

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 Earth must be a sphere. Around 200 B.C., Eratosthenes (3rd century B.C.), a Greek **astronomer**, actually computed Earth’s size while demonstrating its curvature. Until the invention of the **telescope** by a later astronomer, these scholars used crude instrumentation to seek the answers about Earth and beyond. Today’s technology and sophisticated instrumentation has allowed us to go far beyond the early astronomers in the study of our celestial neighborhood.

Origins of Astronomy



Earth

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. The Greeks proposed the first models of the universe. In one of these first models, Ptolemy (2nd century A.D.) also supported the view that Earth was the stationary center of the universe—a view popular at that time.

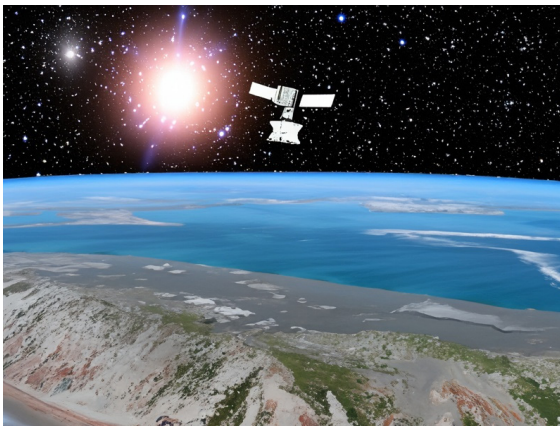
The Polish astronomer Nicholas Copernicus (1473–1543) was one of the first to challenge that view. He proposed that Earth was a planet, like the other five known planets, and that it revolved around the sun—the center of the universe. Later astronomers, such as Tycho Brahe, collected data to attempt to disprove his controversial theory. Ironically, in the early 1600s a German astronomer, Johannes Kepler (1571–1630) used this data to support the Copernican theory. Kepler proposed three laws that described the movement of the planets.

Probably the most well known of early astronomers is the Italian astronomer Galileo Galilei (1564–1642). 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 relief of our moon, and sunspots. Galileo was another scientist who was persecuted for his views and 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 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



space probe taking pictures of the coast of Florida

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. The *Pioneer*, *Mariner*, and *Viking* were our earliest probes. *Voyager II* has visited Jupiter, Saturn, Uranus, and is continuing on past Neptune and beyond. Information from probes increases our knowledge of space.

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.

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*.)



astronaut walking in space

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.



astronauts in the space shuttle

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.

Communication 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.

Global Positioning Systems (GPS) 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



satellite

measurements are used for critical navigation applications. The 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. Radio **transmitters** are used to send information to receiving stations on the ground. Antennas detect all kinds of radiation around the spacecraft.



space shuttle

The spacecraft itself is valuable for data collection. A reusable spacecraft designed to transport astronauts, materials, and satellites to and from space—called the **space shuttle**—acts as a taxi and helps to speed up technological research and improvements. Animals are sent into space to test how the effects of a flight could affect a person's breathing, heart action, muscle tension, body temperature, and other physiological functions. The shuttle carries such **payload** as communication satellites, telescopes, special scientific experiments, and scientific equipment to be placed in orbit. After each mission is completed, the main portion of the



space shuttle

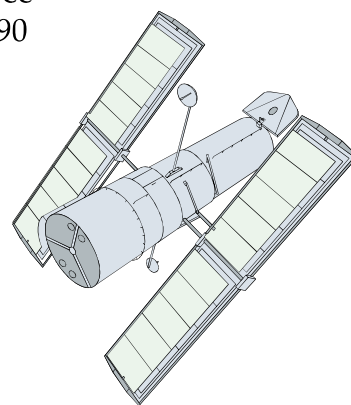
four-element shuttle system—the **orbiter**—glides back to Earth and lands like an airplane.

The United States and Russia have also launched **space stations**—space vehicles with living quarters, work space, and all of the equipment and systems necessary for astronauts to work and live. The space stations carry telescopes, cameras, computers, and anything needed for research projects. Future space stations may become factories or power stations for our future energy needs.

Back on Earth, all telescopes are used to concentrate information 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 are forced to study Earth and space more 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 see 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. It was designed to last 15 years, with servicing every three years, the 43-foot Hubble was put into orbit in 1990 and began transmitting data back to Earth. An international project, the telescope contains equipment developed by the European Space Agency and a variety of United States institutions.

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



Hubble Telescope

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 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.

NASA Research



astronaut

Although many of us are unaware of them, the NASA space program has 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 transfers 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 transfer 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.

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.

