Ancient Astronomy

Myths, folklore and legends were used to explain observations in the night sky.

First Nations people of the Pacific Northwest – believed the night sky was a pattern on a great blanket overhead, which was held up by a spinning 'world pole' resting on the chest of a woman named Stone Ribs.

Inuit in the high Arctic – used a mitt to determine when seal pups would be born, by holding the mitt at arm's length at the horizon.

The Ancient Egyptians built many pyramids and other monuments to align with the seasonal position of certain stars.

Aboriginal Peoples of Southwestern Alberta used key rocks, which aligned with certain stars, in their medicine circles.

Solstice

– the shortest and longest periods of daylight
Winter solstice - shortest period of daylight
(N. Hemisphere - *Dec. 21*)
Summer solstice – longest period of daylight
(N. Hemisphere - *June 21*)

The Ancient Celts set up megaliths, in concentric circles, at Stonehenge to mark the winter and summer solstices.
Ancient African cultures set large rock pillars into patterns to predict the timing of the solstices as well.

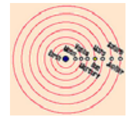
Equinox

– represents periods of equal day and night
Autumnal equinox – occurs in the fall
(N. Hemisphere – *Sept. 22*)
Vernal equinox – occurs in the spring
(N. Hemisphere - *Mar. 21*)

The Mayans of Central America built an enormous cylinder shaped tower, at Chichen Itza, to celebrate the two equinoxes.

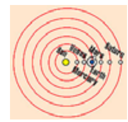
Planetary Models

Ancient cultures tried to explain the motions of the stars and planets. Two models of how the planets moved in space evolved over time.



GEOCENTRIC
Aristotle's Model
Assisted by Pythagoras and Euclid

The Earth is the center of our Solar System



HELIOCENTRIC
Copernicus' Model
Confirmed by Galileo and Kepler (Elliptical orbits were proposed by Kepler)

The Sun is the center if our Solar System

Discovery through Technology

The earliest astronomers used several tools to chart the position of objects in the sky and to predict where the sun, moon, and certain stars would move. Objects in the night sky served as a timekeeper and navigational aid.

Early Telescope
Quadrant
Armillery Sphere
Astrolabe
Sextent
Merket
Cross-staff

When you view an object in the sky you are seeing it as it was in the past. It has taken the light a very long time to reach the Earth. The Hubble telescope is capturing light from 12 billion years ago.

Distance in Space

The **astronomical unit** is used for measuring 'local' distances in the solar system. It is equal to the distance from the center of the Sun to the center of the Earth (approximately 149,599,000 kms).

A **light year** is equal to the distance light travels in 1 year (approximately 9.5 trillion kms). It is used for longer distances – to stars and galaxies. The distance to our nearest star, **Proxima Centauri** is a little over 4 light years.

A **parsec** is a basic unit of length for measuring distances to stars and galaxies, equal to 206,265 times the distance from the earth to the sun, or 3.26 light-years, The nearest star, **Proxima Centauri** is about 1.31 parsecs from the Earth.

STARS

Birth of Stars - Stars form in regions of space where there are huge accumulations of gas and dust called **nebulae**. **Interstellar matter**, which makes up part of the nebulae, originated from exploding stars. The process of 'star-building' is known as **fusion**, which releases great amounts of energy and radiation.

A star is a hot, glowing ball of gas (mainly hydrogen) that gives off light energy. Stars vary in their characteristics. Very hot stars look blue, while cooler stars look red.

Stars fall into distinct groupings. In the 1920's, Ejnar **Hertzsprung** and Henry Norris **Russell** compared the surface temperature of stars with its brightness (luminosity). They graphed their data to show the relationship between **brightness and temperature** of stars was not random.

GALAXIES

A galaxy is a grouping of millions or billions of stars, gas and dust. It is held together by gravity.

The **Milky Way Galaxy** is the galaxy our solar system is a part of. It is shaped like a flattened pinwheel, with arms spiraling out from the center.

Black holes are actually invisible to telescopes. Their existence is only known by an indirect method – when celestial material comes close to a black hole it becomes very hot and very bright

The formation of our solar system is based on the 'protoplanet hypothesis', which follows three steps:
1. A cloud of gas & dust in space begin swirling
2. Most of the matter (more than 90% of it) accumulates in the center – forming the Sun
3. The remaining materials accumulate (forming planets) and circle the Sun

Star Groups

Constellations are the groupings of stars we see as patterns in the night sky. There are 88 constellations and many are explained in Greek Mythology.

Asterisms are also groupings of stars but are not officially recognized as constellations.

TRACKING OBJECTS IN SPACE

Elliptical paths can help Astronomers and scientists to trace and predict where bodies in space are, have been and will be in the future. The understanding of orbits has led to the discovery of many different comets.

NASA tracks asteroids, comets and meteors that have been discovered by observatories and amateur astronomers.

