



A cluster of galaxies—each galaxy holding possibly millions of stars.



M51—the whirlpool galaxy.



The Pleiades - a small open cluster of stars visible to the naked eye, known as the “seven sisters” also referred to as the “jewel box” when viewed with a telescope.

## Space and the Solar System

### The Universe

The **Universe** is all of space. It contains many galaxies separated by vast expanses of empty space.

A **galaxy** is a large cluster of thousands, or millions of stars (e.g. our galaxy is the Milky Way).

A **star** is a large body of matter that is undergoing nuclear fusion and emitting light and heat. The Sun is a star.

A **planet** is a large body in orbit around a star.

A **moon** is a natural satellite of a planet. Earth has one moon.

### The Solar System

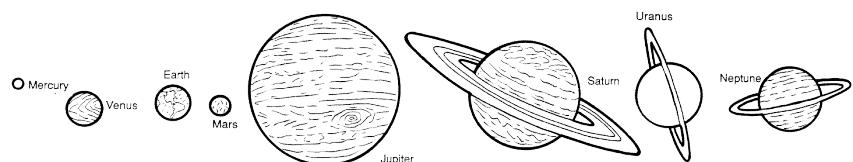
The sun and many other stars have a solar system. A **solar system** consists of a central star and all the objects held to the star by gravity.

Our solar system has 8 planets;

**Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune.**

Pluto was once classed as a planet, but astronomers now consider it to be a dwarf planet.

If you want to remember the order of the planets from the Sun the following memory aid may prove useful



***My Very Educated Mother Just Said Uh-oh No Pluto***

### Distance in Space

The distances involved in space are huge: the distance is so large that we measure it in light years. A light year is the distance that light travels in a year.

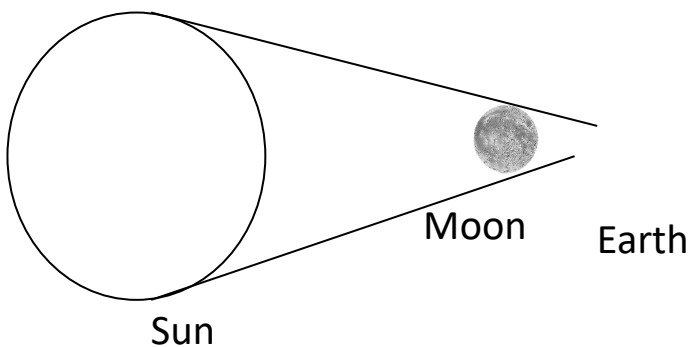
A light year is the speed of light in metres per second multiplied by the number of seconds in a year.

$$1 \text{ light year} = 300\,000\,000 \times 365.25 \times 24 \times 60 \times 60 \\ = 9\,460\,000\,000\,000\,000 \text{ m}$$

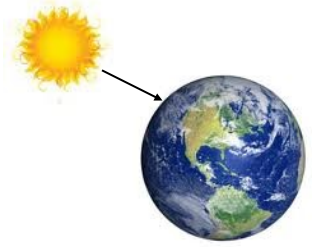
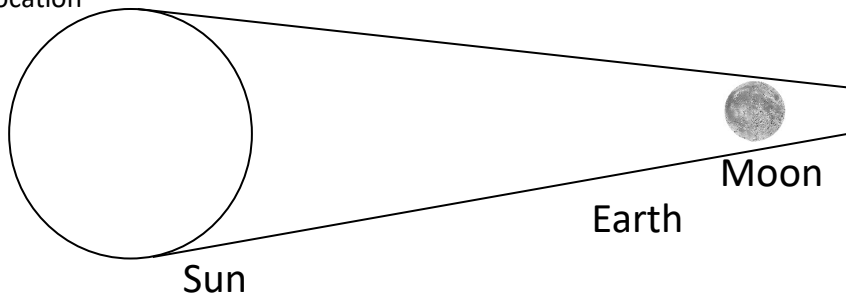
Distance	Time for light to travel
Earth to the moon	1 second
Earth to the Sun	8 minutes
Earth to the nearest star (after the sun)	4.5 years
Earth to the other side of the galaxy	100 000 years
Earth to the Andromeda Spiral	2 000 000 years

### Eclipses

A **solar eclipse** occurs when the Moon passes between the Sun and the Earth, and the Moon fully or partially covers the Sun as viewed from some location on Earth.



