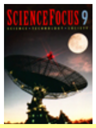


# Science Focus 9

**Unit E**

## Space Exploration

**Space Link:** NASA http://www.nasa.gov/home/index.html

**Topic 1**

### For Our Eyes Only
- Frames of Reference
- What Our Ancestors Saw
- Ancient Myths
- Sky Co-ordinates
- The Stars as a Frame of Reference
- The Earth-Centred Model
- The Sun-Centred Model

**Topic 2**

### Stronger Eyes and Better Numbers
- Telescopes
- Galileo's Approach to Inquiry
- Resolving Power
- Copernicus's Sun-centred Revolution Continues
- Universal Gravitation

**Topic 3**

### The Spectroscope: New Meanings In Light
- Spectral Lines
- Spectroscopy: The Science of Colour
- Diffraction Gratings
- Spectroscopy for Astronomers
- The Doppler Effect
- An Amazing Tool

**Topic 4**

### Bigger and Smarter Telescopes
- New Discoveries
- Combining telescopes
- Adaptive Optics
- Distance to the Stars

**Topic 5**

### What Channel Is This?
- Radio Telescopes

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### Above the Atmosphere and Under Control
- Rockets – Getting Up There
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- Global Positioning System ( GPS )

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### The Solar System Up Close
- The Sun
- Traveling through The Solar System
- Data Cards for the Inner Planets
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- Exploring the Outer Planets
- Voyager Today

**Topic 8**

### People In Space
- Breaking Free of Earth's Gravity
- The Apollo Program
- Meeting in Space
- The Space Shuttle
- The International Space Station

## Topic 1 - For Our Eyes Only

### Frames of Reference

A frame of reference is a set of axes of any kind that is used to describe positions or motions of things. The stars, the Sun and the planets do not rotate around the Earth, but seem to because the Earth is rotating on its axis. The Earth is our fixed frame of reference. To locate positions on Earth, the equator and the prime meridian (latitude and longitude) are the axes used.
Reference Frames and Coordinate Systems - http://theory.uwinnipeg.ca/physics/intro/node9.html
Concepts of Earth and Space - http://nssdc.gsfc.nasa.gov/planetary/

### What Our Ancestors Saw

Objects in the sky have fascinated humans throughout time. The explanations of how these celestial objects came to be are even more fascinating. Ancients developed their ideas of what was happening in the sky and explained it with their frame of reference. The constellations were patterns that seemed to tell stories about people. Stars are not always in the sky at the same time, but change positions over time – giving rise to the creation of calendars. The Sun and the Moon have their own pattern or rising and setting – the Moon also has phases. Mercury, Venus, Mars, Jupiter, and Saturn were special 'stars' called planets – meaning 'wanderer'.
http://www.electric-cosmos.org/ouruniverse.htm - http://www.utsc.utoronto.ca/~shaver/ancient.htm
http://www.vedicobservatory.org/YPreface.html

### Ancient Myths

Myths, folklore and legends were used to explain what ancient people observed 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.
- **Aboriginal tribes** – Algonquin, Iroquois and Narragansett believed the constellation Ursa Major was a bear running from hunters.
- **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.
- **Ancient Egyptians -** The Sun God – Ra – was carried in a sacred boat across the sky every day.

**Solstice** represents the shortest and longest periods of daylight
http://www.equinox-and-solstice.com/
*Winter solstice* - shortest period of daylight (Northern hemisphere - *Dec. 21*)
*Summer solstice* – longest period of daylight (Northern 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
http://solar.physics.montana.edu/YPOP/Classroom/Lessons/Sundials/equinox.html
Autumnal equinox – occurs in the fall (Northern hemisphere - *Sept. 22*)
Vernal equinox – occurs in the spring (Northern hemisphere - *Mar. 21*)

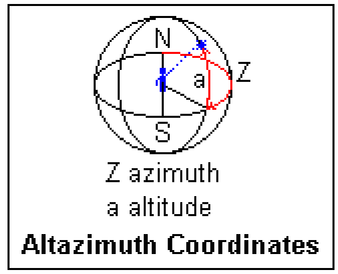
- The **Mayans of Central America** built an enormous cylinder shaped tower, at Chichen Itza, to celebrate the two equinoxes.
- The **Ancient Egyptians** built many pyramids and other monuments to align with the seasonal position of certain stars.
- **Aboriginal Peoples of Southwestern Alberta** used key rocks, which aligned with certain stars, in their medicine circles.

**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.
http://www.enchantedlearning.com/subjects/astronomy/stars/constellations.shtml
**Asterisms** are also groupings of stars, but are not officially recognized as constellations.
http://www.cns.uni.edu/~morgan/astro/asterisms.html