Planet summary cards
Other Bodies in Space

(Use the SPACE Content Card Set to review details about the planets and objects in space)

OUR SOLAR SYSTEM

Our system of one star and eight planets was born about 4.6 billion years ago. All of the pieces were created at the same time. Although it was a 'BIG BANG'. It actually took billions of years for the entire system to develop. All of the gases, dust, and pieces of the system were around at the start. Eventually a star, eight planets, some smaller ***dwarf planets*** (like Pluto), and an asteroid belt developed. There wasn't even a star when the Solar System started out. Planets can be classified as ...

TERRESTRIAL	JOVIAN
(rocklike)	(gaseous)
Mercury, Venus, Earth, and Mars	Jupiter, Saturn, Uranus, and Neptune

THE SUN

The central controlling body of our solar system

Rotation: 30days
Revolution: Stationary
Atmosphere: Mostly Hydrogen, helium.

Temperature: 5,500°C
Diameter: 1,392 mil km
Distance from Sun: 149.6 mil km
Number of Moons: 0

Our **Sun** is a normal main-sequence star. It is the largest object in the solar system containing more than 99.8% of the total mass of the Solar System

The Sun has many mythological names the Greeks called it Helios and the Romans called it Sol. The Sun is about 70% hydrogen and 28% helium. This changes slowly over time as the Sun converts hydrogen to helium in its core. The Sun's power is produced by nuclear fusion reactions within its core. The surface of the Sun, called the photosphere, is at a temperature of about 5800 K. Sunspots are "cooler" regions at 3800 K. In addition to heat and light, the Sun also emits a low density stream of charged particles known as the **solar wind** which travels throughout the entire solar system.

MERCURY

Named by early Romans after the messenger of their gods.

Rotation: 59days
Revolution: 88days
Atmosphere: Helium, oxygen, hydrogen

Temperature: -193°C to 342°C
Diameter: 4,878 KM
Distance from Sun: 57.9 mil km
Number of Moons: 0

Mercury is the closest planet to the Sun and the eighth largest. It is named after the messenger of the Gods.

Mercury has been known since 300 BC. It was given separate names for its apparitions as a morning and an evening star. Mercury rotates three times in two of its years. Mercury is similar to the Moon: its surface is heavily cratered and very old; it has no plate tectonics. Mercury is the second densest major body in the solar system, after Earth. Mercury actually has a very thin atmosphere consisting of atoms blasted off its surface by the solar wind. Mercury has a small magnetic field whose strength is about 1% of Earth's and has no known satellites.

VENUS

Named after the Roman goddess of beauty and love.

Rotation: 17hr, 50min
Revolution: 165yrs
Atmosphere: Nitrogen, carbon dioxide, argon, water vapor, sulfur dioxide.
Temperature: 455°C
Diameter: 12,100 KM
Distance from Sun: 108.2 mil km
Number of Moons: 0

Venus is the 2nd planet from the Sun and the 6th largest. It has been known since prehistoric times and named after the goddess of love and beauty, often considered Earth's sister planet.

Venus is the brightest object in the sky except for the Sun and the Moon. It is sometimes (inaccurately) referred to as the "morning star" or the "evening star". It's orbit is the most circular. Venus shows phases when viewed with a telescope from Earth. Galileo's observation of this provided important evidence supporting Copernicus's Heliocentric Theory of the solar system. Venus probably once had large amounts of water like Earth but it all boiled away. Venus has no magnetic field, perhaps because of its slow rotation.

MARS

The name derives from the Roman god of war.

Rotation: 24.66hr
Revolution: 687yrs
Atmosphere: Carbon dioxide, nitrogen, water vapor, some oxygen, with traces of CO, Ne, and others.
Temperature: -124°C to -31°C

Diameter: 6,790 km
Distance from Sun: 227.9 mil km
Number of Moons: 2

Mars is the 4th planet from the Sun and the 7th largest. It is named after Mars, the Greek god of War. It is often referred to as the **Red Planet**

Mars has been known since prehistoric times. Mars surface area is about the same as the land surface area of Earth. Olympus Mons: the largest mountain in the Solar System rises 24 km above the surface of Mars. There is clear evidence of erosion in many places on Mars including large floods and small river systems. At some time in the past there was clearly some sort of fluid on the surface. Mars has a very thin atmosphere composed mostly of the tiny amount of remaining CO_2 (95.3%) N_2 (2.7%), Ar (1.6%) with traces of O_2 (0.15%) and H_2O (0.03%).

EARTH

Our home planet, The third planet from the sun.

Rotation: 23hr, 56min, 4.09053 sec.
Revolution: 365.256days
Atmosphere: 78% nitrogen, 21% oxygen, argon, carbon dioxide, helium, neon.
Temperature: -89°C to 58°C
Diameter: 13,000 km
Distance from Sun: 149.6 mil km
Number of Moons: 1

Earth is the 3rd Rock from the Sun and the 5th largest. It is the only planet whose name does not derive from Greek or Roman mythology. It is derived from Old English and Germanic.