**Lunar eclipses** occur when the Moon passes through the Earth's shadow. This can only occur when there is a full moon. Unlike a solar eclipse, an eclipse of the Moon can be observed from nearly an entire hemisphere. For this reason it is much more common to observe a lunar eclipse from a given location



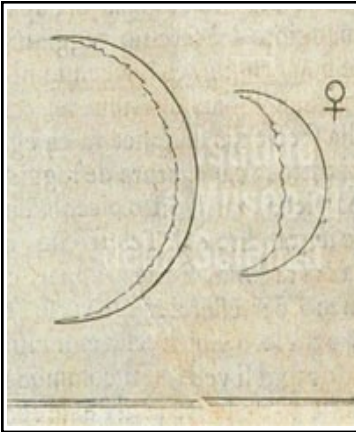
Light takes about 8 minutes to reach us from the sun.



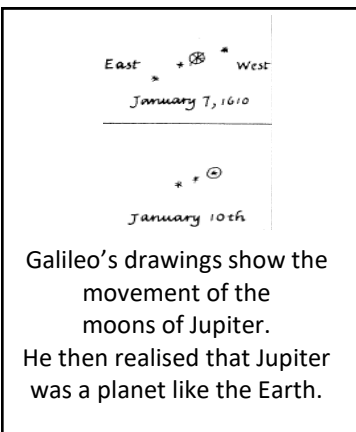
A total solar eclipse.



The moon moves through the Earth's shadow in a Lunar eclipse.



Galileo used a telescope to view the planets. His drawings of Venus show that it has phases, like the moon.



Galileo's drawings show the movement of the moons of Jupiter. He then realised that Jupiter was a planet like the Earth.

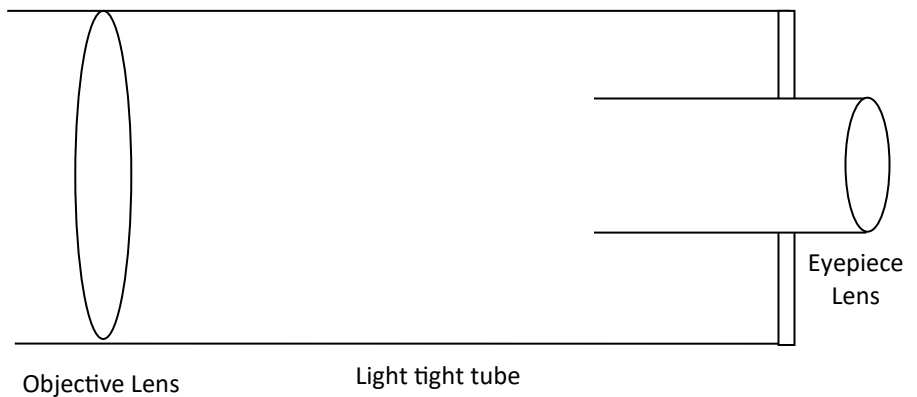


## Signals From Space

### The Telescope

Telescopes are used by astronomers to magnify distant objects. They make the image bigger and brighter. This allows the astronomer to see fine detail and faint objects.

Astronomical telescopes will have a basic construction: They have a large objective lens and a small eyepiece lens. These are fitted at opposite ends of a 'light tight' tube. The eyepiece lens is usually mounted in sliding draw tube. Adjusting the draw tube will focus the telescope.



Part	What it does	How does it achieve this
Objective Lens	Collects the light from the object and forms an image inside the tube.	The large diameter lens collects more light. Generally the larger the lens the better the telescope.
Eyepiece Lens	Magnifies the image formed by the objective lens	The eyepiece acts like a small, powerful, magnifying glass.
Light Tight Tube	Holds the lenses in place and blocks out other light sources	Usually tight fitting and painted matt black inside—to absorb stray light.



**Caution: NEVER look directly at the Sun with a telescope or binoculars! They collect lots of LIGHT and HEAT, which is focussed at the back of the eye.**

### Radio Telescopes

Light is a small part of a group of waves. These waves are invisible, but can carry information that the astronomer can use. Many other frequencies are blocked by our atmosphere, but radio waves pass through the atmosphere easily. Radio telescopes are used to view space at other frequencies that are invisible to our eye. These don't look like optical telescopes at all.



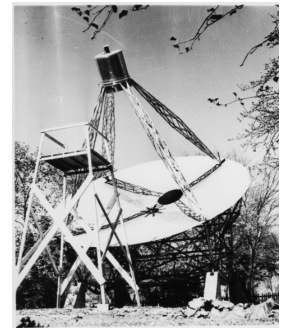
The Urumqi radio telescope in Western China

Radio telescopes can see information that is invisible to the naked eye.

