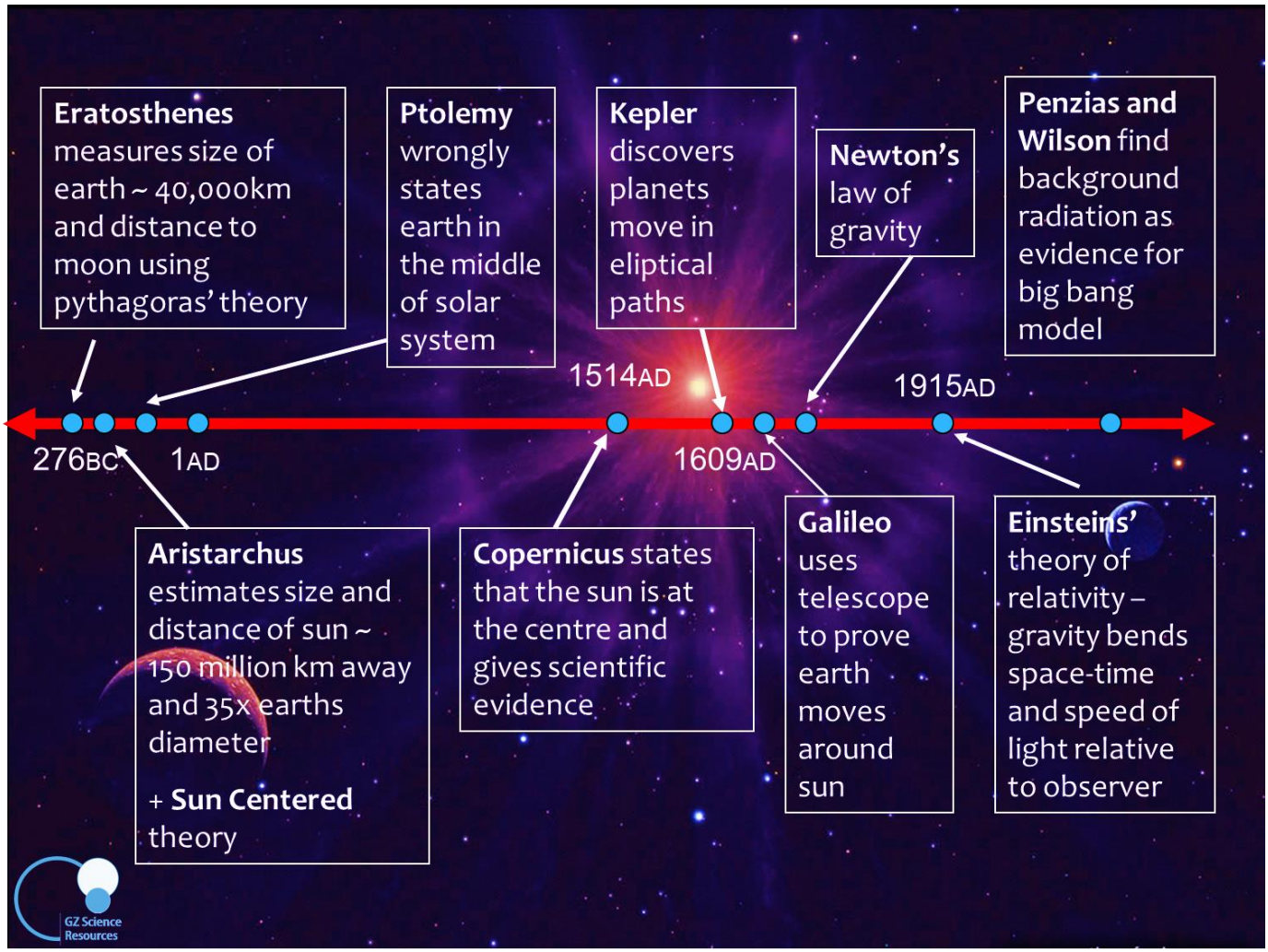
GZ Science Resources

Knowledge about our Earth and its place in the Solar System has accumulated by Scientists over thousands of years

Humans have always looked up at the stars and sky and tried to make sense of what they saw. Before we started to use the process of science to explain how the world around us worked, we had many myths and legends to help us understand what we could observe and how it came to be.

Ranginui (Rangi) the Sky Father and Papatuanuku (Papa) and the Earth Mother embrace in darkness. Their children soon become restless and worn out from the living conditions. Tanemahuta (Tane) wishes to separate the mother and father. Most of the sons finally agree with the plan and the children begin to divide Rangi and Papa, even though their task is very difficult. Tane finally succeeds as he places his shoulders against the earth and his feet against the sky. Now that the separation is complete, there is a clearly defined sky and earth.



The Big Bang Theory is currently accepted explanation of the beginning of the universe

Most astronomers believe that the universe came into existence in a single moment – called the Big Bang theory. Latest research has the Universe dated at 13.8 billion years old.

The Big Bang theory states that the universe started as just an extremely concentrated point of energy. This began to expand extremely rapidly in all directions and matter formed out of the energy. All the sub-atomic particles in the universe were made in the first few minutes. As the universe cooled, the sub-atomic particles formed Hydrogen and Helium atoms. This matter formed the raw material for stars and galaxies.

