STUDYING AND EXPLORING SPACE

Our ability to understand our solar system and the universe beyond has grown by dramatic leaps in the last few decades. The truth is, though, that all that lies beyond our own home planet has fascinated people for countless centuries. Using very basic as well as very complex tools, humans have been able to discover and understand amazing realities about our solar system, the universe, planets and stars, how they all formed and how they are all changing.

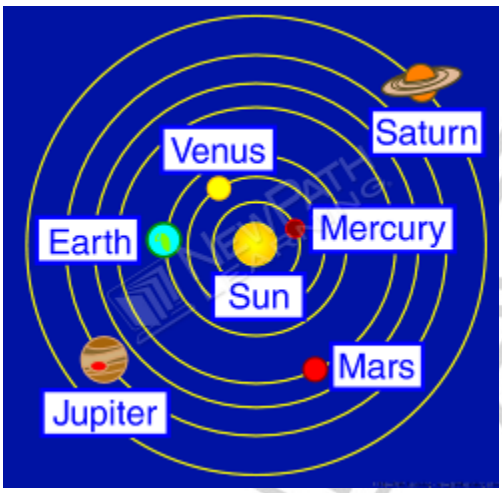
The Early Space "Explorers"

Using simple tools and the power of observation, early theories about our solar system and the planets within it proved to ultimately be remarkably accurate. Of course, much was inaccurate, too.

The ancient Greek astronomer named Ptolemy carefully studied all the ancient knowledge he could gather about the planets and astronomy in general and from that information created what is now known as ' concluded that the Ea and the planets all

Ptolemy's picture of the universe

It wouldn't be until the mid 16th century that a new (and revolutionary) theory about our solar system would be proposed. In 1543, a Polish astronomer named Nicolaus Copernicus (1473-1543) concluded that the Earth rotates on its own axis, that the *sun* is the center of the universe and that all the planets revolve around it.



Some call this the **Copernican Theory**. In technical terms, it is called the **principle of heliocentric planetary motion**.

Galileo Galilei (1564-1642) was the first person to use a telescope to study the moon and planets. He also discovered moons orbiting Jupiter. His observations supported Copernicus's theory that the sun is
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1727), the
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explained that gravity is the force that causes planets to orbit the sun and moons to orbit their planets. This picture, drawn by Isaac Newton, shows his theory that if a ball were thrown hard enough it would leave Earth's gravitational pull until it was in orbit around the Earth.

Traveling into Space

Our understanding of space, the planets, the stars and the universe as a whole made quantum leaps forward in the twentieth century. Edwin Powell Hubble (1889-1953) was an American astronomer who, in 1923, showed that the universe is expanding. He used photographs to prove that there are galaxies beyond our own. Prior to this, scientists believed that our galaxy was the *entire* universe.

Studying space from Earth has provided dramatic and rich information. But the Earth's atmosphere distorts incoming light and images of objects in space. To get the clearest view of the universe, one must get beyond Earth's atmosphere and use space-based telescopes.

It may be very surprising to discover that some of the most basic information about our universe has been discovered very recently using space-based telescopes. In 1990, the Hubble Space Telescope (clearly named in honor of the great 20th century astronomer) was launched by NASA and has provided some of the most spectacular images of the universe ever seen. Dramatic advances in physics and optics have allowed space-based telescopes like Hubble to see a wide range of electromagnetic radiation, far more than just visible light. This information has revealed more about the universe than we would ever have been able to know from even the best land-based telescopes.

Rockets

Spac without the develo y that rockets an e visions and stories nspired a Russian te motion of rockets. Though Tsiolkovsky never actually built and experimented with rockets, this Russian became known as the Father of rocket theory. His work prepared the way, however, for the work of Robert Goddard who built and experimented with the very first rockets. Consequently, Goddard is commonly referred to as the Father of modern rocketry.

From the standpoint of physics, rockets operate based on **Newton's third law of motion** that states that for every action there is an equal and opposite reaction. Rocket fuel is burned inside the rocket in a **combustion chamber**. The force that is exerted out of the rocket's exhaust nozzle equals the force of the gas pushing at the *top* of the combustion chamber. When the force pushing at the top of the combustion chamber is greater than the force of gravity holding the rocket on Earth, the rocket moves upward. This force that moves the rocket is called **thrust**.

For rockets to move people and machinery into space and completely out of Earth's gravitational pull, they must reach **escape velocity**. The escape velocity from Earth's gravitational pull is 11 km/second. A rocket must travel at 8 km/s to achieve **orbital velocity**. Orbital velocity is the speed and direction needed to orbit the Earth.

Lesson Checkpoint: What is 'escape velocity'?

Early Space Missions

The first application of rocketry was military: they were used to deliver bombs. Late in the 1950's, though, the former Soviet Union launched a rocket that put the first satellite, Sputnik, into orbit around the Earth. This marked the beginning of a **space race** between the United States and the Soviet Union. In 1961, the Soviet Uni country to cosmonaut States res with an ag program o first Ameri t human to step on e.)