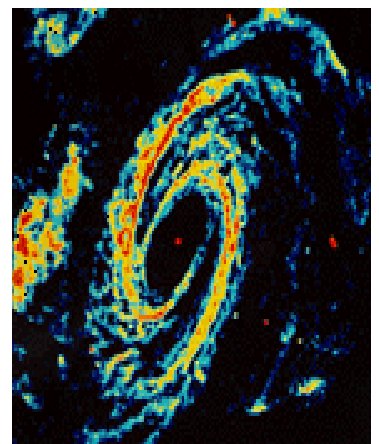


This composite image of the Whirlpool Galaxy, M 51, shows that the radio emission from the galaxy's cold hydrogen gas extends well beyond the optical light emitted by its stars

(Credit: NRAO/AUI, J. Uson).



Reber's first "dish" radio telescope - Wheaton, IL 1937





## Space Travel

When we walk, ride a bicycle, or drive a car, we are able to start, stop, and change direction by pushing against the road. When space craft are in space there is nothing to push against.

There is no friction in space, and no air resistance, so Newton's laws are very apparent in the motion.

**Newton's 1st Law:** *A body will remain at rest, or move at constant speed, in a straight line, unless acted on by an unbalanced force.*

In other words, moving space crafts just keep moving! They would move forever, in a straight line, if the rocket engines were not fired and they were not pulled away by planets, or stars.



With the rocket engine firing the ship accelerates.

**Newton's 2nd Law:** *If a body is acted on by an unbalanced force. It will accelerate, in the direction of the force, with an acceleration proportional to the force and inversely proportional to the mass.*

When the rocket engine is turned off, the rocket moves at constant speed in a straight line, unless pulled off this 'line' by gravity.



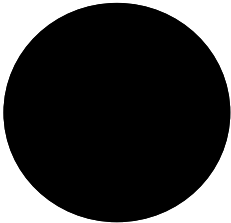
**Newton's 3rd Law:** *Every "action force" has an equal, but opposite, "reaction force."*

**Rocket motion:** The rocket pushes the burning gas backward and this produces a forward force on the rocket.



The rocket pushes the exhaust gases backwards.

The exhaust gases push the rocket forwards.



Did you know ?

A "black hole" of diameter 1.8 cm would have a mass about the same as the Earth.



Did you know?

Black holes may form worm-holes that tunnel through shortcuts to other parts of the Universe or even other Universes.

### Gravity

Mass is the amount of matter or substance an object has. It is measured in kilograms, kg.

Weight is a force. It is the pull of gravity on an object.

All masses pull on each other ! The planets and moons are so big that they can have very noticeable pulls. The gravitational field strength (g) of a planet is a measure of the force of gravity on 1 kg.

On Earth this is nearly 10 N/kg. On the moon gravity is only 1.6 N/kg, so you would feel much lighter on the moon. Even though your mass is the same.

Planet	g (N/kg)
Mercury	3.7
Venus	8.8
Earth	9.8
Mars	3.7
Jupiter	25.9
Saturn	11.4
Uranus	10.9
Neptune	11.9

### Gravitational Acceleration

Galileo demonstrated that heavy objects and light objects all accelerate at the same rate under gravity when dropped. This is true for all objects, except objects like feathers, paper sheets and parachutes, where air resistance is significant. Air resistance slows some objects down.

On the moon there is no air, so a feather will drop like a stone or a hammer! This was demonstrated by an Apollo 15 astronaut when he dropped a feather and a hammer together.

*See the picture to the  
Right of Commander David Scott.*



Astronaut in free fall (orbit) around the earth.



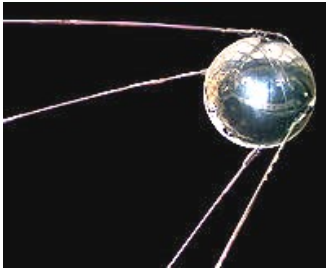
Edwin "Buzz" Aldrin on the moon. Even with almost a 150kg suit he is still lighter than his own weight on Earth.



Commander David Scott  
(Apollo 15, 1971)

October 4, 1957.

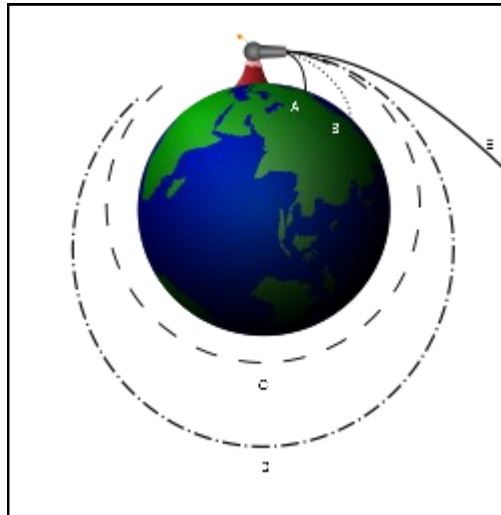
The Russians launch the first man made Earth satellite  
– Sputnik 1



## Satellites

Sir Isaac Newton explained that a satellite could orbit the Earth, even though it was always falling towards it.

