telescope** around 1600 led to more discoveries. Although he did not invent the *telescope*, Galileo Galilei (1564-1642), an Italian *astronomer*, introduced the use of the telescope for *astronomy* in 1609. Today's technology and sophisticated instrumentation have allowed us to go far beyond the early astronomers in the study of our celestial neighborhood.

Origins of Astronomy

Humankind has always been interested in the skies or *heavens*. Many early civilizations (including the Egyptians and Babylonians) recorded their observations and ideas on astronomy. The early Greeks are credited with many discoveries. Aristotle, a Greek who lived about 500 B.C., believed that everything in the sky revolved around Earth. This is known as the **geocentric** *theory*. The Greeks proposed the first models of the **universe**. In one of these first models, Ptolemy (2^{nd} century A.D.) also supported the *geocentric* view that Earth was the stationary center of the *universe*—a view popular at that time.

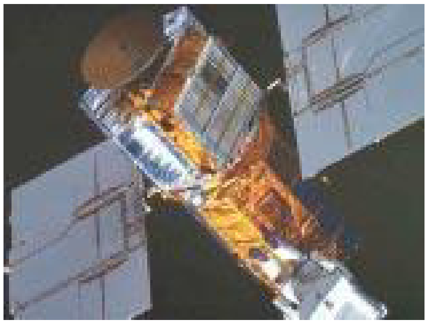
The Polish astronomer Nicholas Copernicus (1473–1543) was one of the first to challenge that view. He proposed that Earth was a planet, like the other five known planets, and that it revolved around the sun—the center of the universe. This is known as the **heliocentric** *theory*.

Later astronomers, such as Tycho Brahe (1546-1601), collected data to attempt to disprove this controversial theory. In the early 1600s a German astronomer, Johannes Kepler (1571-1630) used this data to support the Copernican theory. Kepler also proposed three laws that described the movement of the planets.

Probably the most well known of the early astronomers is the Italian astronomer Galileo Galilei. He is considered the *father of modern astronomy*. Galileo built his own telescopes and made many astronomical observations. He discovered the first four moons of Jupiter, the rings of Saturn, sunspots, and he studied the craters of our moon. Galileo was persecuted for his views. He held that the sun was the center of our **solar system**. For holding this *heliocentric* theory, he was sentenced to house arrest for the last 10 years of his life.

Even before Galileo first pointed his telescope skyward, people were interested in the movements of the sun, moon, and stars. The moon is perhaps the most studied celestial object. The first astronomical phenomenon to be understood was the cycle of the moon. Today we know that cycle as the phases of the moon. The early Greek scholars realized that *solar eclipses* were simply the obscuring of the sun as the moon passes directly between Earth and the sun.

Today we are able to gather information about the *solar system* through the use of **space probes**. *Space probes* are rocket-launched vehicles that carry instruments and equipment used to gather and record data in deep space. These probes have a radio system to send pictures and information to Earth.



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The first American space probe was launched on January 31, 1958 and was known as Explorer I. It had a Geiger counter to detect **cosmic rays**. This was the first of the Explorer probes. Over 70 of them were launched. The Pioneer spacecrafts were the first to travel through the asteroid belt and study the planets. Pioneer 10 was launched on March 2, 1972 and is now over eight billion miles away in the Kuiper Belt. Other space probes have included Mariner 1-10, Viking 1 and 2, and Voyager 1 and 2. Voyager 1 now the most distant human-made object in the solar system. The Deep Space Network (DSN) supports Voyager 1 and 2. The Voyager spacecrafts, though launched in 1975, are still heading out of our solar system.

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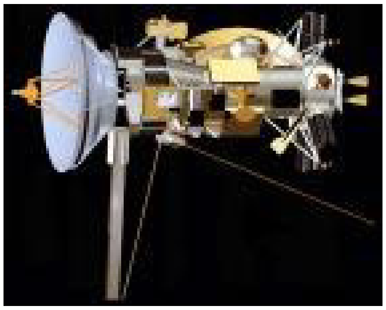
Launched in 1989, the Galileo spacecraft traveled more than four and a half billion kilometers (nearly three billion miles). It circled Jupiter 34 times, sending back 14,000 pictures and other data over the course of seven years, crashing into Jupiter in September 2003. The Cassini-Huygens mission to Saturn was launched in October of 1997. After gravity assists from Venus, Earth, and Jupiter, Cassini arrived at Saturn on July 1, 2004.