Earth is the densest major body in the solar system. Unlike the other terrestrial planets, Earth's crust is divided into several separate solid plates which float around independently on top of the hot mantle below. The Theory of Plate Tectonics describes this and is characterized by two major processes: spreading and subduction. 71 % of the Earth's surface is covered with water. Earth is the only planet on which water can exist in liquid form on the surface. The Earth's atmosphere is 77% nitrogen, 21% oxygen, with traces of argon, carbon dioxide and water.

SATURN

The Romans named this planet after their god of agriculture.

Rotation: 10hr, 39min
Revolution: 29.5 yrs
Atmosphere: 91% hydrogen, 6% helium, methane, ammonia, hydrogen sulfide, water and more.
Temperature: -176°C
Diameter: 120,563 km
Distance from Sun: 1,429 mil km
Number of Moons: 20

Saturn is the 6th planet from the Sun and the 2nd largest. Saturn is named after the god of agriculture, Cronus

Saturn is the most distant of the five planets known to the ancients. Galileo was the first to observe Saturn with a telescope in 1610. In 1659 Christiaan Huygens discovered Saturn's rings. This planetary ring system remained unique until 1977 when very faint rings were also discovered around Uranus, Jupiter and Neptune. Saturn is the least dense of the planets - its specific gravity (0.7) is less than that of water. Titan, Saturn's moon, is the second-largest moon in the solar system and scientists believe that its nitrogen-rich atmosphere might be similar to what Earth's atmosphere was like long ago.

JUPITER

The Romans named this planet after the king of their gods.

Rotation: 9hr, 55min
Revolution: 11.86yrs
Atmosphere: 90% Hydrogen, 10% helium, trace amounts of methane, ammonia, water.
Temperature: -149°C
Diameter: 147,700 km
Distance from Sun: 778.3 mil km
Number of Moons: 16 and 23 smaller satellites

Jupiter is the 5th planet from the Sun and the largest planet in our Solar System. It is named after the Greek God Zeus, who was the King of the Gods

Jupiter is the fourth brightest object in the sky and has been known since prehistoric times as a bright "wandering star". In 1610 **Galileo** discovered Jupiter's four large moons, Io, Europa, Ganymede and Callisto (the Galilean satellites) and recorded their motions back and forth around Jupiter. This was the first discovery of a center of motion not centered on the Earth. It supported Copernicus's Heliocentric Theory of the motions of the planets (The Sun is the center of our solar system, with the planets orbiting around it). Jupiter has a Great Red Spot in its atmosphere that can be seen by observers.

NEPTUNE

The Romans named this planet after the god of the sea.

Rotation: 17hr, 50min
Revolution: 165yrs
Atmosphere: Hydrogen, Helium, Methane, Ethane

Temperature: -230°C
Diameter: 48,591.8 km
Distance from Sun: 4,504 mil km
Number of Moons: 8

Neptune is the 8th planet from the Sun and the 4th largest (by diameter). Neptune is smaller in diameter but larger in mass than Uranus.

In mythology **Neptune** (Poseidon) was the god of the Sea. After the discovery of Uranus, it was noticed that its orbit was not as it should be in accordance with Newton's laws. It was therefore predicted that another more distant planet must exist. Neptune was first observed in 1846.

Because Pluto's orbit is so eccentric, it sometimes crosses the orbit of Neptune making Neptune the most distant planet from the Sun for a few years.

URANUS

Named after the roman and Greek god of sky.

Rotation:	17hr
Revolution:	84yrs
Atmosphere:	Methane ice, hydrogen, helium
Temperature:	-216°C
Diameter:	51,118 km
Distance from Sun:	2,875 mil km
Number of Moons:	20

Uranus is the 7th planet from the Sun and the 3rd largest. Uranus is larger in diameter but smaller in mass than Neptune

Uranus is the earliest supreme god. Uranus was the son and mate of Gaia the father of Cronus (Saturn) and of the Cyclopes and Titans (predecessors of the Olympian gods). Uranus was discovered by William Herschel while systematically searching the sky with his telescope in 1781. It had actually been seen many times before but ignored as simply another star. Herschel named it "the Georgium Sidus" (the Georgian Planet) in honor of his patron King George III of England. The name "Uranus" was then proposed to conform to the other planetary names from classical mythology.

PLUTO

Named after the Greek god of the underworld.

Rotation:	6days, 9hrs, 18mins
Revolution:	248yrs
Atmosphere:	Nitrogen, methane, carbon monoxide.
Temperature:	-225°C
Diameter:	2,345 km
Distance from Sun:	5,900 mil km
Number of Moons:	1

Pluto orbits beyond the orbit of Neptune (usually). Pluto is named after the Greek God of the underworld, Hades.