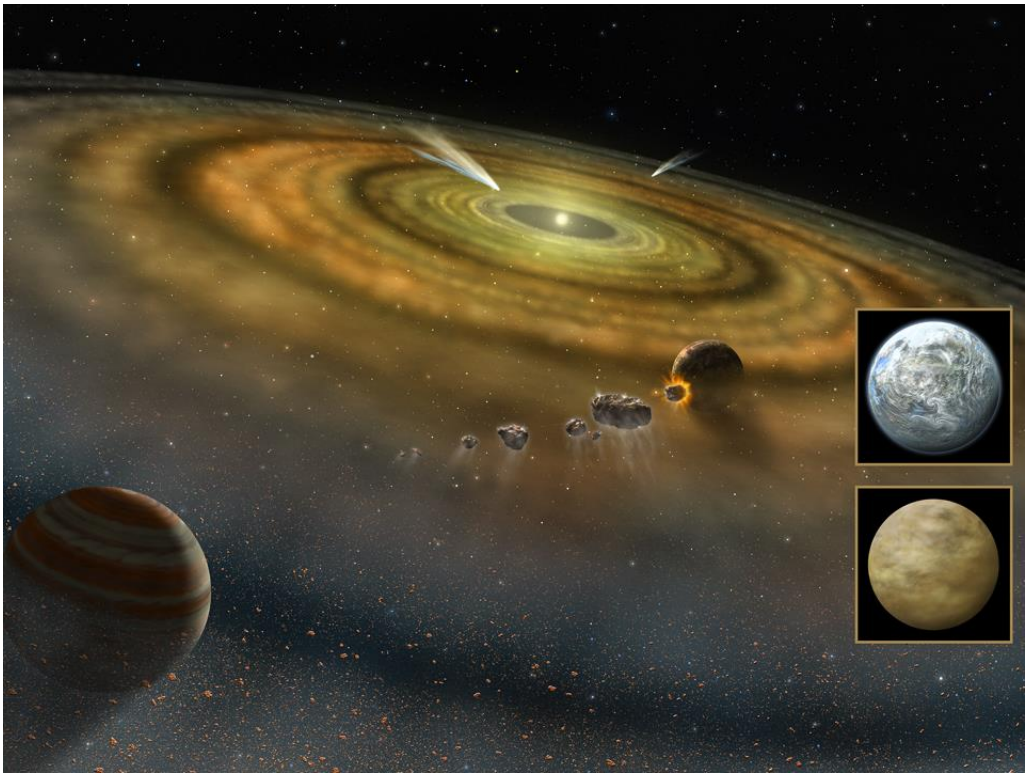
Penzias and Wilson and their evidence for the Big Bang theory

Penzias and Wilson find background radiation in 1964 using a radio telescope, as evidence for Big Bang model. The microwaves they discovered are from the left over EM radiation waves first released from the Big Bang. The Big Bang theory for the origin of the universe now becomes widely accepted.

Making of the Solar System

Around 4.6 billion years ago, our Solar System was formed from a huge cloud of stardust (debris from older exploded stars) contracted under gravity

The mass began to spin as it contracted – much like a figure skater – and formed a disc with a bulge at the center.
The bulge developed into the sun, which contains 99% of the Solar System mass.
The sun got hotter as the material compressed together, until finally it was hot enough for a nuclear reaction to start



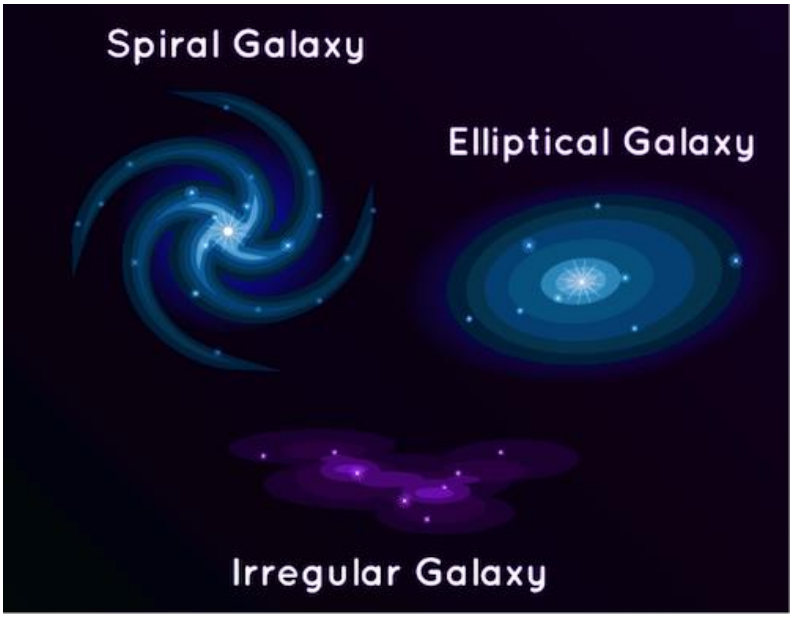
The Earth, Sun, Planets and stars have all formed from matter left over from the Big Bang

The remaining material was flung out along a single plane and material lumped together at various distances from the sun to form planets.

The gravity created by the planets mass causes the planets to become spheres.

The gravity of the sun causes the planets to orbit the sun rather than traveling away. Moons around planets were created in a similar way to the planets around the sun.