## Sky Co-ordinates

**Altitude** and **Azimuth** are calculated from the observer's (*the person in blue*) position:

**Altitude** tells you "*how far above the horizon the object 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.



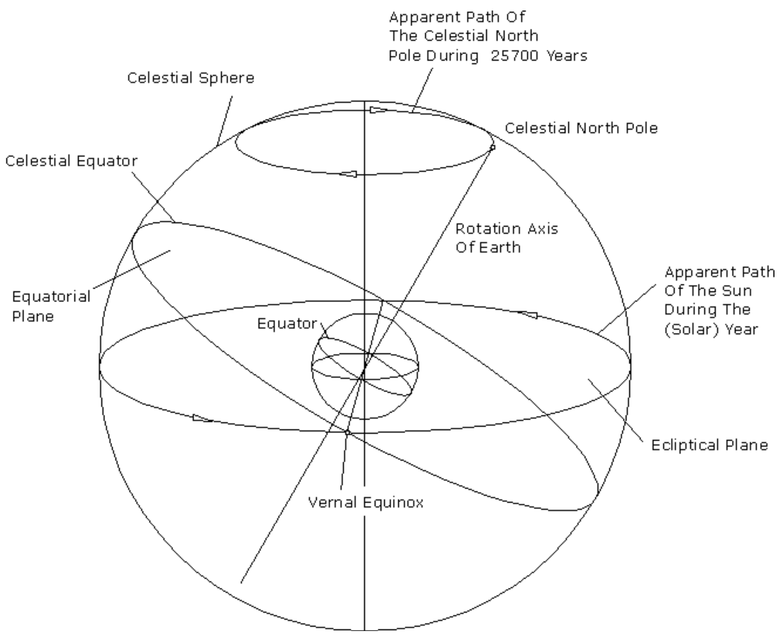

**Azimuth** determines "*which compass direction it can be found in the sky*." An azimuth of zero degrees puts the object in the North. An azimuth of 90 degrees puts the object in the East. An azimuth of 180 degrees puts the object in the South, and one of 270 degrees puts the object in the west. Thus, if you are told 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.

Java script applet: http://www.kemi.fi/kk021498/Java/sunapplet.html

**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.




http://www.ortelius.de/kalender/basic_en.php

## The Stars as a Frame of Reference

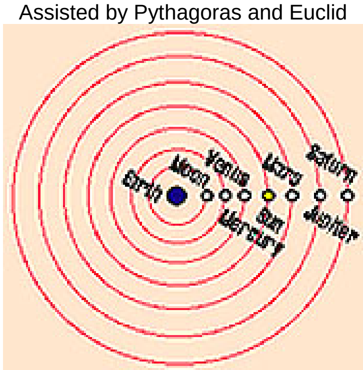
Ancient cultures tried to explain the motions of the stars and planets, with their frame of reference being the Earth. To track the actual motion of each celestial body in space, you need to use the stars as your frame of reference, instead of the Earth. To do this you would make an observation of which celestial body you are studying and include other stars in relation to it. Make subsequent observations and include those same stars. Over a period of time you would be able to determine in which direction the celestial body you are studying is moving.

## The Earth-Centred Model

The Earth was fixed and the center of the solar system with all celestial bodies in space rotating around it.

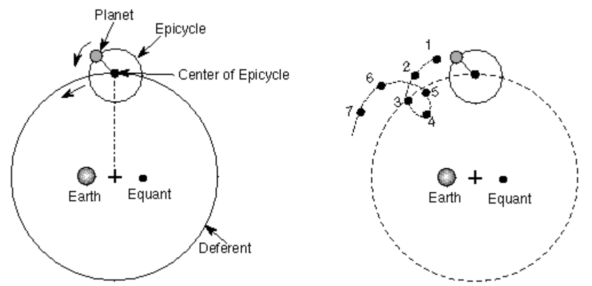
**Geocentric**

Aristotle's Model -
Assisted by Pythagoras and Euclid




The stars were 'the firmament of fixed stars'

One of the problems this model faced was trying to explain the retrograde motion (reversal of direction) of Mars, Jupiter and Saturn. To account for this Ptolemy developed a model that gave Aristotle's planets another level of circular motion called epicycles.




Center of epicycle moves counter-clockwise on deferent and epicycle moves counterclockwise. Epicycle speed is uniform with respect to equant. The combined motion is shown at right.

Deferent motion is in direction of point 1 to 7 but planet's epicycle carries it on cycloid path (points 1 through 7) so that from points 3 through 5 the planet moves backward (retrograde).

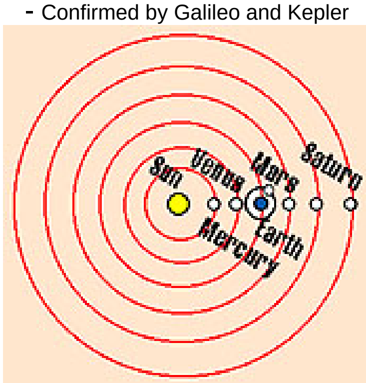
**Animation of the Heliocentric and Geocentric Models** - http://www.astro.utoronto.ca/~zhu/ast210/both.html

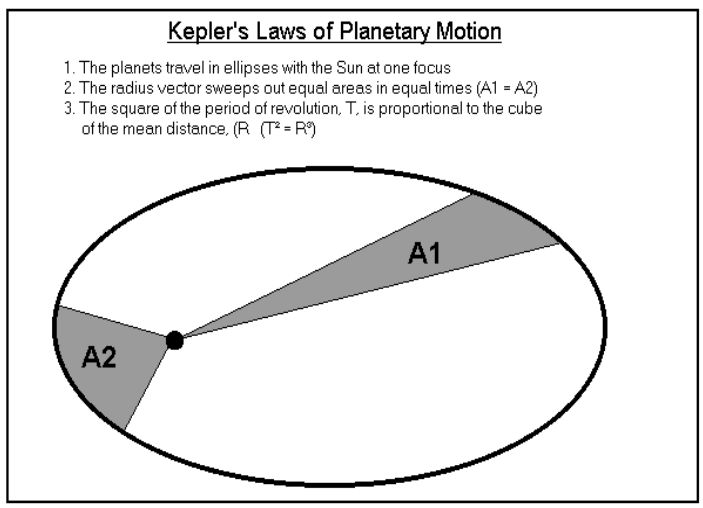
## The Sun-Centred Model

Nicholas Copernicus developed this model, in which the Sun was fixed and a rotating Earth revolved around it.