The MErcury Surface, Space, ENvironment, GEochemistry, and Ranging (MESSENGER) mission was launched from Cape Canaveral, Florida in August 2004. MESSENGER will be in position to enter Mercury orbit in March 2011. During flybys set for January 2008, October 2008, and September 2009, MESSENGER will map nearly the entire planet in color; image most of the areas unseen by Mariner 10; and measure the composition of the surface, atmosphere, and magnetosphere. It will be the first new data from Mercury in more than 30 years.



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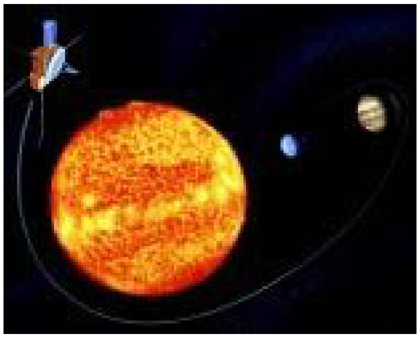
Gathering Information about Earth and Space

Artificial satellites and unmanned rockets have been used to pave the way for our travel into space. Unmanned rockets are powered by controls from stations on Earth. The direction, location, and speed of the rockets are controlled by using special computer or radio signals. A number of *artificial* **satellites** have been launched into space. Many of them receive and send radio and television signals which have improved worldwide communications. Other types of *satellites* include remote sensing, navigation, search and rescue and reconnaissance.



Unmanned rockets are powered by controls from stations on Earth.

It is difficult to go through a day without using a **communications satellite** at least once. Do you know when you used a *communications satellite* today? Did you watch television? Did you make a long-distance phone call, use a cellular phone, a fax machine, a pager, or even listen to the radio? Well, if you did, you probably used a communications satellite, either directly or indirectly.

Communications satellites allow radio, television, and telephone transmissions to be sent live anywhere in the world. Before satellites, transmissions were difficult or impossible at long distances. The signals, which travel in straight lines, could not bend around the round Earth to reach a destination far away. Because satellites are in orbit, the signals can be sent instantaneously into space and then redirected to another satellite or directly to their destination.

Satellites can have a passive role in communications. For example, satellites can be used just to bounce signals from the Earth back to another location on the Earth. Other satellites play a more active role. They carry electronic devices called **transponders** and can receive, amplify, and re-broadcast signals to the Earth.

The first **telecommunication** satellite launched in 1960 was called the Echo I. It was a plastic balloon with a thin aluminum coating. This coating was much like a mirror—it reflected light and radio waves. The Echo I was used to relay or reflect telegrams, telephone calls, and pictures back to

Earth, crossing oceans and continents. Television pictures are relayed the same way. (The prefix *tele-* means *at or from a distance*.)

Communications satellites are now used by many nations. The Intelsat—the world's largest satellite system—has 102 member nations and 250 ground stations. This satellite system provides a 240 channel link between the United States and Europe. The Intelsat system was used by the United States to relay the landing of *Apollo 11* on the moon. It is also used for the transmission of telephone, educational, medical, and other types of communication. More and more satellites are being placed in orbit as we expand our use of *telecommunications* (cell phones, beepers, satellite television, and the Internet). Many companies and agencies now have their own satellites, and personal satellites are not far off in the future.

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Three lunar probes took pictures of the moon that helped scientists choose a spot for the Apollo *moon landing.*

Lunar probes have included Clementine and the Lunar Prospector mission. On December 3, 1996, it was announced that data acquired by the Clementine spacecraft indicated that there was ice in the bottom of a crater on the moon. The Lunar Prospector mission to the moon was launched in fall of 1997. The mission ended on July 31, 1999, when the spacecraft was directed to crash into a crater near the moon's south pole as part of an experiment to confirm the existence of water ice on the moon.