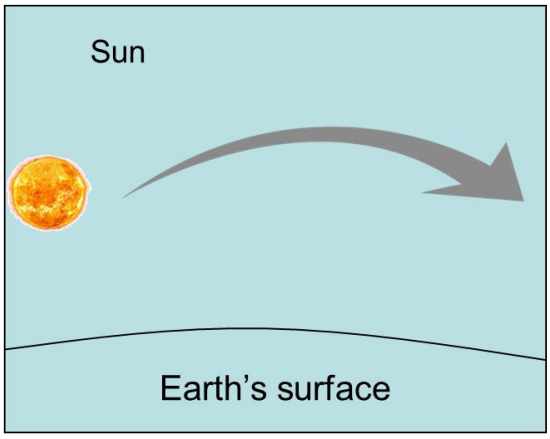
Our Galaxy “The Milky Way”



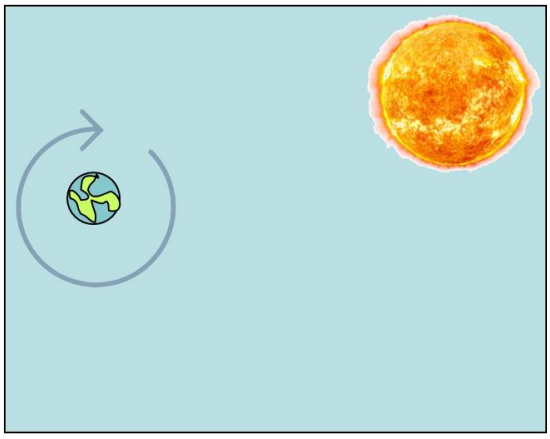
Our Sun, and the Planets orbiting around it, is just one of an estimated 100 – 400 billion other stars that make up our Galaxy “The Milky Way”, many of them also having planets. A galaxy is made up of billions of stars as well as gas and dust. The components of the galaxy are held together by gravitational attraction., and move together. There are estimated to be around one hundred billion galaxies in the Universe. The shape of our galaxy is called a spiral., but galaxies come in many different shapes and sizes.

The daily and annual movements of Earth

Actual movement of heavenly bodies occurs when they are moving from one point to another through space. Apparent movement occurs when stationary objects appear to move across the sky due to the motion of the Earth.



Apparent movement of the sun across the sky during the day.



Actual movement of Earth and Sun

Why do the Stars move across our night sky?

From Earth we can see stars in the sky – it is difficult to see them during the day because the sunlight overpowers the starlight but they are still there.

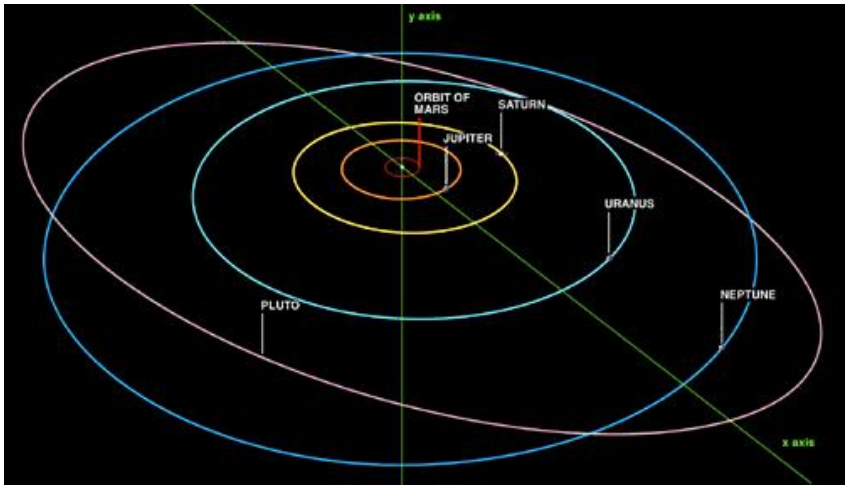
Stars do move but because they are so far away from us, we cannot normally detect this easily. It is because the earth is moving. Earth spins on its axis once every 24hours eastwards. Earth orbits around the sun once every year.

A year is one complete orbit of the Sun

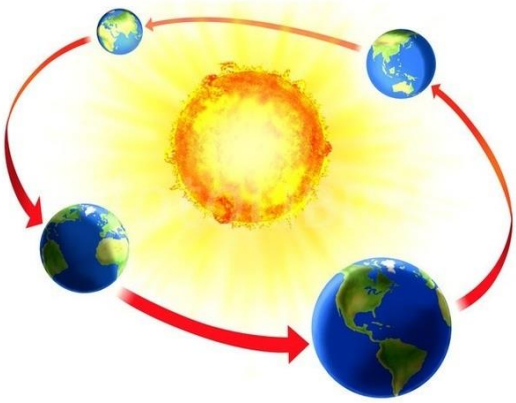
The Earth completes an entire orbit around the sun in 365 days. A year is the period of one revolution of a planet's orbit. Different planets have different lengths of time to complete one orbit or year. All planets in the solar system orbit around the Sun.

The year length of Planets differ

The planets orbit around the Sun in the same direction - counter-clockwise. They also orbit around on the same plane (except for the dwarf planet Pluto which appears to have been "knocked off course" by another object in the past. The closer to the Sun, the shorter a Planet's year is.



The Earth orbits around the Sun, like the other planets, and the Moon orbits around the Earth



Planets orbit stars. Planets do not give off their own light, but they reflect light from stars. Earth orbits the Sun once every 365.25 days. (1 year). Earth spins anti-clockwise on an axis at 23.5° to the plane it orbits around the sun. Earth takes 24hours to complete one rotation, only one-half of Earth is exposed to light from the sun at any given time; creating periods of day and night.

The Sun is the closest star to the Earth

A star is a mass of extremely hot gas. It gives off heat and light energy produced by nuclear reactions.