**Heliocentric**

Copernicus' Model
- Confirmed by Galileo and Kepler




http://www.thetech.org/exhibits/online/satellite/4/4d/4d.1.html

Elliptical Orbits - http://collections.ic.gc.ca/satellites/english/anatomy/orbit/elliptic.html

## Topic 2 - Stronger Eyes and Better Numbers

### Telescopes
http://www.nas.nasa.gov/NAS/SpaceSettlement/

Telescopes allow us to see objects that are very distant in space.
**Optical Telescopes** http://cdsweb.u-strasbg.fr/astroweb/optical.html

In 1608, Hans Lippershey made one of the first telescopes – but it was Galileo Galilei who made practical use of it. The observations he made included:

- The moon had blemishes (mountains and craters like the Earth).
- Sun spots indicated that it rotates on its axis.
- Jupiter's moons orbit the planet.
- Planets were disk-shaped, but because the stars were still pinpoints, they were further away.

### Galileo's Approach to Inquiry

Galileo's observations supported Copernicus's Sun-centered model but not Ptolemy's Earth-centered model. The reason for his beliefs was that, the moons he observed orbiting Jupiter, indicated that the earth was not the centre of the universe.

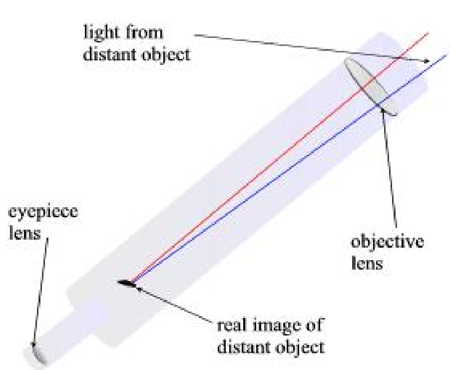
### Resolving Power

*Resolving power* is the kind of power that produces finer detail of the object being viewed because of the diameter of the objective lens. 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.

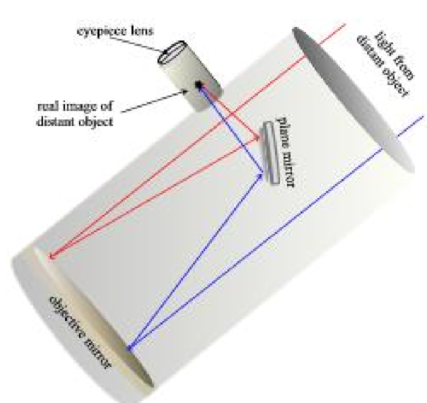
### Refractors and Reflectors

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




**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.



Review Optical Telescopes Notes Grade 8 Science Focus

Topic 5: Extending Human Vision http://www.edquest.ca/content/view/188/

An innovation for ground-based optical reflecting telescopes is the use of **segmented mirrors** (a segmented-mirror telescope uses several lightweight-segments to build one large mirror).

**Interferometry:** Combining Telescopes for Greater Power. 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.

http://www.space.com/scienceastronomy/astronomy/interferometry_101.html

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.

**Hubble Facts**: http://hubblesite.org/reference_desk/facts_.and._figures/

## Copernicus's Sun-centred Revolution Continues

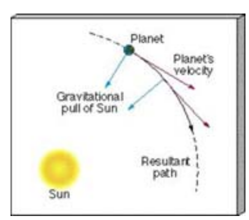
Although Galileo's observations helped to confirm the Sun-centered model of the universe, it was Johannes Kepler who solved the remaining problem of the epicycles. To do this, his calculations insisted that the orbits of the planets should be *elliptical*, instead of circular. An ellipse is a figure that looks like a squashed circle.

Tycho Brahe was an observation genius in astronomy before the age of the telescope. The mural, or Tychonian, quadrant was actually a very large brass quadrant, affixed to a wall. Its radius measured almost two meters and was graduated in tens of seconds. Sightings were taken along the quadrant through the small window in the opposing wall, to which Tycho points. The clock shown at the bottom right, accurate to seconds, allowed the observers to note the precise moment of observation.

With access to Tycho Brahe's star charts, Kepler mathematically worked out the orbit of Mars and found that it only worked if the orbit was elliptical. He also figured out the shape and scale of the entire known solar system.

## Universal Gravitation

Isaac Newton stated the law of universal gravitation eighty years after Kepler's contribution about elliptical orbits of the planets. Newton's law states that there is a gravitational force between all objects that pulls them together.




An orbit is the result of the attractive force of gravity balancing the straightforward movement of a planet because of velocity.

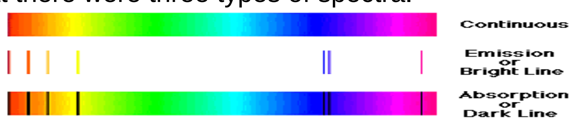
## Topic 3 - The Spectroscope: New Meanings In Light

### Spectral Lines

Isaac Newton passed a beam of light through a prism to produce a *spectrum* of colors. If you pass the light through a narrow slit before sending it through a prism (a *spectroscope* is a device that does this) the spectrum will be in more detail. Joseph von Fraunhofer used a spectroscope to observe the spectrum produced by the Sun. He noticed dark lines, called *spectral lines*, but didn't know what they meant. He found these spectral lines throughout the solar system.

### Spectroscopy: The Science of Colour

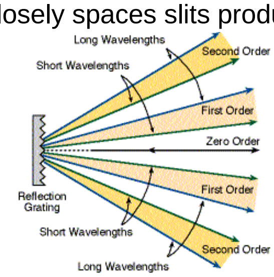
The significance of the spectral lines was discovered about 50 years later when Kirschoff and Bunsen, two chemists used a spectroscope to observe various chemicals when they were heated. They found some of the lines missing in some of the chemicals. Each particular element had its own unique spectral lines. This led to the science of *spectroscopy – the study of spectra*, as a part of chemistry. They found that there were three types of spectra.