By the end of the 1960's the United States had developed a complete program that not only developed rockets that could put heavy payloads into space, but had also developed a manned space program that put **astronauts** on the moon and returned them safely to Earth. The organization created by the United States to improve rocket technology and to explore the moon and space is called the National Aeronautics and Space Administration (NASA).

There were a number of missions throughout the 1960's that prepared for the moon landings. The Apollo missions were the space flights that eventually landed the United States on the moon. The first purpose of the moon landings was purely political in that we intended to strengthen American national pride in light of the accomplishments of the Soviet space program. However, the technologies developed for NASA and space travel proved to be invaluable for science, technology and use in everyday life. In addition, important scientific information about the moon was collected during the lunar missions, including

studies of solar wind activity, moonquake activity, and collections of rock and dust samples from the moon's surface.

By the mid-1970's, the focus of space work for the United States and NASA shifted from moon landings to regular travel into space in a reusable craft. These missions would be used for a number of purposes including scientific studies of the effects of weightlessness on astronauts and for a variety of experiments from growing plants to growing crystals and more. The Space Shuttle has also placed telescopes and other equipment in space, such as large pieces of the International Space Station.

The advancement of the Space Shuttle program was that the air craft is reusable. Remember that the Saturn V rocket that transported astronauts to the moon, for example, was a single-use vehicle. *All* the components of the Saturn V rockets, including the vehicles that landed on the moon and returned the astronauts to Earth, were used only once. The **Space Shuttle** was the first generation space vehicle *designed* to be used over and over again.

In addition to the Space Shuttle program, NASA has developed and launched a number of **space probes** that have gathered spectacular images and invaluable information about planets in the far reaches of our solar system. A space probe is a vehicle equipped with scientific instruments that travels to other planets and moons to study their features, compositions and movements.

Magellan Space Probe

The Viking 1 and Viking 2 probes were sent to study Mars in 1975. In 1997 the Mars Pathfinder mission sent two movable robotic rovers to study the surface of Mars. Mars is of particular interest because it is physically similar to Earth and it may have had significant quantities of water at one time that could have allowed the development of some form of life.

The Pioneer, Voyager and Galileo missions were unique because the purpose of these space probes was to study the outer portions of the solar system. Specifically, these probes studied **solar wind,** Jupiter, Saturn, Uranus and Neptune. *Stardust* was the first space probe designed to study a comet.

New concepts for space exploration are developing all the time. NASA has a New Millennium program that focuses on the development of new technologies in space probes. For example, *Deep Space 1* is a new breed of space probes. Its purpose is to study the universe using new and p ue because it articles. This **ion p** as traditional

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First ional relations, including relations between nations that have in other areas have been at odds with one another. (For example, two of the principal partners in the ISS are the United States of America and Russia.)

Second, it is a platform for specialized scientific research in a weightless environment. Similarly, it allows the study of the effects of weightlessness on humans. Zero gravity has dramatic effects on bone density and muscle tone. Scientists are continually learning how to counteract these effects while living in space. The ISS promises to be an important base of specialized research designed to improve space travel and living in space as well as bringing benefits to life on Earth.

Lesson Checkpoint:
Name one advantage of the International Space Station.

Solar Radiation

There are big dreams for activity in space. Some believe the moon will be a place where specialized materials and products can be manufactured. Perhaps the moon and Mars can be mined for important mineral resources. Perhaps a colony of people could live on the moon. For these goals to be achieved, astronauts will have to overcome many obvious challenges for living in space such as oxygen supplies, weightlessness and all its physical consequences, and temperature control. Another challenge is the danger from **solar radiation**.

Radiation from a number of sources is moving throughout the universe. The sun produces the full spectrum of electromagnetic radiation. In addition, **cosmic background radiation** travels in all directions throughout the universe. Cosmic background radiation is faint microwave radiation. It was discovered in the mid 1960's by A. Penzias and R.W. Wilson. It is thought that this cosmic background radiation is electromagnetic energy that is left over from the "Big Bang" or massive explosion which scientists theorize was the beginning

states that the ur n years ago. It is of matter,

Some e to humans known to c is more th also includes ionizing radiation, solar protons, and high-energy electrons and protons. Astronauts must be protected from these various radiation dangers. Space suits are designed to provide this protection. For example, the gold protective layer on the visor of the astronauts' headgear protects them from ultraviolet radiation.

Despite the exciting progress in space exploration, space is ultimately a hostile environment. Sending humans into space, particularly for extended periods of time, will always present significant technological challenges. While these challenges are being studied, unmanned space probes will continue to peek into the far reaches of the solar system and the universe. This is a very exciting time of human history to be an astronomer!