He imagined a large gun firing a cannonball from the top of a large mountain. If the ball was fired at a high enough speed it would fall down, yet never hit the ground, as the Earth's surface would curve away.



### Newton's Cannon

If it is fired fast enough, a cannonball can orbit the whole world, never hitting the ground, yet always falling.

Watch out, you could hit yourself in the back of the head!

## Free Fall

Astronauts orbiting the Earth appear to be weightless ! They actually are falling towards the Earth. Remember Newton's first law ? If they were truly weightless, they would be travelling in a straight line. However they are falling at the same rate as the space ship, and everything in the ship. They appear to float around the space ship.



April 12, 1961.

Yuri Gagarin, the first man in space, spent 1h 48mins aboard Vostok 1.



Ed White's "space walk" in 1965 was more like a space float.

### Take off....

The rocket engines burn enormous amounts of fuel to provide the energy to get the space craft into space.

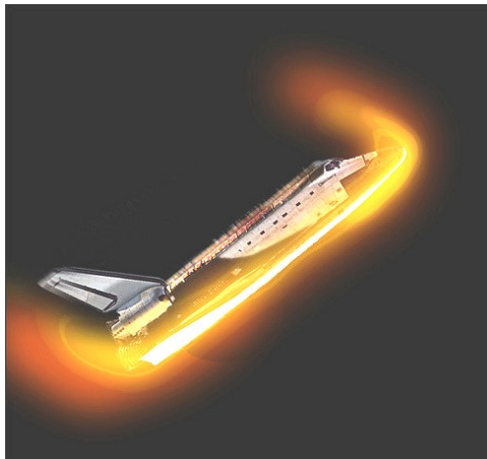


### ...and return.

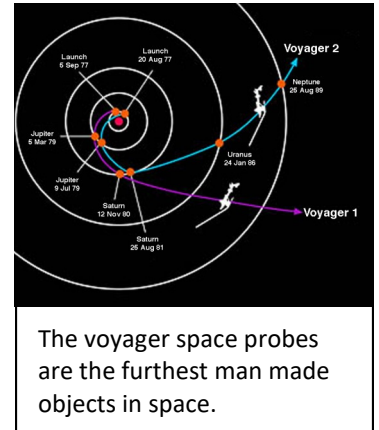
The energy from the fuel burned during *take-off* was converted into potential and kinetic energy (the ship is at a great height and is travelling very fast). This energy must be lost if the ship is to return safely to the ground. Energy cannot be destroyed, so it must be converted. The only option is to change it to heat due to friction (this is what the brakes on your bike do to remove your kinetic energy so that you can stop safely).

### Re-entry

*Friction from the air converts kinetic energy into heat. The underside of the shuttle is covered with ceramic tiles and painted with black evaporating paint.*



*The black paint radiates heat. It also removes heat as it evaporates and the tiles insulate the astronauts from the worst effects of the heat. Even still, it can become very uncomfortable in the cabin.*



The voyager space probes are the furthest man made objects in space.



Did you know that dogs beat us in the space race? First to space was Laika, in 1957. She was sent up by the Russians, but died in orbit.



Would you like to go into space ? Richard Branson has plans to launch Space tourist trips. Early trials are underway.



The Viking Space Probe took this photo of the Martian surface. Is that really a face, or a trick of the light?

## Life on other planets (Are we alone?)

Since Galileo demonstrated that Jupiter was a planet, people have speculated that there may be life on 'other worlds.'

Many people believe that some unidentified flying objects (UFOs) are actual aliens from another planet. Some people believe that the world government actively cover up UFO and alien encounters. Some people claim to have met, or even been abducted by, aliens. There is also evidence of hoaxes by people, and, of course, the possibility that people are mistaken.

## Is it likely that there is life on other planets?

### Facts supporting the possibility of life on other planets.

The universe is truly enormous. There will very likely be countless other planets with water and a warm temperature, sunlight etc. Such 'Goldilocks Planets' would be *just right* for life to flourish.

We are here, so life is a possibility elsewhere.

### Facts counting against the possibility of life on other planets.

The vast majority of planets would be hostile to life (as far as we can imagine).

We have found no evidence of any life on other planets in our solar system, beside our own.