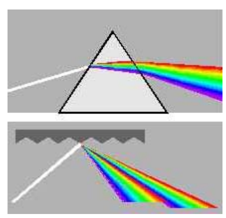


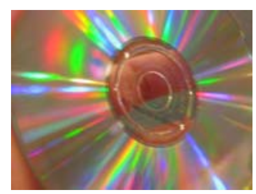

### Diffraction Gratings

http://www.thespectroscopynet.com/Educational/diffraction.htm

Besides splitting light using spectroscopes or prisms, a *diffraction grating* can, by using thousands of closely spaces slits produce much better detail in the spectrum it produces.



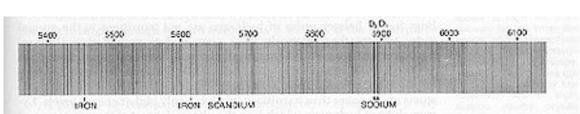



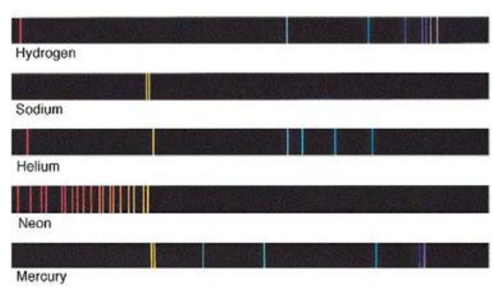


The rainbow spectra that can be observed on a CD are produced because the grooves on a CD act as a diffraction grating.

### Spectroscopy for Astronomers

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'.



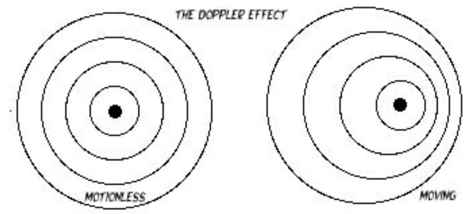



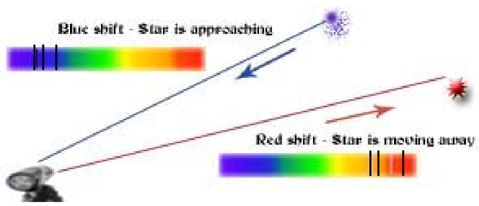

The spectra of the star are then compared to known spectra of elements to determine the star's composition. This is called *spectral analysis*. A **spectrometer** is used to do this.

By attaching spectroscopes to their telescopes, astronomers are able to observe a star's spectra, but because the distant stars are much dimmer than our Sun, only some of the elements in the spectra can be identified. Those that cannot be identified remain as inferences, based on what astronomers know about certain types of stars.

## The Doppler Effect

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**, which sends out a radio signal and receives one back from the vehicle. To determine the speed of the vehicle, the hand-held device records the difference in the outgoing wavelength and incoming wavelength.

## An Amazing Tool

The spectroscope is an amazing tool. It's application to astronomy has helped astronomers determine the composition of distant stars

## Topic 4 - Bigger and Smarter Telescopes

### New Discoveries

Bigger telescopes enable astronomers to discover new bodies in space.

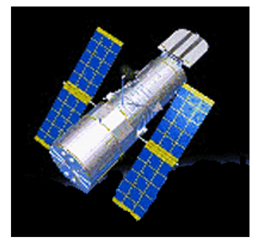
Sir William Herschel built a huge reflecting telescope and discovered the planet Uranus with it in 1773.

The largest refracting telescope was built at the Yerkes Observatory near the end of the nineteenth century. With it, Gerald Kuiper discovered methane gas on Saturn's moon, Titan, and two new moons of Uranus.

### Combining Telescopes ( *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.
http://www.space.com/scienceastronomy/astronomy/interferometry_101.html

### The Hubble Space Telescope ( HST )



http://hubble.nasa.gov/
http://hubblesite.org/newscenter/

**Hubble Facts**:
http://hubblesite.org/reference_desk/facts_.and._figures/

*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.

### Adaptive Optics

The NTT (New Technology Telescope) is called 'adaptive optics' because computers control the image, always adapting the mirror to changes in the Earth's atmosphere. Astronomers attach adaptive optic technology to older telescopes as well. The computers remove the blurred effect of the atmosphere.

### Distance to the Stars

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

(Map of the Milky Way)

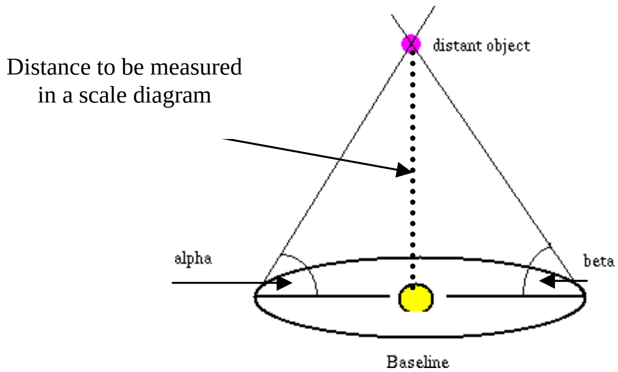
Birth of Stars (Great site showing an animation of how a star is born)
Stars form in regions of space where there are huge accumulations of gas and dust called **nebulae**. **Interstellar matter**, which makes up part of the nebulae, originated from exploding stars.

