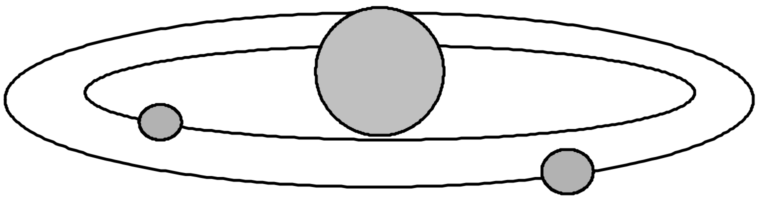
North Chadderton School

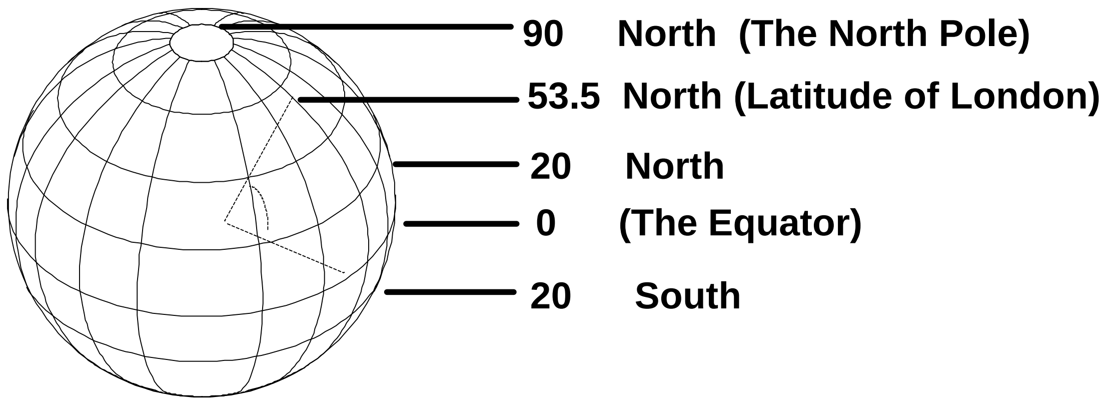
# Introduction to Astronomy and Space Science



A self-study booklet

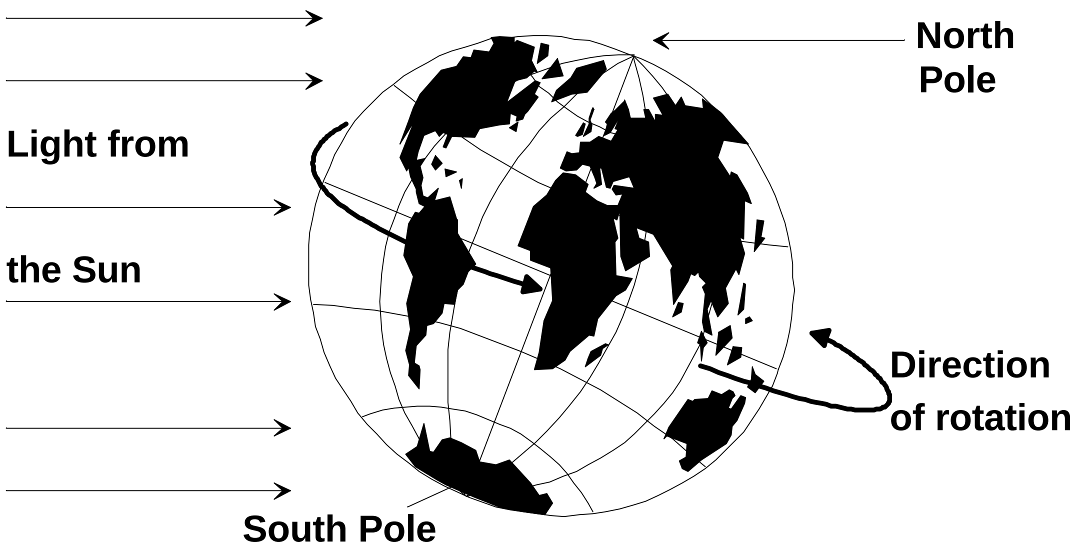
Introduction

In this section we will need to use the word **latitude.**
Latitude of a place, such as London, is how far it is North or South of the Equator. It is measured as an angle, in degrees.




**1. Day and Night**

The Earth spins on its axis. This rotation takes 24 hours.
During this time most places on Earth spend some time facing the Sun (day), and some time facing away from the Sun (night)



The tilt of the Earth's axis is the reason why  places at different latitudes have different lengths of day and night.