Pluto is much smaller than any of the official planets and is smaller than seven of the solar system's moons, including Earth's Moon. It is now classified as a "dwarf planet". Pluto was accidentally discovered in 1930 by mathematical calculations which later turned out to be in error - predicting a planet beyond Neptune, based on the motions of Uranus and Neptune. Not knowing of the error, Clyde W. Tombaugh at Lowell Observatory in Arizona did a very careful sky survey which turned up Pluto anyway.

THE MOON

The Moon is Earth's only natural satellite and is the only celestial body in space visited by humans.

Rotation:	27.3 days
Revolution:	Stationary
Atmosphere:	Hydrogen, helium, argon
Temperature:	-233/123ºC
Diameter:	3,474 km
Distance from Sun:	384,403 km
Number of Moons:	0

The Moon is a natural satellite of Earth and has been known since prehistoric times. It is the 2nd brightest object in the sky after the Sun.

As the **Moon** orbits around the Earth once per month, the angle between the Earth, the Moon and the Sun changes; we see this as the cycle of the Moon's **phases**. The time between successive new moons is 29.5 days (709 hours).

The gravitational forces between the Earth and the Moon cause some interesting effects. The most obvious is the **tides**. The Moon has no atmosphere or magnetic field.

METEORS

'Shooting Stars'

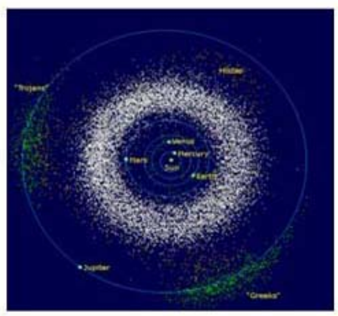
Meteors are chunks of rock, often from the clumping of cosmic dust, or chips off of asteroids. They are quite small too, usually being the size of a peanut. A meteor is the object streaking across the sky. On August 25th, 1995, a huge meteor between the size of a baseball and basketball fell to earth. Those are usually rare, and are commonly known as shooting stars. When meteors enter Earth's atmosphere, they hit it with the speed of fifty times the velocity of a bullet. Because this is so fast, they usually burn up quickly too. Not as brilliant as a comet, they still have a long tail of gases and chemicals that quickly burns up when it hits the atmosphere.

Many **meteoroids** are part of a meteor shower.

A **Meteoroid** is a small particle of debris in the Solar System. The visible path of a meteoroid that enters Earth's atmosphere is called a **meteor**, or commonly a "shooting star". If a meteor reaches the ground, is then called a **meteorite**. Most meteorites come from asteroids and comets. A small number of meteorites have been shown to be of Lunar or Martian origin.
One of the Martian meteorites, known as ALH84001 is believed to show evidence of early life on Mars. Meteorites are extremely important material evidence of the origins of the universe.

ASTEROIDS

Asteroids, sometimes called minor planets or planetoids, are small bodies in orbit around the Sun. They are smaller than planets but larger than meteoroids. The term "asteroid" has applies primarily to bodies in the inner Solar System. The distinction between asteroids and comets is made on visual appearance: Comets show a perceptible coma while asteroids do not. The largest asteroid by far is Ceres. It is 974 km in diameter and contains about 25% of the mass of all the asteroids combined.



COMETS

There are **long-period** comets and **short-period** comets. Long-period comets usually take over 200 years to orbit the Sun. Short-period comets make it around in less than 200. The nucleus of a comet has icy chunks and frozen gases with bits of embedded rock and dust. As a comet nears the Sun, it begins to warm up. The comet's atmosphere - the coma - grows larger. The Sun's heat causes ice on the comet's surface to change to gases, which fluoresce like a neon sign. "Vents" on the Sun-warmed side release fountains of dust and gas for tens of thousands of kilometers. The pressure of sunlight and the flow of electrically charged particles, called the solar wind, blow the coma materials away from the Sun, forming the comet's long, bright tails, which are often seen separately as straight tails of electrically charged ions and an arching tail of dust.

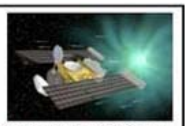
'DIRTY ICEBALLS'

Impacts from comets played a major role in the evolution of the Earth, primarily during its early history billions of years ago. Some believe that they brought water and a variety of organic molecules to Earth.

The tails of comets always point away from the Sun.

COMET MISSION

"STARDUST"



In 2004, the **STARDUST** mission encountered **Comet Wild2** and collected samples. Astronomers hope to learn more about the origins of the Solar System and the universe from those particles. The most interesting compounds will be those that contain carbon because they may hold the keys to the origins of life. Comets could have hit the Earth millions of years ago and helped seed organic (carbon-based) life.

COMET MISSION

"DEEP IMPACT"

The **Deep Impact** mission sent a projectile to collide with a comet. Deep Impact successfully hit Comet Tempel 1. The spacecraft then analyzed the scattered dust and ice.