- The sun consists of extremely hot gases held together in a sphere by gravity.
- Nuclear reactions occur inside the sun
- Hydrogen is changed into helium
- Huge amounts of energy are released
- The interior temperature is 14 million °C
- The surface temperature is 5,800 °C
- The sun emits radiant energy (light/heat)

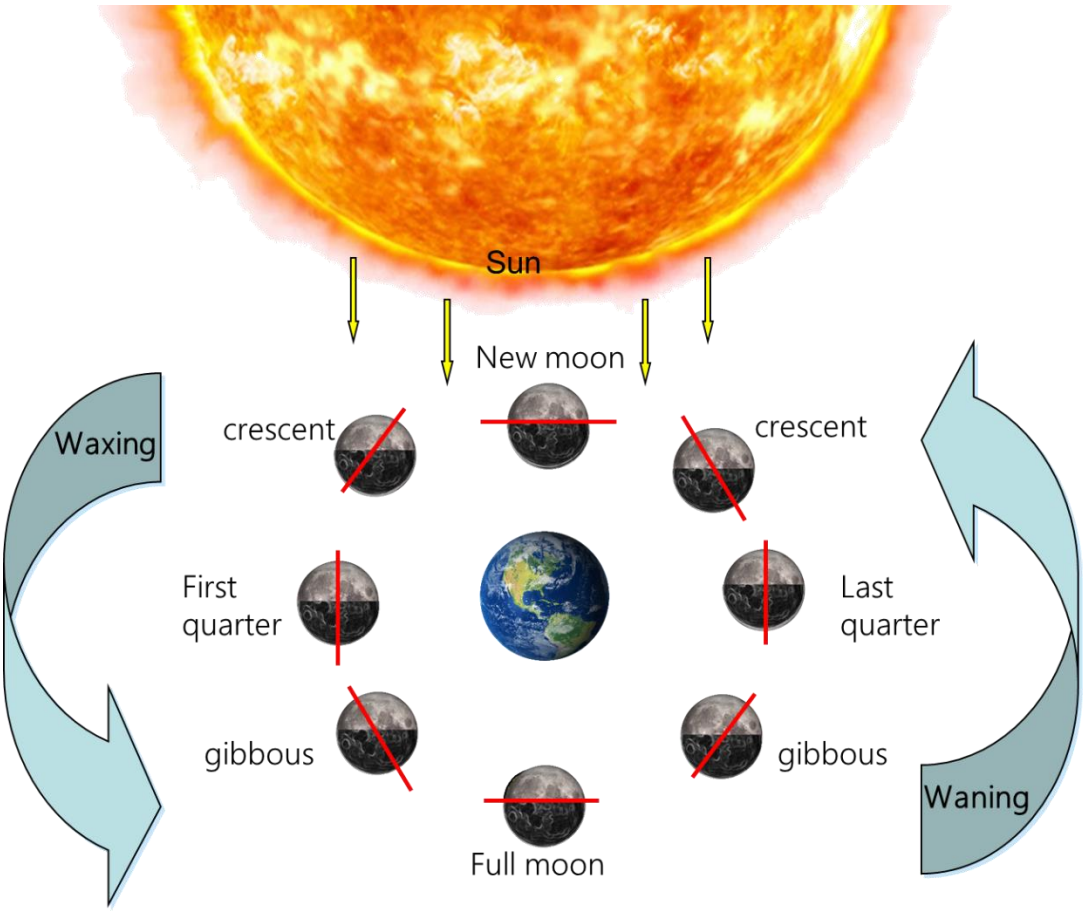
The Earth has one natural satellite, The Moon.

A satellite is the name given to a small object that orbits a planet.

Planets have their own natural satellites called moons. The Mass of the planets results in gravity, causing the moons to orbit. Earth has just one moon – called the Moon. The Moon is made of solid rock and is covered in craters. The Moon's gravity pulls at the earth (the water moves towards it but solid earth cannot) and creates tides twice a day. The Moon spins on its axis at exactly the same rate as it orbits around the Earth so we only ever see the same side facing us. There is no dark side of the Moon because all parts of it eventually receive sunlight.

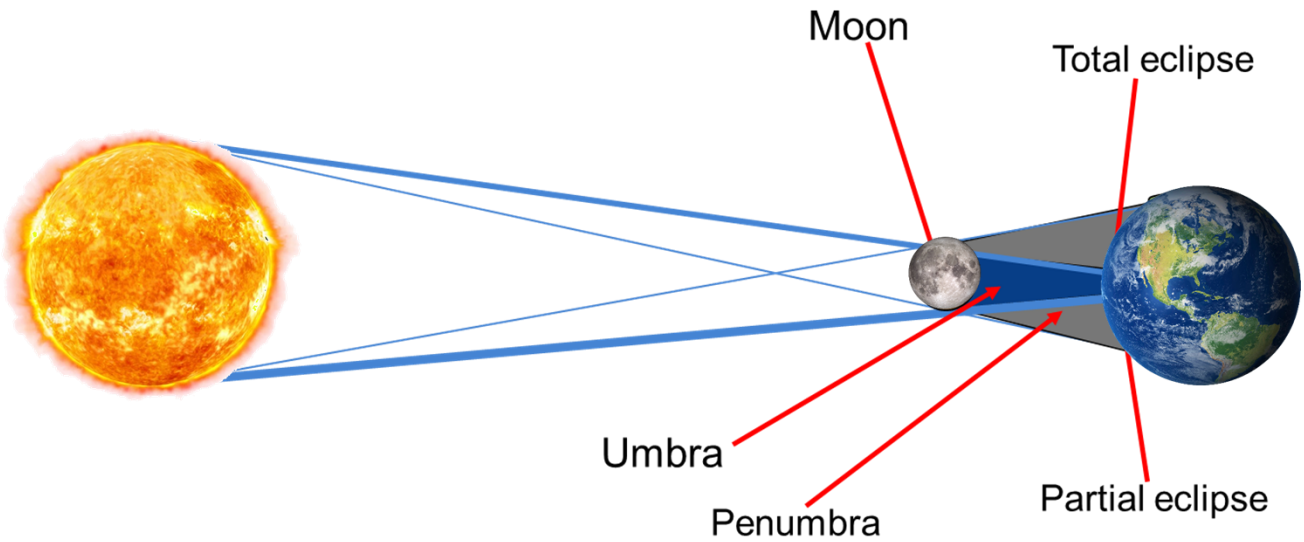
The Lunar cycle and the phases of the moon