Telescopes enable astronomers to see further into space and identify distant stars. The problem they still have is how far are they from the Earth? The answer to this question lies in two methods. Triangulation and Parallax are two ways to measure distances indirectly, on the ground, or in space.

***Triangulation***

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.

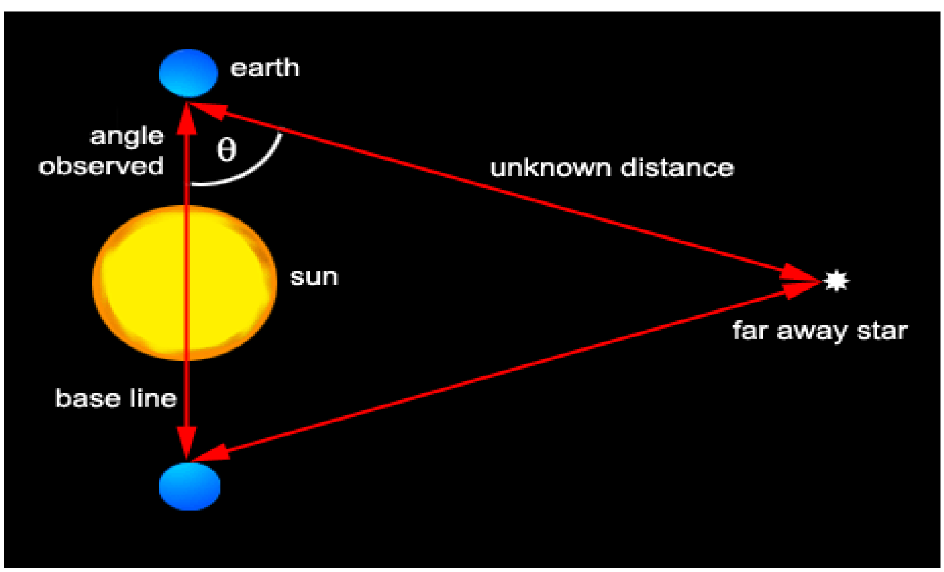
To measure the distance indirectly, you need to know the length of one side of the triangle (baseline) and the size of the angles created when imaginary lines are drawn from the ends of the baseline to the object.




There are two activities in the Textbook **p. 390-391, 392** that you can do to practice this skill.

***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.



## Topic 5 - What Channel Is This?

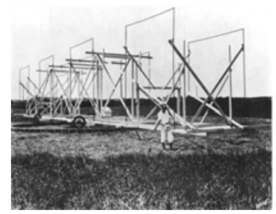
### Radio Telescopes

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 telescope in Arecibo, Puerto Rico.

In 1932 Karl Jansky built a radio antenna that was able to identify radio waves from space.

Grote Reber built a radio dish based on Jansky's antenna findings, where he 'listened' to the sky during the 1930's. He discovered that the strongest radio waves came from specific places in space. The static Rober heard became louder when he tuned into these *radio objects*. The loudest being our Sun in the Milky Way Galaxy.



### Bigger Radio Telescopes

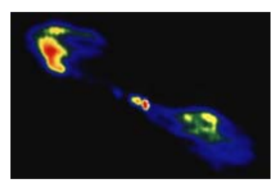
Radio waves have wavelengths that are millions of times longer than light waves, meaning that these waves give less resolution, but can penetrate dust clouds in the galaxy, where light waves cannot.

### Seeing Radio Waves

Radio telescope waves provide data, which astronomers graph, using computers to store the data and false color it to produce images of the radio waves, which are coded to the strength of the waves. Blues for low intensity, and as the signal gets stronger the colors go through greens, yellows, reds and whites. Radio observations have provided a whole new outlook on objects we already knew, such as galaxies, while revealing pulsars and quasars that had been completely unexpected.

### Optical Connections

Radio astronomers wanted to connect their radio waves with visual data obtained from optical telescopes. Until the resolution of radio telescopes improved making the connection was difficult. It is now common.

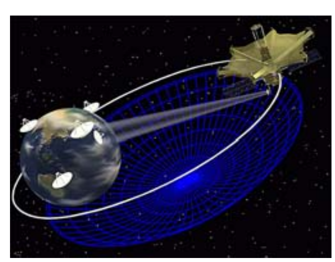


### Connecting Radio Telescopes

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, which uses **27** telescopes arranged in a **Y**, can improve accuracy even more.

### Radio Telescopes Bigger Than Earth

Telescopes can now be connected without wires, thanks to computers and clocks. This method is called Very Long Base Interferometry ( VLBI ). With this technique, images 100 times that of the largest optical telescope can be captured. This is done by capturing images from any or all radio telescopes in the world. Imagine a telescope as large as the Earth itself.
http://www.ballaerospace.com/p2prog.html



## Topic 6 - Above the Atmosphere and Under Control

### Rockets – Getting Up There

The science of rocketry relies on a basic physics principle that you learned in Grade 7.

***For every action – There is an equal and opposite reaction***

There are three basic parts to a Rocket:
http://www.grc.nasa.gov/WWW/K-12/airplane/rktparts.html

- 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 cabins, food, water, air, and people.

Rockets have been around a long time and were originally used as fireworks and weapons.
http://www.grc.nasa.gov/WWW/K-12/TRC/Rockets/history_of_rockets.html

| | |
|---|---|
| **400 B.C** | - Archytas used escaping steam to propel a model pigeon along some wires |
| **1st Century** | - Chinese used gunpowder to propelled 'flaming arrows' |
| **17th Century** | - 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 |

### Rocket Fuel

Rockets need combustible fuel to make them fly. All fuels create exhaust which comes out the end of the rocket. The speed of the exhaust leaving the rocket is called the *exhaust velocity*, which determines the *range* of the rocket. The *gravitational escape velocity* had to be achieved (**28,000 km/h**), if humans were to venture into space.