Deep Space 1 visited Comet Borrelly in 2001

Giotto visited Comet Halley in 1986

HALEY'S COMET

In 1682 Edmund Halley observed the comet named after him

Halley's Comet is classified as a **short period comet**, a classification given to any comet that takes less than 200 years to orbit the Sun.

Records of Halley's Comet appearances suggest it was observed in 12 BC and in 5 BC. and it has been speculated that Halley's Comet is the **Star of Bethlehem** that the Wise Men saw around the time of the birth of Jesus.

COMET HALE-BOPP

1995

In 1995, an unusually bright comet outside of Jupiter's orbit (7.15 AU!) was discovered independently by Alan Hale and Thomas Bopp. The new comet, designated C/1995 O1, is the farthest comet ever discovered by amateurs and appeared 1000 times brighter than Comet Halley did at the same distance. Normally, comets are inert when they are beyond the orbit of Jupiter, so it has been speculated that Comet Hale-Bopp is either a rather large comet or experienced a bright outburst (or both).

COMET KOHOUTEK

Discovered in 1973 by Czech astronomer Luboš Kohoutek. Kohoutek was dubbed the **"comet of the century".**

Comet Kohoutek is a **long period comet**. Next sighting will be in about 75,000 years. In 1973 scientists theorized that Kohoutek was an Oort Cloud Object. It was believed that this was the comet's first visit to the inner solar system, which would result in a spectacular display of outgassing. Infrared and visual telescopic study has led many scientists to conclude, in retrospect, that Kohoutek is actually a Kuiper belt object, which would account for its apparent rocky makeup and lack of outgassing.

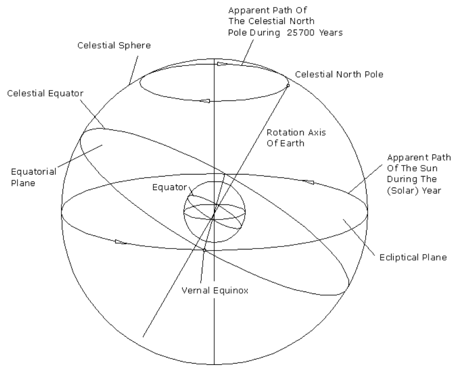
COMET SHOEMAKER LEVY

Approached Jupiter's gravity in 1992 breaking into 21 pieces – finally hitting JUPITER's surface in 1994

The intense heat and speed of the smaller pieces turned into massive explosions that formed fireballs larger than earth.

Altitude and **Azimuth** are calculated from the observer's position:
Altitude gives you the "*how above the horizon it is*"; the point straight overhead has an altitude of +90 degrees; straight underneath, an altitude of -90 degrees. Points on the horizon have 0 degree altitudes. An object halfway up in the sky has an altitude of 45 degrees.
Azimuth determines "*which compass direction it can be found in the sky*." An azimuth of zero degrees puts the object in the North. An azimuth of 90 degrees puts the object in the East. An azimuth of 180 degrees puts the object in the South, and one of 270 degrees puts the object in the west. Thus, if Guide tells you that an object is at altitude 30 degrees, azimuth 80 degrees, look a little North of due East, about a third of the way from the horizon to the zenith.
Zenith is the position in the sky directly overhead.
The path in the sky along which the Sun takes is called the **ecliptic**.

The **Celestial Sphere** is the name given to the very large imaginary ***'sphere of sky'*** surrounding the Earth



The ***gravitational escape velocity*** has to be achieved (**28,000 km/h**), if humans are to venture into space.

400 B.C	- Archytas used escaping steam to propel a model pigeon along some wires
1st Century	- Chinese used gunpowder to propelled 'flaming arrows'
1700's	- Polish General uses solid fuel rockets in war
Early 1900's	- Konstantin Tsiolkovskii suggested liquid fuel be used for rockets
1920's	- Wernher Von Braun developed the V-2 rocket for war
1926	- Robert Goddard launched the world's first liquid-propellant rocket.
Oct. 4, 1957	- Sputnik was launched by the Russians
Nov, 1957	- Laika (a dog) survived in Earth orbit for 7 days
1961	- Explorer I launched by USA
1962	- Alouette launched by Canada
1969	- First man on the moon
1981	- First launch of the Shuttle

THE SCIENCE OF ROCKETRY

The science of rocketry relies on a basic physics principle: For every action, there is an equal and opposite reaction.

There are three basic parts to a Rocket:

The **structural and mechanical elements** are everything from the rocket itself to engines, storage tanks, and the fins on the outside that help guide the rocket during its flight.

The **fuel** can be any number of materials, including liquid oxygen, gasoline, and liquid hydrogen. The mixture is ignited in a combustion chamber, causing the gases to escape as exhaust out of the nozzle.

The **payload** refers to the materials needed for the flight, including crew, living quarters, food, water, air and equipment for the mission.