As the Moon revolves around the Earth it appears to change shape. These different shapes are called the phases of the Moon.



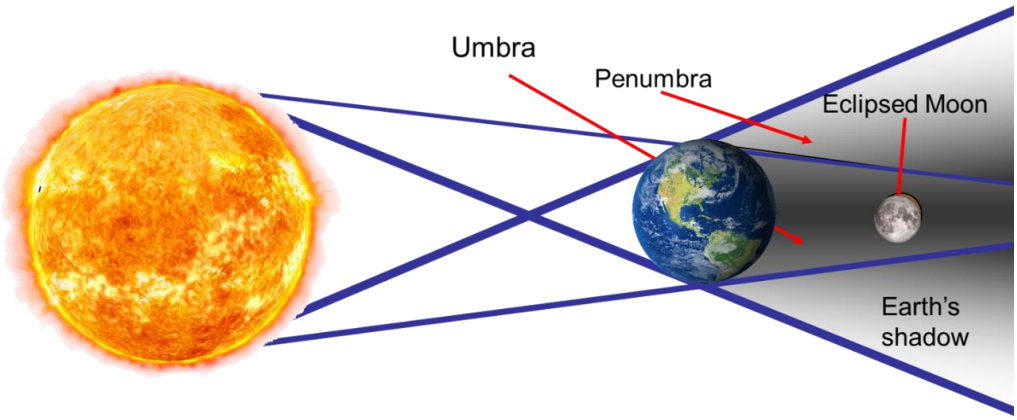
Eclipses occur when one body in space moves into the shadow of another body

Solar eclipses occur when the new Moon passes between the Sun and Earth. Total solar eclipses are very rare events as the Moon is so small in comparison to the distance to the Sun. A total eclipse allows us to see the corona (outside layer) of the Sun and Stars behind the Sun, whose light is bent by gravity. Einstein used this observation during a total eclipse as evidence for his theory of general relativity.



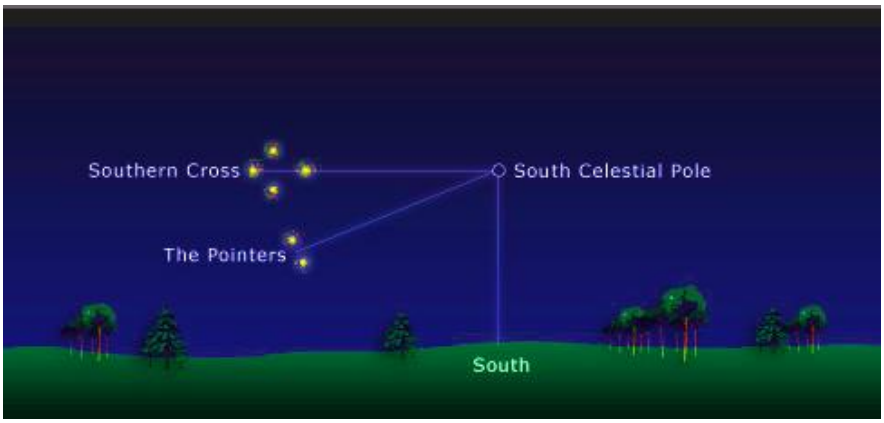
Lunar eclipses occur when a full Moon moves into the shadow of the Earth

Earth's axis is tilted some 23.5 degrees against the Earth–Sun plane (which causes the seasons); and the Earth–Moon plane is tilted about 5 degrees against the Earth-Sun plane (without a tilt, there would be an eclipse every two weeks, alternating between lunar eclipses and solar eclipses).



Visual objects in the New Zealand night sky include the Southern Cross, and Matariki (the Pleiades)

People have grouped stars into imagined patterns called constellations since ancient history. The most famous constellations are those that form the 12 signs of the zodiac (Leo, Aries, and Cancer etc.) but our most well-known and visible constellation seen only in the Sothern hemisphere is the Southern Cross.



Because of Earth's rotation the stars are not in the same place throughout the night

As the earth orbits the Sun we see a different portion of the sky. There are some stars we see at all times of the year from New Zealand, like the stars that form the constellation the Southern Cross, and others that we never see, like the North Star.