Robert Goddard launched the first liquid fuel rocket in 1926. The rocket was *staged* (having more than one section that drops off once its fuel is used up, making the rest of the rocket lighter and able to fly higher.

### The V-2 Rocket

Werner von Braun built the 1st ballistic missile for the Germans during World War II (1942). A ballistic missile is a bomb that is powered by a rocket engine. The V-2 rocket successfully found a target that was 200kms away. The Americans captured von Braun and his rocket team. As a result of their work NASA was born.

The Russians were not far behind as Sergi Korolev designed the *Vostok, Voshkod and Soyuz* rockets which carried 'cosmonauts' into space first.

### Computers – Making Adjustments

In the 1960's the Americans and the Russians were racing to launch spacecraft into orbit using rockets. They needed to use computers to calculate and control their orbits. The first computers on the ground (which filled large rooms) controlled the spacecraft in orbit. As computers became smaller they were put onboard the spacecraft and worked with computers on the ground to control the flight. Their vital role was to calculate orbits, locate satellites (and space junk), collect, store, and analyze data and to maneuver around these obstacles in orbit.

Rockets are used to blast spaceships into orbit but cannot send them on long journeys throughout the solar system. A technique called *gravitational assist* is a method of acceleration which enables a spacecraft to achieve extra speed by using the gravity of a planet. The planet's gravity attracts the craft causing it to speed up and change direction (a slingshot effect), sending it on to the next planet.

Computers improve our ability to see the stars better. *Charge coupled devices* (CCD's) record these images, by converring light signals into digital format. They are then sent by a computer where they are processed in ways that can remove 'noise' and sharpen images. The Hubble Space telescope gets a clearer view of the stars, because it isn't affected by the Earth's atmosphere.

## Satellites and Orbits

http://www.thetech.org/hyper/satellite/
http://www.hq.nasa.gov/office/pao/History/sputnik/
History of Satellites http://inventors.about.com/library/inventors/blsatellite.htm
Space Transport Firsts **http://www.tbs-satellite.com/tse/online/thema_first.html**

Satellites can be **natural** – small bodies in space that orbit a larger body ( the Moon is a satellite of the Earth ), and they can be **artificial** – small spherical containers loaded with electronic equipment, digital imaging and other instruments that are launched into Earth's orbit to perform one of four functions:

## Communication Satellites

These satellites provide 'wireless' technologies for a wide range of applications. Digital signals have resulted in clearer communications and more users. **Anik 1** (launched by Canada in 1972) transmitted the first television broadcasts by satellite.

## Satellites for Observation and Research

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. Numerous applications are now possible including:

- Monitoring and forecasting weather
- **LANDSAT** and **RADARSAT** (*are not in geosynchronous orbit*) – follow ships at sea, monitor soil quality, track forest fires, report on environmental change, and search for natural resources.
- Military and government surveillance

## Remote Sensing

Those satellites in low orbits perform remote sensing – a process in which digital imaging devices in satellites make observations of Earth's surface and send this information back to Earth. The activities include providing information on the condition of the environment, natural resources, effects of urbanization and growth. This information is usually used for planning purposes.

## Satellites as Personal Tracking Devices ( GPS ) Global Positioning System ( GPS )

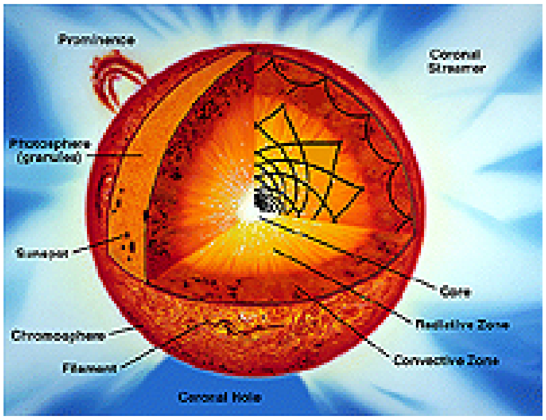
The **Global Positioning System** (**GPS**) allows you to know exactly where you are on the Earth at any one time.

The system involves the use of **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.

## Topic 7 - The Solar System Up Close

### The Sun




The Sun is made up of mostly hydrogen gas. It is 1.4 million km in diameter. Its temperature is about 15 million degrees Celsius. 600t of hydrogen are converted, by nuclear fusion, into helium per second. This is the energy released from the Sun. The Sun emits charged particles in all directions. This solar wind bombards the Earth at 400km/s, but the magnetic field of the Earth protects us.

### Traveling through The Solar System

http://www-spof.gsfc.nasa.gov/stargaze/Sintro.htm (INCREDIBLE!)
http://liftoff.msfc.nasa.gov/academy/space/solarsystem/solarsystemjava.html
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

Recent Histories of the Origins of the Solar System Hypotheses
The only way to see the detail on the planets in our solar system was to send spacecraft up close to take pictures and send them back to the Earth.

### The Moon

The first other world to see up close was the Moon. On July 17, 1969 Neil Armstrong and Edwin Aldrin landed on the moon for a first hand look.

The Inner Planets - Mercury, Venus, Mars and the Earth - are considered the terrestrial planets because of their composition. The Outer Planets – Jupiter, Saturn, Uranus, Neptune, and Pluto – are similar because of their gaseous composition.