Future Space Transport Technology

Ion Drives - engines that use xenon gas instead of chemical fuel. The xenon is electrically charged, accelerated, and then released as exhaust, which provides the thrust for the spacecraft. The thrust is 10 times weaker than traditional engine fuels, but it lasts an extremely long time. The amount of fuel required for space travel is about 1/10 that of conventional crafts.

Solar Sail Spacecraft use the same idea as sailboats. They harness the light of the Sun. The Sun's electromagnetic energy, in the form of photons, hits the carbon fibre solar sails, and is transmitted through the craft to propel it through space. These spacecraft could travel up to 5 times faster than spacecraft today.

Shuttles, Probes and Space Stations

Shuttle

Shuttles transport personnel and equipment to orbiting spacecraft

Mariner 10

Space probes contain instrumentation for carrying out robotic exploration of space

International Space Station

Space Stations are orbiting spacecraft that have living quarters, work areas and support systems to enable personnel to live in space for extended periods

Manned interplanetary space missions, possibly to Mars or Jupiter (one of it's Moons), or the colonization of the moon are the future. Building a remote spacecraft-launching site (on the Moon, or on the International Space Station) is the first step to enable interplanetary flight to become a reality and will reduce the cost dramatically.

Space probes are unmanned satellites or remote-controlled '*landers*' that put equipment on or close to planets where no human has gone before. Probes have done remote sensing on Mercury and Jupiter, taken soil samples on Mars, landed on Venus, and studied Saturn's rings up close. The most recent probes to explore Mars are still there. They are looking for evidence of water to determine if Mars at one time could have sustained life.

The only place that has been explored by humans in space, other than our Earth is the Moon. Apollo 11 was the first landing and there have been many others since. The next step is to establish a base for interplanetary manned missions to Mars.

To go boldly where no human has gone before

Space Hazards

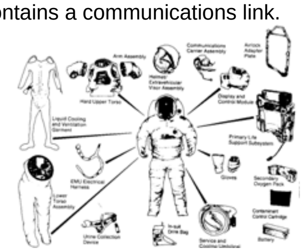
Environmental Hazards - Space is a vacuum with no air or water. Cosmic or solar radiation and meteoroids are the greatest dangers. Because there is no atmosphere, the temperatures in space have both extremes– from extremely hot, to extremely cold. There is also no atmospheric pressure to help regulate the astronaut's heartbeats.

Psychological Challenges - Long trips can present psychological difficulties, as well as claustrophobic feeling of tight living conditions.

Physiological Challenges - microgravity can cause problems because of the effects of weightlessness on the human body. Bones have less pressure on them and so they expand. They also lose calcium and become more brittle. The heart doesn't have to pump as hard to circulate blood. Muscles weaken and shrink. Depth perception is also affected.

The Space Suit

The space suit is a mobile chamber that houses and protects the astronaut from the hostile environment of space. It provides atmosphere for breathing and pressurization, protects from heat, cold, and micrometeoroids, and contains a communications link.



The suit is worn by the astronauts during all critical phases of the mission, during periods when the command module is not pressurized, and during all operations outside the command and lunar modules whether in space, in the International Space Station, or on the moon.

"Space Age" Materials and Systems

Many materials that were originally designed for a space application have practical applications on the Earth. These are called **'spin-offs'.**

Applications on Earth of technology needed for space flight have produced thousands of "spinoffs" that contribute to improving national security, the economy, productivity and lifestyle. It is almost impossible to find an area of everyday life that has not been improved by these spinoffs. Collectively, these secondary applications represent a substantial return on the national investment in aerospace research. We should be spending more.

Examples can be found in the fields of computer technology, consumer technology, medical and health technology, industrial technology, transportation technology, and public safety technology.

Life-Support systems have to be artificially produced in space. Clean water, fresh air, comfortable temperatures and air pressure are essential to life. All these support systems, including a power supply to operate them, must be operational on the Space Station at all times. Almost 100% of the water in the station must be recycled. This means that every drop of wastewater, water used for hygiene, and even moisture in the air will be used over and over again. Storage space is also a problem, making recycling essential for survival.

The main functions of the life-support systems include: recycling wastewater, using recycled water to produce oxygen, removing carbon dioxide from the air, filtering micro-organisms and dust from the air and keeping air pressure, temperature and humidity stable
Oxygen is produced in space by the **electrolysis** of water - **H_2O** can be split into hydrogen and oxygen. Astronauts' use the oxygen and the hydrogen is vented into space (could possibly be developed into fuel for the space craft in the future).

Satellites

Satellites can be **natural** – small bodies in space that orbit a larger body (the moon is a satellite of the Earth), or they can be **artificial** – small spherical containers loaded with electronic equipment, digital imaging and other instruments that are launched into Earth's orbit **-** A **geosynchronous** orbit is one that enables a satellite to remain in a fixed position over one part of the Earth, moving at the same speed as the Earth.
They are designed to perform one of four functions: Communication - Observation and Research - Remote Sensing and GPS.
Global Positioning System allows you to know exactly where you are on the Earth. The system uses 24 GPS satellites positioned in orbit, allowing for 3 to always be above the horizon to be used at any one time. The three GPS satellites provide coordinated location information, which is transmitted to a GPS receiver (hand-held) to indicate the person's exact position on the Earth.