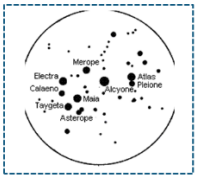
Constellations are seen as a 2-dimensional view (like seeing them on a flat sheet) of 3-dimensional space – where stars in a single constellation are at different distances from earth. Different constellations are seen at different times of the year and from different places on Earth. Stars that make up a constellation may be brighter because they are closer to Earth and/or they are bigger/brighter stars

Main constellations in the Southern Night Sky

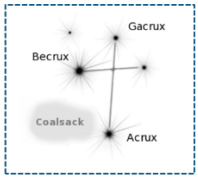
Scorpio

Taurus

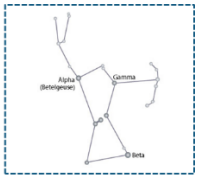
Sagittarius



Pleiades



Crux



Orion

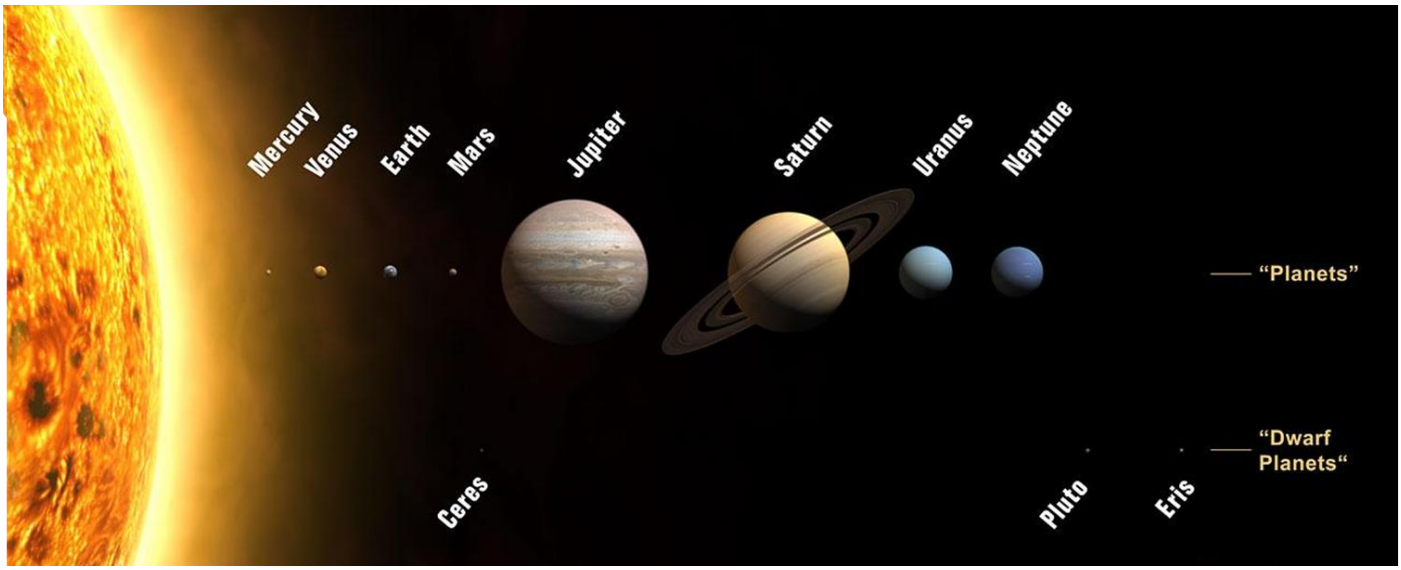
Matariki

Matariki is the Māori name for a cluster of stars – a seven-star constellation that appears in late May or early June each year. Each winter the stars of Matariki and Puanga signal the end of one year in Aotearoa and the beginning of the next.

The rise of Matariki is a time to celebrate and prepare for the Māori New Year. It was a time when crops were harvested, and seafood and birds were collected – a time of celebration and food, but also a time for preparing and storing for times of shortage ahead. Matariki was a time to practise manaakitanga – to share kai and present offerings to others.

The Features of our Solar System

The solar system is made up of the Sun, the nine planets that orbit the Sun and various natural satellites, asteroids, comets and meteors.



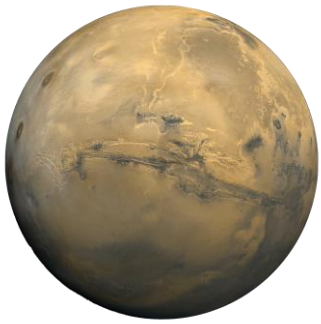
The Terrestrial Planets

Terrestrial planets are those planets (and possibly dwarf planets) that are similar to Earth — with bodies largely composed of rock: Mercury, Venus, Earth and Mars. Venus is the Planet which is the closest size to Earth but because of it's thick poisonous atmosphere creating extremely hot surface temperatures, Mars is the closest in environment.

The Gas Giants

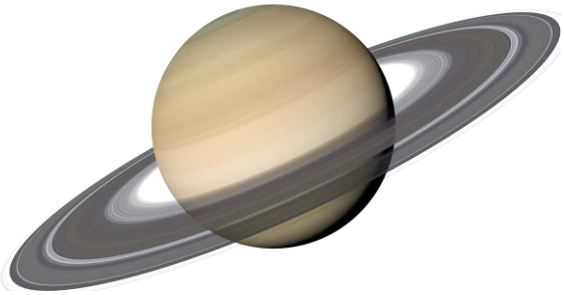
The gas Giants are Planets with a composition largely made up of gaseous material and are significantly more massive than terrestrials: Jupiter, Saturn, Uranus, Neptune. Ice giants are a sub-class of gas giants, distinguished from gas giants by their lack of hydrogen and helium, and a significant composition of rock and ice: Uranus and Neptune.