**Planet Data** http://www.edquest.ca/content/view/208/
provides information that helps to summarize the data from pages 412-413 **Data Cards for the Inner Planets** and pages 414-415 **Data Cards for the Outer Planets**.
These sites also are very helpful:
http://nssdc.gsfc.nasa.gov/planetary/planetfact.html
http://www.seds.org/billa/tnp/

### Exploring the Outer Planets ( To boldly go where no human has gone before )

Observation equipment is sent out into space to explore distant areas of our solar system. *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 **Spirit** and **Opportunity**. They are looking for evidence of water to determine if Mars at one time could have sustained life.

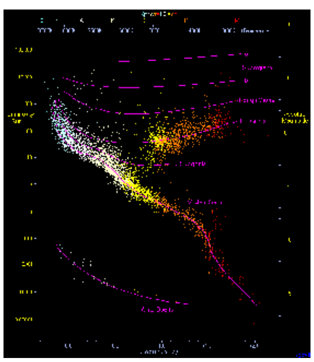

The only place that has been explored by humans in space, other than our Earth is the Moon. **Apollo 11** was the first landing and there have been many others since. The next step is to establish a base for interplanetary manned missions to **Mars**.

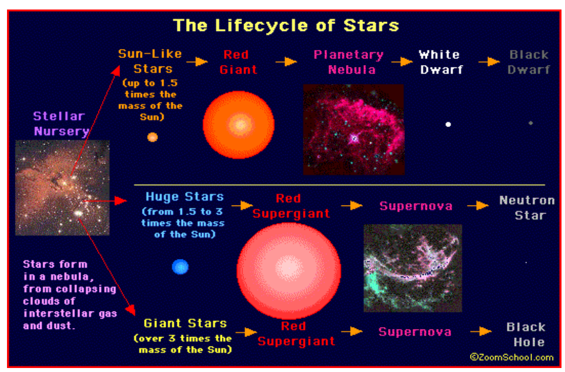
Distribution of Space and Matter
http://zebu.uoregon.edu/~soper/Galaxies/distribution.html
Elliptical paths can help astronomers and scientists to trace and predict where bodies in space are, have been and will be in the future. The understanding of orbits has led to the discovery of many different comets. **NASA** tracks asteroids, comets and meteors that have been discovered by observatories and amateur astronomers.

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.

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. Light from the Sun takes about 5 minutes to reach the Earth, whereas light from Pluto takes about 5 hours. The farther away, the longer light takes to reach the Earth. Light from the stars in the center of the universe takes about 25,000 years to reach the Earth. The Hubble telescope is capturing light from 12 billion years ago.

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. 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.



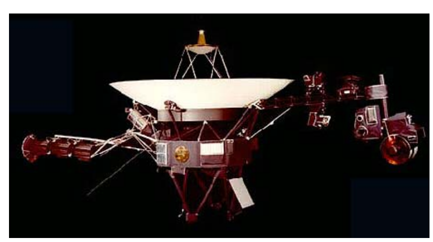



The process of 'star-building' is known as **fusion**, which releases great amounts of energy and radiation.

**Voyager Today**

Voyager 1

As of 2002, *Voyager 1* is about 12.5 billion km from the Earth and *Voyager 2* is 9.8 billion kms from the Earth.
The communication *time lag* in transmissions is about 23 hours for Voyager 1 and 18 hours for Voyager 2.



Voyager 2

## Topic 8 - People In Space

The race for space supremacy began just over 50 years ago. As a result many technologies were fast-tracked to make sure whoever developed them first, would make it into space first.

Space travel can have its dangers. 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).

Over 4000 missions have been sent into 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.

*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. 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 fall into the ocean, making recovery and clean-up less costly.

Russian
Space Station MIR

Re-entry and burn-up

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.

### Breaking Free of Earth's Gravity

The energy it takes to get up into orbit and stay there is huge. Gravity must be overcome and to do so, takes a speed of 8km/s. This is called *escape velocity*. Even when the gravity of the Earth is overcome, there are other hazards in this *'unfriendly to humans*' space environment, which can cause a mission to fail and possibly be a disaster, resulting 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 | 1986 | 2003 |
|---|---|---|
| – 3 astronauts of **Apollo 1** died during a training exercise | – 7 astronauts died when the **Space Shuttle Challenger** exploded shortly after launch | – 7 astronauts died when the **Space Shuttle Columbia** broke apart during re-entry |
|  |  |  |
| **Details** | **Details** | **Details** |

Other accidents or lost missions have occurred that have cost many millions of dollars and thousands of hours of work, including most recently, the European Rover on Mars -Beagle- that did not return any data, or signal, after it landed. Sometimes decisions may have to be made that will ultimately determine if missions are to fail.

## The Space program – Notable Achievements

### Sputnik
The Soviet Union was the 1st to successfully orbit a satellite - *Sputnik 1* in 1957

### Vostok
The first person in space was also a Russian. *Yuri Gagarin* orbited the Earth in *Vostok 1* at an altitude of 302 km for 108 minutes. In 1963 *Valentina Tereshkova* was the 1st female to travel into space in *Vostok 6*.

### Freedom 7
Project Mercury brought the first American - *Alan Shepherd* - into orbit on May 5, 1961, aboard *Freedom 7*. Shepherd flew a suborbital flight, which is just above the atmosphere, but not completely in orbit. The 1st orbital flight was made by *John Glenn* in 1962.

### Moon Landing - Apollo 11
The Apollo 11 lunar (Moon) landing almost didn't occur, because the original landing site was found to be too rocky. With a precise amount of fuel, an alternate landing site had to be chosen on the first try, or the mission would be scrubbed. In the summer of 1969 *Neil Armstrong* and *Edwin Aldrin* were the 1st humans to set foot on another place in space, when they landed on the Moon.