Telescopes

In 1608, Hans Lippershey made one of the first telescopes – but it was Galileo Galilee who made practical use of it. Optical telescopes are 'light collectors'. The series of lenses or mirrors enable the optical device to collect and focus the light from stars. There are two types of optical telescopes. The first telescope designed was a simple **refracting telescope**. It uses two lenses to gather and focus starlight. There is a limit to the size of lens that a refracting telescope can have. Diameters over 1 meter will cause the lens to warp. **Reflecting telescopes** use mirrors instead of lenses to gather and focus the light from the stars. A process called **'spin-casting'** today makes mirrors, by pouring molten glass into a spinning mould. The glass is forced to the edges, cooled and solidified. Mirrors as large as 6m across have been made using this method. One of the newest innovations for ground-based optical reflecting telescopes is the use of **segmented mirrors** (uses several lightweight-segments to build one large mirror).

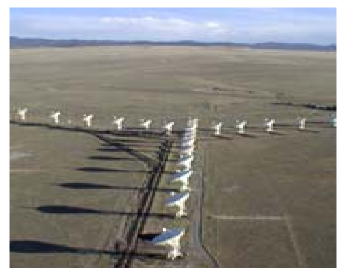
Interferometry

The technique of using a number of telescopes in combination is called interferometry. When working together, these telescopes can detect objects in space with better clarity and at greater distances than any current Earth-based observatory.

Radio Telescopes - Radio waves are received from stars, galaxies, nebulae, the Sun and even some planets. With the development of radio telescopes, astronomers gain an advantage over optical telescopes, because they are not affected by weather, clouds, atmosphere or pollution and can be detected day or night. Much information has been gained about the composition and distribution of matter in space, namely neutral hydrogen, which makes up a large proportion of matter in our Milky Way galaxy. Radio telescopes are made of metal mesh and resemble a satellite dish, but are much larger, curved inward and have a receiver in the center.

Radio Interferometry

By combining several small radio telescopes (just like they do with optical telescopes) greater resolving power can be achieved. This is referred to as radio interferometry, improving the accuracy and performance of the image in making radio maps. The greater the distance between the radio telescopes the more accurately they can measure position. Arrays, like the ***Very Large Array*** in Sorocco, New Mexico use 27 telescopes arranged in a Y, to improve accuracy even more.



The Hubble Space Telescope (HST)

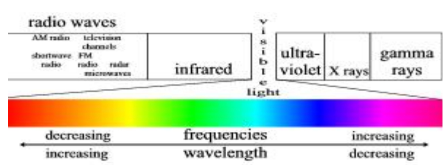
http://hubble.nasa.gov/

http://hubblesite.org/

The HST makes one complete orbit of the Earth every 95 minutes. To improve the views of space, astronomers are able to access images from a telescope in space. Free from the interferences of weather, clouds humidity and even high winds, the Hubble Space Telescope, launched in 1990, orbits 600 kms above the Earth, collecting images of extremely distant objects. It is a cylindrical reflecting telescope, 13 m long and 4.3 m in diameter. It is modular (parts can be removed and replaced) and is serviced by shuttle astronauts.

ELECTROMAGNETIC ENERGY

Besides the visible light that optical telescopes can give us, other forms of **electromagnetic energy** can also give us information about objects in space. This energy travels at the speed of light, but has different wavelengths and frequencies from those of visible light.



Energy with a short wavelength has a high frequency. Gamma rays are the most dangerous and radio waves are the safest. Visible light is measured in micrometers with 1 micrometer equal to 1 millionth of a meter.

Using Electromagnetic Energy

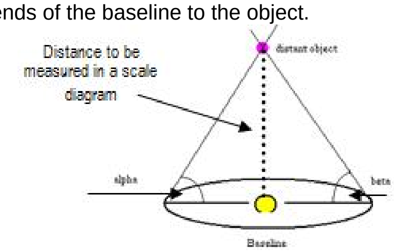
To View Objects in Space

Ultraviolet radiation is absorbed by the atmosphere and therefore cannot be studied very well from Earth. A distant planet orbiting a distant star cannot be seen because of the bright light from its star. However, when viewed in the infrared spectrum through a radio telescope, the stars brightness dims and the planets brightness peaks. The Keck Observatory in Hawaii is actively searching for planets, with its radio telescope. Other discoveries include fluctuations in microwave energy left over from the formation of the universe; X-rays emitted from black holes and pulsating stars; and huge bursts of gamma rays appearing without warning and then fading just as quickly.

Measuring Distance in Space

Triangulation and Parallax are two ways to measure distances indirectly, on the ground, or in space.