The Planets of the Solar System (not shown to scale)

Mercury Radius (Earth 1:0.38) Distance from Sun AU (Earth 1:0.39) Spin (day) 58.7 days Orbit (year) 87.9 days Cloud top temperature -180°C to 430°C Moons 0 Gravity (Earth 1:0.38) Because its surface consists of rough, porous, dark-coloured rock, Mercury is a poor reflector of sunlight. Mercury has only an extremely thin atmosphere, containing sodium and potassium, apparently spreading from the crust of the planet. In 1991 powerful radio telescopes on Earth revealed signs of vast sheets of ice in Mercury's polar regions 	Venus Radius (Earth 1:0.95) Distance from Sun AU (Earth 1:0.72) Spin (day) 243 days - Retrograde Orbit (year) 224.7 days Average Surface temperature 460°C Moons 0 Gravity (Earth 1:0.98) The surface pressure is 96 times that on the Earth —more dense than water; the atmosphere of the planet consists almost wholly of carbon dioxide (CO_2). The cloud base is at 50 km and the cloud particles are mostly concentrated sulfuric acid. Venus rotates very slowly on its axis, and the direction is retrograde (opposite to that of the Earth). 
Earth Radius 6,378km Distance from Sun (AU=1)149,600,00km Spin (day) 23.93 hours Orbit (year) 365.26 days Average Surface temperature 15°C Moons 1 Gravity 9.8ms^{-2} The Earth and its satellite, the Moon, also move together in an elliptical (nearly circular) orbit about the Sun. The temperature of the Earth allows for water to exist in its three states and it is the only planet where life is found. 	Mars Radius (Earth 1:0.53) Distance from Sun AU (Earth 1:1.52) Spin (day) 24.6 hours Orbit (year) 686.9 days Average Surface temperature -87°C to 17°C Moons 2 Gravity (Earth 1:0.38) The reddish colour of the planet results from its heavily oxidized, or rusted, surface. Conspicuous bright caps, composed of frozen water and CO_2, mark the planet's polar regions. 

Jupiter
Radius (Earth 1:11.2)
Distance from Sun AU (Earth 1:5.2)
Spin (day) 9.9 hours
Orbit (year) 11.9 years
Cloud top temperature -125°C
Moons 16
Gravity (Earth 1:2.34)
Jupiter's composition is very similar to that of the original gas cloud from which the solar system formed—a composition that survives in today's Sun. The proportion of helium is about 24 per cent, close to the amount in the Sun. Proportions of heavier elements, such as carbon, nitrogen, and sulfur have been increased by billions of years of bombardment by meteoroids and comets.

Saturn
Radius (Earth 1:9.42)
Distance from Sun AU (Earth 1:9.54)
Spin (day) 10.6 hours
Orbit (year) 29.5 years
Cloud top temperature -140°C
Moons at least 18
Gravity (Earth 1:0.93)
The average density of Saturn is only one eighth that of the Earth, as the planet consists mainly of hydrogen. The enormous weight of Saturn's atmosphere causes the core to be compressed into a metallic state. The visible rings may be only 5 m thick. They are thought to consist of aggregates of rock, frozen gases, and water ice.



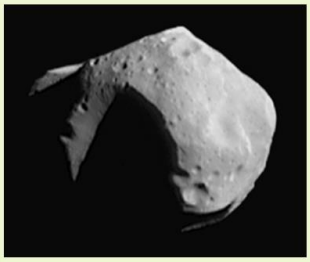
Uranus
Radius (Earth 1:4.01)
Distance from Sun AU (Earth 1:19.2)
Spin (day) 17.2 hours - retrograde
Orbit (year) 84 years
Cloud top temperature -200°C
Moons at least 27
Gravity (Earth 1:0.90)
Uranus's axis is "lying down" in relation to its orbit. The consequence is that each pole faces the Sun for 42 years (half the "year" of Uranus) and then is in darkness for 42 years. Uranus's atmosphere consists largely of hydrogen and helium, with a trace of methane. The two largest moons are Oberon and Titania.

Neptune
Radius (Earth 1:3.88)
Distance from Sun AU (Earth 1:30.1)
Spin (day) 16.1 days
Orbit (year) 164.8 years
Cloud top temperature -200°C
Moons 8
Gravity (Earth 1:1.13)
The temperature of the surface of Neptune is about -218° C much like Uranus, which is more than 1.5 billion km closer to the Sun. Scientists assume, therefore, that Neptune must have some internal heat source. The atmosphere consists mostly of hydrogen and helium, but the presence of up to three per cent methane gives the planet its striking blue colour.

Small Solar System bodies

Asteroid

The term asteroid is generally used to indicate a diverse group of small celestial bodies that drift in the solar system in orbit around the Sun.



Comet

A comet is a small body in the solar system that orbits the Sun and (at least occasionally) exhibits a coma (or atmosphere) and/or a tail.

Meteor

A **meteor** is the visible path of a meteoroid that enters the Earth's (or another body's) atmosphere, commonly called a **shooting star** or **falling star**.

Telescopes (space, optical and radio) have helped humans investigate space

Light

A light telescope is a light gathering device, which increases the brightness and size of planets and stars.

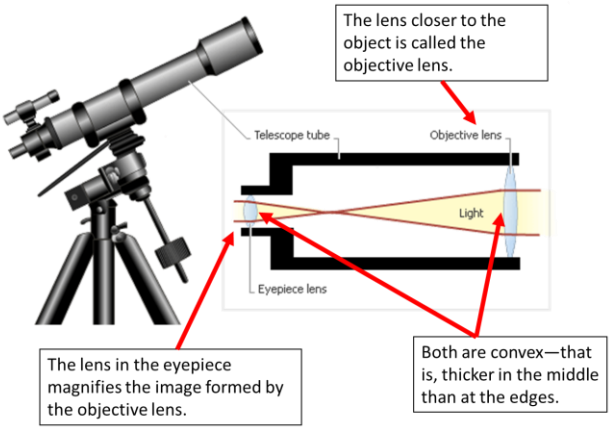
Radio

These telescopes are recognised by their large collecting dishes which detect and magnify radio waves from space.