Space flights have been made safer because of the information gathered by these satellites and rockets. The *Mercury* space capsule provided scientists with data and experience in space flight itself. The *Gemini* space capsules provided **astronauts** with experience in controlling spacecrafts and working in space. Vehicles docked in space while the *astronauts* walked in space. The three **lunar** probes—Ranger, Lunar Orbiter, and Surveyor—took pictures of the moon that helped scientists choose a spot for the *Apollo* moon landing. The

Surveyor probe actually landed on the moon, giving scientists an abundance of valuable information.

astronaut walking in space

In the 18th century, scientists used hot-air balloons to measure weather conditions. Today, we have more than 8,000 weather stations around the world that make observations about our weather conditions. Reports are made by airplane pilots, ships at sea, and radar stations. Satellites are also used to monitor our weather. They are able to observe Earth's oceans and other areas where there are no weather stations. The **weather satellites** send back pictures that show how weather changes from hour to hour. These pictures help us to follow large weather patterns, and they improve the accuracy of our weather predictions. Television stations show daily satellite pictures of weather patterns.

Global Positioning Systems (GPS), which are now in cell phones, are space-based radio positioning systems that provide 24-hour three-dimensional position, velocity, and time information to users anywhere on or near the surface of Earth. These measurements are used for critical navigation applications. The Navigation Signal Timing and Ranging (NAVSTAR) system, operated by the United States Department of Defense, is the first GPS system available for nonmilitary uses. GPS is currently available in some cars and for marine navigation systems. GPS is also used to measure the movements of Earth's crust, to track the weather, and to help locate earthquakes.

By combining GPS with computer mapping techniques, we will be better able to identify and manage our natural resources. Intelligent vehicle location and navigation systems will let us find more efficient routes to our destinations, saving millions of dollars in gasoline costs and also preventing the cause of tons of air pollutants. Travel aboard ships and aircraft will be safer in all weather conditions.

Sources Used to Collect Information

The collection of information about Earth and space requires the use of some very specialized equipment. The satellites used for information collection often have much of this specialized equipment built into them. The *weather satellites* that send information to Earth about the weather can take pictures of cloud covers. Hurricanes can be tracked, allowing enough time to give hurricane warnings. Temperature **detectors** help us learn how temperature changes at different heights in the atmosphere. *Cosmic ray detectors* gather information about cosmic radiation, which is harmful to people. To collect scientific data, microphones are mounted on the satellite to record the sound of meteors hitting the satellite. These recordings give scientists information for improving satellites and increasing knowledge of meteors.

In the development of the space program for the United States, the National Aeronautics and Space Administration (**NASA**) agency has used manned space travel to gather information about Earth and space. The early missions of the *Apollo* spacecraft provided data and practice for landing on the moon. Subsequent landings on the moon provided over 2,000 samples of moon rock for study. Television cameras aboard today's spacecraft send pictures of the moon, Earth, and other planets back to scientists on Earth.

Once the Apollo program was completed, *NASA* felt it was necessary to develop a reusable spacecraft. This led to the new era of human space travel aboard the reusable spacecraft known as the **space shuttle**. The *space shuttle* consists of an **orbiter**, two solid rocket boosters, and a liquid fuel tank. The shuttle allows technological research in the microgravity environment of an orbit and serves as a vehicle in which to transport astronauts, materials, satellites, and other **payloads**. Astronauts take animals into space to test the effects of microgravity on their physiology. Additionally, astronauts themselves are studied to see how space flight affects a

NASA developed a reusable spacecraft know as the space shuttle.

person's breathing, heart action, muscle tension, body temperature, and other physiological functions. The shuttle carries such *payloads* as communications satellites, telescopes, special scientific experiments, and scientific equipment to be placed in orbit. The shuttle also serves as a transport vehicle to bring astronauts to and from the International Space Station. After each mission is completed, the *orbiter* glides back to Earth and lands like an airplane glider. The two solid rocket boosters are jettisoned off at take-off and land in the Atlantic Ocean to be retrieved and reused. Radio **transmitters** are used to send information to receiving stations on the ground. Antennas detect all kinds of radiation around the spacecraft.

The shuttle is a vehicle which can transport astronauts, materials, satellites, and other payloads.

The United States and Russia have also launched **space stations** with living quarters, work space, and all the equipment and systems necessary for astronauts to work and live. The *space stations* carry telescopes, cameras, computers, and anything needed for research projects.

America's first experimental space station was called Skylab, which was designed for long missions. Skylab had three manned missions from 1973-1974. The Skylab program objectives were to prove that humans could live and work in space for extended periods and to expand our knowledge of solar astronomy. It was the site of nearly 300 scientific and technical experiments: medical experiments on humans' adaptability to zero gravity, solar observations, and detailed Earth resources experiments.