Triangulation - is based on the geometry of a triangle. By measuring the angles between the baseline and a target object, you can determine the distance to that object.
To measure the distance indirectly, you need to know the length of one side of the triangle (baseline) and the size of the angles created when imaginary lines are drawn from the ends of the baseline to the object.



Parallax

Parallax is the apparent shift in position of a nearby object when the object is viewed from two different places. Astronomers use a star's parallax to determine what angles to use when they triangulate the star's distance from the Earth. The larger the baseline, the more accurate the result. The longest baseline that astronomers can use is the diameter of Earth's orbit. Measurements have to be taken six months apart to achieve the diameter of the orbit.

A Star's Composition
Astronomers refract the light from distant stars to determine what the star is made of. Stars have dark bands in distinct sequences and thicknesses on their spectra. Each element that is present in the star creates its own black-line 'fingerprint'. The spectra of the star are then compared to known spectra of elements to determine the star's composition. A spectrometer is used to do this.

Direction of Movement

A change in the pitch (frequency) of sound waves because they are stretched or squeezed is known as the **Doppler Effect.** Changes in the sound waves can be measured to determine how fast and in what direction a light-emitting object is moving. The position of the dark bands is what shifts in the light waves of a moving star. The spectrum of an approaching star shows the dark bands shifting to the blue end of the spectrum, whereas, the shift is to the red part of the spectrum if a star is moving away from the Earth. The amount of shift indicates the speed at which the star is approaching or moving away. There are also practical applications that use the Doppler Effect. Law enforcement officers detect the speed of an approaching vehicle by using a **radar gun**. To determine the speed of the vehicle, the hand-held device records the difference in the outgoing and incoming sonar wavelength.

Dangers of Space Exploration

The dangers of the '*unfriendly* space environment include: accidents that may result in loss of life, economic setbacks and many years of work.

There are tragedies that bring to life the true dangers of space travel, such as:

1967

3 astronauts of **Apollo 1** died during a training exercise

1986

7 astronauts died when the **Space Shuttle Challenger** exploded shortly after launch

2003

7 astronauts died when the **Space Shuttle Columbia** broke apart during re-entry

A launch can be affected by many dangers, including highly explosive fuel, poor weather, malfunctioning equipment, human error and even birds.

Once in flight, the spacecraft can be affected by floating debris, meteoroids and electromagnetic radiation (coronal mass ejections – or, solar flares).

Re-entering Earth's atmosphere also has it dangers (as proven by the Colombia disaster). The re-entry path the spacecraft takes must be perfect, otherwise, if it is too shallow - it will bounce off the atmosphere, and if it is too steep – it will burn-up.

Space junk refers to all the pieces of debris that have fallen off rockets, satellites, space shuttles and space stations that remain in space. This can include specks of paint, screws, bolts, nonworking satellites, antennas, tools and equipment that is discarded or lost.

Hazards in Space

Micrometeorites are constantly bombarding spacecraft and the International Space Station. They travel at extremely high velocity and can cause great damage. Once they enter the atmosphere, they usually burn up.

Hazards on Earth

Some debris in space will enter the atmosphere and will not totally burn up. When this occurs, it may land in populated areas and cause loss of life or damage to property. Some satellites, or decommissioned space stations, that re-enter the atmosphere have radioactive parts and can contaminate a very large area, costing a lot of money and hours to clean it up. Some burn up in the atmosphere and those parts that don't, can fall into the ocean, making recovery and clean-up less costly.

Pros and Cons of Space Exploration

Disease, poverty, hunger, pollution and terrorism are all problems that face the people of the Earth. Spending billions to explore space, or spending billions to solve the conditions we currently experience is an ongoing debate that likely will never be solved. With depleting natural resources, population increases and advances in technology, the exploration of space may be the only option in the future.
Resources in Space - mean economic wealth. Energy supplies appear to be unlimited – solar energy from the Sun and mineral resources from the Asteroid belt. The cost of travel in space could be cut substantially if fuel and construction material is readily available in space. The Moon is one of the first places scientists looked for resources where they were able to process hydrogen and oxygen from Moon rock. The oxygen could be used for life support and hydrogen for fuel on lunar bases. Combining the two, water can be produced.

Potential Space Issues

Political	Ethical	Environmental
Who owns space?	Is it right to spend so much on space, instead of fixing Earth's problems?	Who is responsible for protecting space environments from alteration?
Who can use the resources in space?	Do we have a right to alter materials in space to meet our needs?	Who is responsible for cleaning up space junk?
Who will determine what goes on in space?	How can we ensure that exploration will be used for good and not evil?	

Many countries have contributed to the **International Space Program**.

Explore the historical perspectives as well as examine what is currently happening and what is being planned for the future by visiting the following websites.

NASA
http://www.nasa.gov/

Canadian Space Agency
http://www.space.gc.ca

European Space Agency
http://www.esa.int/esaCP/index.html

AsianPacificSpaceCO
http://www.apsco.int/