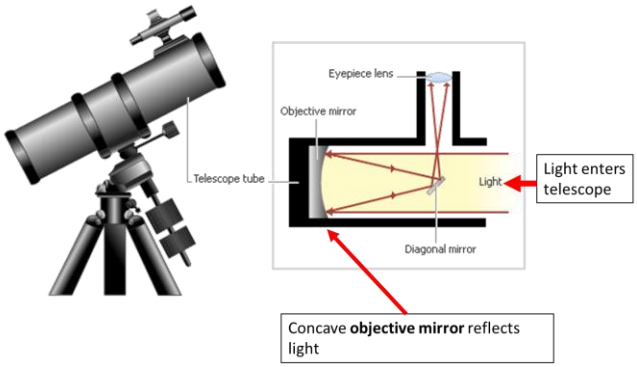
Space

These space telescopes detect infra-red and ultra-violet waves without interference from Earth's atmosphere.

Light refracting Telescope



Light reflecting telescope

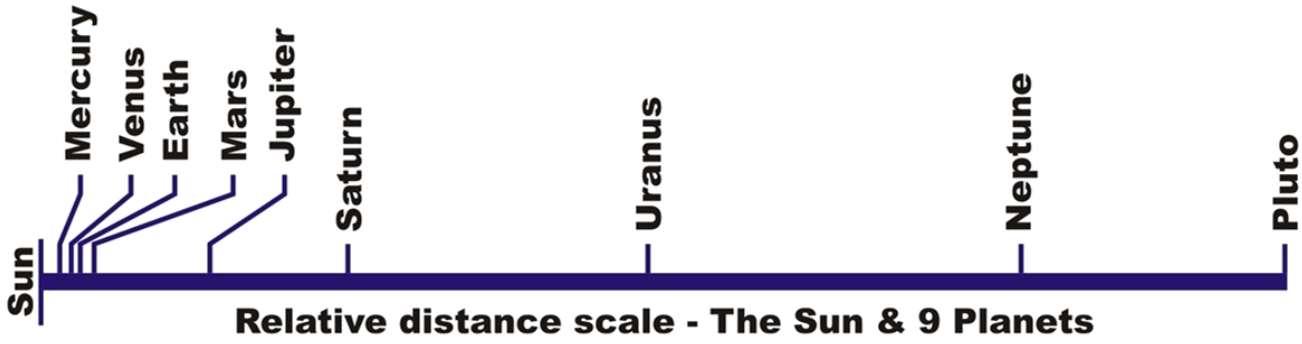


The large distances between the components of the solar system

Most of the solar system is empty space; distances are so huge it takes a long time to travel between planets. Travelling at the speed of a fast passenger jet, 1000km, it would take 16 days to reach the Moon – ~384,000km away. Astronauts reached the Moon in four days however, as they were travelling much faster. They needed to reach at least 40,000km to escape Earth's gravity (called the escape velocity).

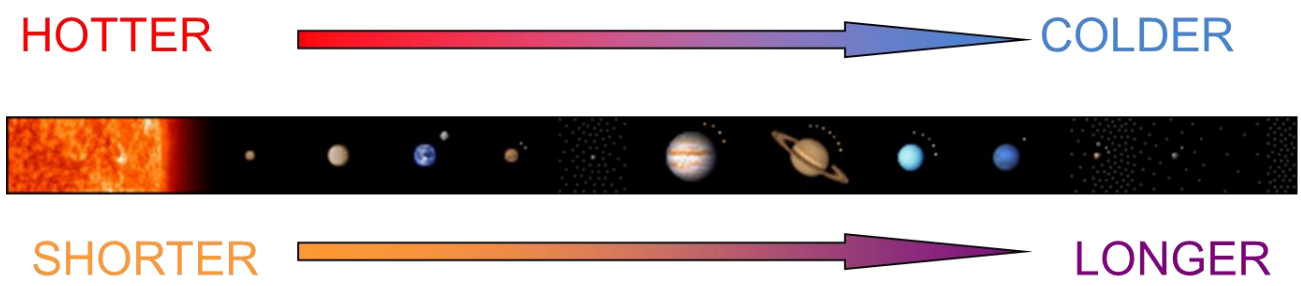
Travelling to Mars will take a lot longer, however. Mars is 203 time further away from Earth than the Moon is. Jupiter is 1635 times further away.

Compared to the large distance between the Earth and the Moon, the distances to the other planets and the Sun is much greater again. The first four planets are relatively close compared to the outer gas planets. Because of the vast distances in the solar system we use Astronomical Units. An astronomical unit is the average distance from the Earth to the Sun.



It gets cooler, the further from the Sun

Huge temperature differences exist in space. The further planets are from the Sun, the colder they are.



A planet's year depends on its distance from the Sun; the farther a planet is from the Sun, not only the longer the distance it must travel, but also the slower its speed, as it is less affected by the Sun's gravity.

Permanent bases on other Planets

To establish permanent bases on the Moon or Mars, systems will be needed to produce food, purify water and create oxygen from the carbon dioxide humans expel. Humans will also have to withstand the effects of radiation, very cold temperatures, isolation and different forces of gravity.