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The first phase of the International Space Station, the Shuttle-Mir Program, began in 1995 and involved more than two years of continuous stays by astronauts and cosmonauts (Russian astronauts) aboard the Russian Mir Space Station and nine Shuttle-Mir docking missions. Knowledge was gained in technology, international space operations, and scientific research. Currently, the International Space Station orbits the Earth. Led by the United States, this space program draws upon the scientific and technological resources of 16 nations including the United States, Canada, Japan, Russia, 11 nations of the European Space Agency, and Brazil. With a permanent human presence in space aboard the International Space Station, there will be new advances in space technology, and a chance for different scientific fields to test new theories and complete experiments in microgravity.

On Earth, all telescopes are used to concentrate signals received from space. Some telescopes use mirrors or lenses to concentrate light waves to view images of planetary objects. Other telescopes, called *radio telescopes*, use large reflecting dishes and antennas to receive radio waves. From the ground, scientists study Earth and space indirectly, through telescopes or planetary probes that gather important information about other planets and send this information back to Earth.

The Hubble Space Telescope is designed to see 10 times more clearly into space than other Earth-based telescopes; it can detect objects one-billionth as bright as the human eye can see. The Hubble telescope circles Earth every 97 minutes, 370 miles (595 kilometers) above the atmosphere. Designed to last 15 years and be serviced every three years, the 43-foot Hubble was put into orbit and began transmitting data back to Earth in 1990. An international project, the telescope contains equipment developed by the European Space Agency and a variety of United States institutions.

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The Hubble telescope's primary mirror (the benchmark by which telescopes are measured) is relatively small at 94.5 inches wide (2.4 meters). A flaw in the mirror was corrected in 1993, and the Hubble has performed remarkably well since then.

The telescope is so sensitive that it can detect the equivalent of a flashlight beam from 250,000 miles away—the distance from Earth to the moon. Since the telescope is located beyond Earth's atmosphere, the telescope can receive ultraviolet and infrared light that doesn't reach Earth's surface.

The Hubble telescope has already given scientists new glimpses into the universe.

The Hubble Space Telescope can be pointed anywhere in space except close to the sun, moon, or Earth's lighted side as the light is simply too bright for its sensitive instruments. Two antennas send out data and receive instructions from the ground via NASA's Tracking and Data Relay Satellite System. A receiving antenna is located in White Sands, New Mexico. The scientific data is then transmitted to other sites. The Hubble telescope has already given scientists new glimpses into the universe from discovering new galaxies to witnessing the formation of a black hole. It will be a useful tool for future scientific discoveries. The Hubble Ultra Deep Field (HUDF) has identified what may turn out to be some of the earliest star-forming galaxies. A good web site to view Hubble images is <http://hubble.stsci.edu/gallery/showcase/text.shtml>.

NASA Research

Although many of us are unaware of them, the NASA space program has had far-reaching effects that touch our daily lives. Technologies developed for the space program have been transferred to uses that are quite different from their original applications. These transferals have had an impact on many areas of life.

In the area of space research, NASA's technologies have created safer space travel for astronauts, provided more accurate information about the solar system, and improved command missions where unmanned satellites can probe space and gather important information. Any dangerous effects of space travel on astronauts are outweighed by the information that NASA is able to gather and put to use. This includes the remote possibility of finding homes for people on other planets.

Communication is another area in which the transferal of technologies has benefitted our everyday lives. Worldwide communications (television and radio) have been greatly improved and continue to improve daily. Our accuracy in forecasting the weather has increased. There are improved warning systems for dangerous storms.

These technologies have improved our military capabilities. While research has provided us with better defenses against foreign invasion, it has also created a nuclear power race among the more powerful countries.

NASA's technologies have created safer space travel for astronauts.

The many research projects must be funded in some way. Funds for science research come from federal government agencies, industry, and private foundations. Many taxpayers object to the expenditure of the billions of tax dollars that are necessary to complete the research projects. It is difficult, however, to dispute the technological advances that have been made in the United States since our decision to explore that great space beyond our Earth.

Summary

People have been interested in studying the sky and celestial bodies since the earliest times. Observations have been recorded since 500 B.C. Our ideas about the universe changed as discoveries were made by scientists such as Copernicus and Galileo. Today, through research conducted by NASA using sophisticated technology, scientists can gather firsthand information. Astronauts travel safely in space shuttles and collect data from space stations. More distant parts of the universe can be studied with probes and satellites. The technological advances in communication and other areas have benefited us in many ways.