*' One small step for man, one giant leap for mankind '*

### Meeting In Space
The Apollo/Soyuz joint mission was tested in 1975. It was the first international space mission. The universal docking model was tested and was successful.

### Life Support Compatibilities http://www.mobilelife.com
To make the system work required the docking module to act as a life raft, replenishing oxygen and getting rid of carbon dioxide. The Americans and Soviets approached the compatibility problem a little differently.

| | Soviet System | American System |
|---|---|---|
| Cabin atmosphere | 80% nitrogen, 20% oxygen at normal air pressure | 100% oxygen at 1/3 air pressure |
| Advantages | Simple, minimal fire hazard | Less decompression issues |
| Disadvantages | Decompression danger | Fire danger, explosion |
| Oxygen replenishment | Chemical reactoions with solid chemicals | Oxygen in high pressure containers |

### Shuttle, Space probes and Space Stations
There are three main types of spacecraft in use:

**Shuttles** transport personnel and equipment to orbiting spacecraft**.** Columbia was the 1st in 1981

**space probes** carry instrumentation for exploration of space

**International Space Stations** are orbiting space centers where research, experimentation, and further exploration can be carried out by people living there for extended periods of time

The '**Canadarm**' was launched in **1981** and has served a very useful purpose on many missions, including launching and retrieving satellites for use or repair, fixed the Hubble Telescope and put modules of the International Space Station together.

## Canadian Contributions to Space Exploration and Observation

http://www.spacenet.on.ca/

**Canadian Space Agency Website:** http://www.space.gc.ca/asc/eng/default.asp

Canada also launched satellites into orbit:

- **Alouette 1** in **1962** – one of the first satellites launched for non-military use
- **Anik 1** in **1972** – communications across the entire country
- **1973** – Canada was the 1st nation to broadcast television signals via satellite

**Brief Summary of Canada's Contributions in Space**:

- **1839** – Sir Edward Sabine establishes the 1st magnetic observatory and discovers that the Aurora Borealis is associated with sunspot activity
- **1962** – 3rd nation to launch a satellite
- **1969** – supplied landing gear for Apollo 11
- **1981** – **Canadarm 1** used for the first time in space
- **1984** – 1st astronaut – Marc Garneau
- **1992** – 1st female astronaut – Roberta Bondar
- **1997** – Technology for the **Mars Pathfinder Mission** - *Sojourner* rover ramp
- **2001** – Chris Hadfield - 1st Canadian to walk in space – he helped deliver the **Canadarm 2** to the **International Space Station**. 

### The International Space Station - A Home In Space

Outside Earth's atmosphere, life-support systems have to be artificially produced. 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 International Space Station at all times.

*Recycling Water*

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
- Keeping air pressure, temperature and humidity stable

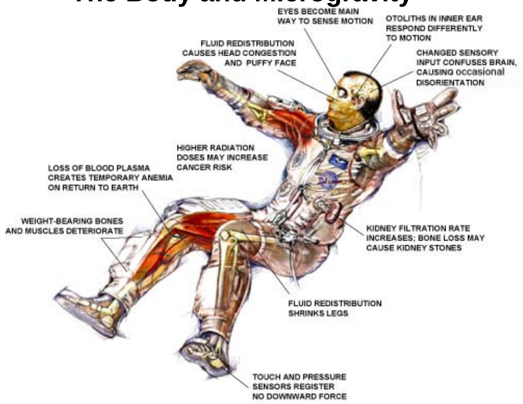
*Producing Oxygen*

**Electrolysis** of water (remember $H_2O$ can be split into hydrogen and oxygen). The astronauts use the oxygen and the hydrogen is vented into space.

To survive in space (which is a cold vacuum), technologies have needed to be developed to overcome the hazards of this harsh environment. A manned flight to Mars would last 2 to 3 years, which is a long time to be in an enclosed environment.

Space is a vacuum with no air or water. Cosmic and 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. Long trips can present psychological difficulties, as can the claustrophobic feeling of such tight living conditions.

## The Body and Microgravity




Living in *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.

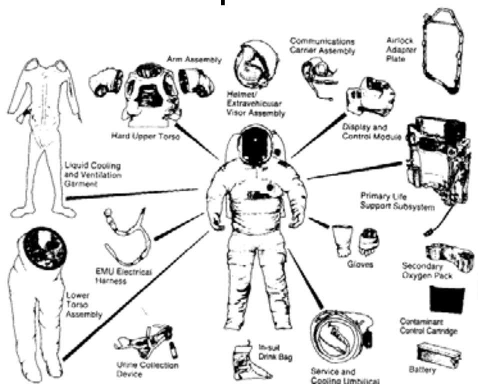
**Muscles** weaken and shrink.

**Depth perception** is also affected.

The *space suit* 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.

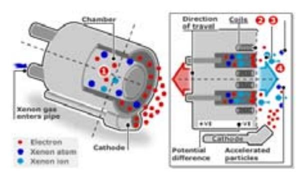
## The Space Suit




Learn what it takes to be an astronaut, by reading **Robert Thirsk's** story - p. 430 in the **Science In Focus 9** textbook.

## The Future of Space Transport Technology

Ion Drives are 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.



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.

A manned interplanetary journey would begin best in space, likely from a space station.

The **International Space Station** could be such a platform to begin the exploration of other planets – most likely MARS and possibly one of Jupiter's moons. As more space stations are built the reaches of space will soon be within our grasp.Private developers and companies are even planning tourist flights and possibly hotels and amusement parks in space, or, on the Moon.