There is no proof that life would spontaneously emerge on a 'goldilocks planet' just because it is perfect. Most scientists believe that life emerged from a "primordial soup" of proteins, but the origin of the first living cells on Earth remains a mystery.

Since Marconi's first radio broadcast, in 1896, we have been sending radio & T.V. waves into space. Earth could be described as a "noisy" planet! SETI (Search for Extra Terrestrial Intelligence) Scientists are listening for other noisy planets and star systems and have been for years. So far they have found none.

## Interplanetary and Interstellar Flight

Earth astronauts have only travelled as far as the moon. Nobody has travelled to another planet. We have sent probes to all the planets in our solar system and there is regular talk of sending people to Mars. The furthest man made objects travelling in space are the voyager probes, launched in 1977. It will be 60 000 years before they pass another star. By this time their nuclear fuel cells will have run out.

This enormous distance is surely a major obstacle to human interstellar space travel ?

## **Origins & Endings**

### **The beginning...**

In 1929 Edward Hubble observed that almost all the other galaxies seemed to be flying apart. He took this as evidence that the Universe is expanding.

This observation seems to confirm the proposition by Georges Lemaître (a Catholic priest and mathematician) that the Universe began in a “Big Bang” event.

The Universe seems to be expanding from a single point. Scientists do not have any firm evidence for any event that caused the ‘Big Bang.’ Many who believe in God see the Big Bang as the point of creation. Some scientists suggest that the universe may be one of many universes constantly being created in a great ‘Multiverse.’

### **...and the end.**

*...of our Solar System.*

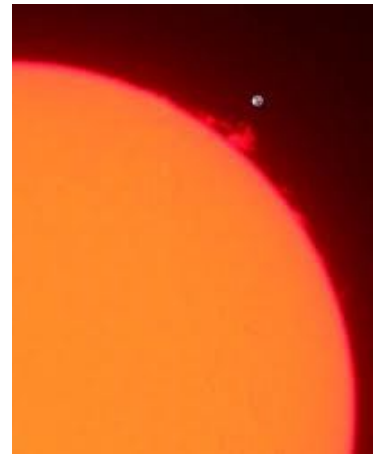
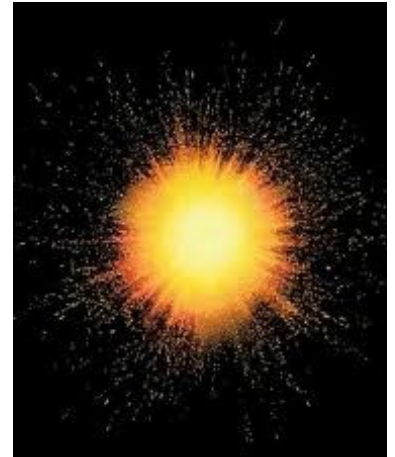
The current scientific theories suggest that the Sun will eventually expand into a “red giant.” It will expand, fill the sky, and eventually swallow our planet as it expands out past us. It will then blow off most of the outer gases and burn out as a “white dwarf.” (Don’t worry, this is millions of years away!)

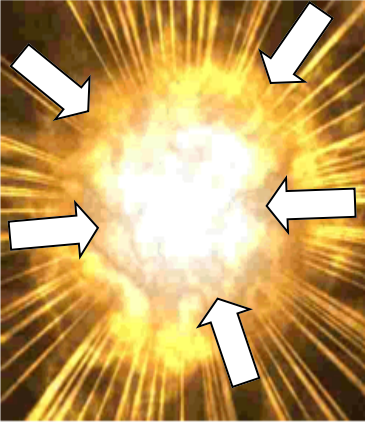
*...and of our Universe.*

Scientists are not sure exactly what will happen to our universe but there are three main theories;

*The Big Freeze (or Heat Death);*

If there is not enough mass in the universe then the current expansion might continue forever. The stars and galaxies will drift further and further apart. One by one stars will burn out or explode. Eventually all stars will burn out and the heat and light will spread out over an ever expanding space. With no stars all of space will become colder & colder....





### *The Big Crunch;*

If there is enough mass in the universe then gravity may stop the expansion and reverse it. (Just like gravity stops a rising stone and pulls it back down). In this case all the stars, planets and all of space will collapse inward and end in a great implosion. All of matter in space will be crushed to a point again in a kind of Big Bang reversal.



### *The Great Rip;*

More recent observations have suggested that the universe is not only expanding, but is also accelerating as it expands. Moving further and faster apart. Scientists were surprised by this and are not clear why this is happening. If it continues the Universe may expand so fast that it literally rips itself apart!!