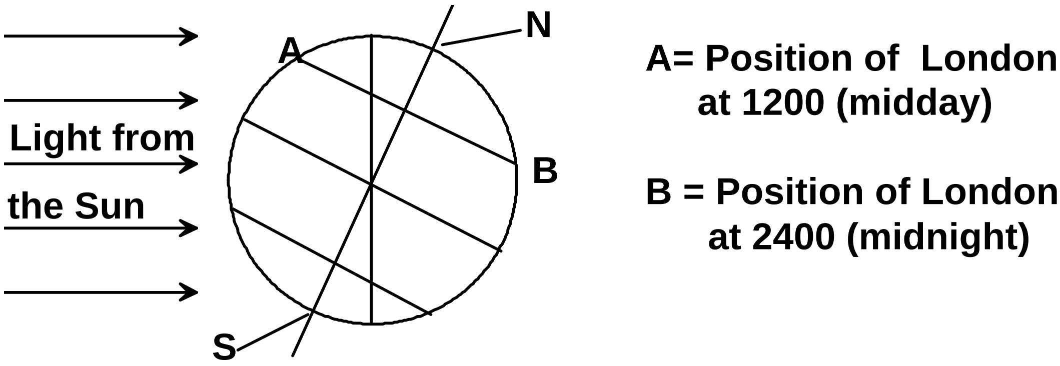



Fig.2

At the time of the year shown in Fig. 2 :

A town in the northern hemisphere will have a longer night than day. This is because Earth is tilting the town **away** from the Sun .
A town in the southern hemisphere will have a longer day than night.
This is because Earth is tilting the town **towards** the Sun .

At the North pole there is 24 hours of night . At the South pole there is 24 hours of daylight.

Fig. 3 shows the position of Earth six months later.It is now moved to the opposite side of the Sun. Places in the northern hemisphere will now have long days and short nights . Places in the southern hemisphere will have short days and long nights.       (Students to shade in the night region !)

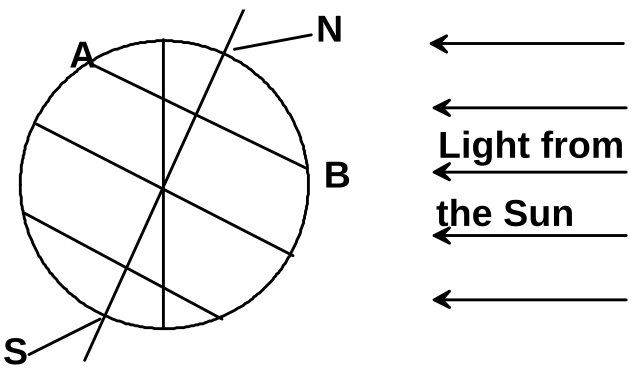


Fig. 3

Table 1 shows the rotation time (one complete spin) and the angle of the spin axis from the vertical for different planets in the Solar system.

| **Planet** | **Time for 1 rotation** | | | **Angle (°)** |
|---|---|---|---|---|
| | **days** | **hours** | **minutes** | |
| Mercury | 58.000 | 15.000 | 31.000 | 0.000 |
| Venus | 243.000 | 0.000 | 14.000 | 177.000 |
| Earth | | 23.000 | 56.000 | 24.000 |
| Mars | 1.000 | 0.000 | 37.000 | 25.000 |
| Jupiter | 0.000 | 9.000 | 56.000 | 3.000 |
| Saturn | | 10.000 | 39.000 | 27.000 |
| Uranus | | 15.000 | 36.000 | 98.000 |
| Neptune | | 18.000 | 26.000 | 30.000 |
| Pluto | 6.000 | 9.000 | 17.000 | 118.000 |

days = Earth days
For most GCSE work we round up an Earth day to 24 hours.

Venus,Uranus,Pluto have spins in the opposite direction to Earth,this is called retrograde motion

Source: Collins Dictionary of Astronomy (1994)

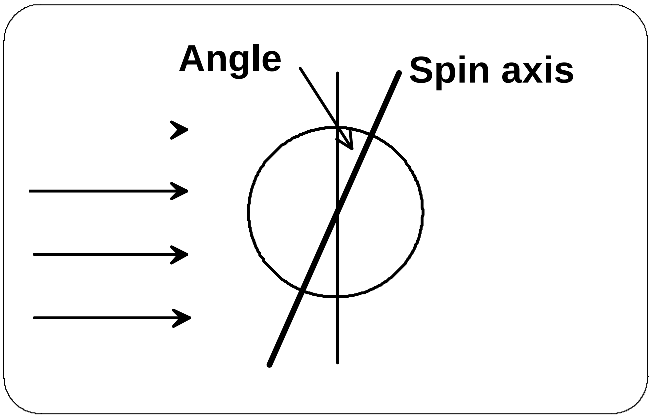
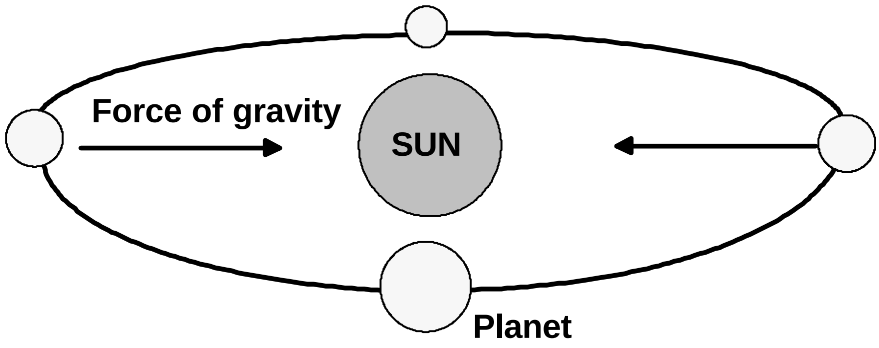



Table 1

## 2. The motion of the planets

Each planet moves around the Sun.We say that a planet **orbits** the Sun. This is because a force of gravity acts on the planet.The force of gravity is always an **attractive** force The force of gravity on the planet acts in a direction **towards** the centre of gravity of the Sun.

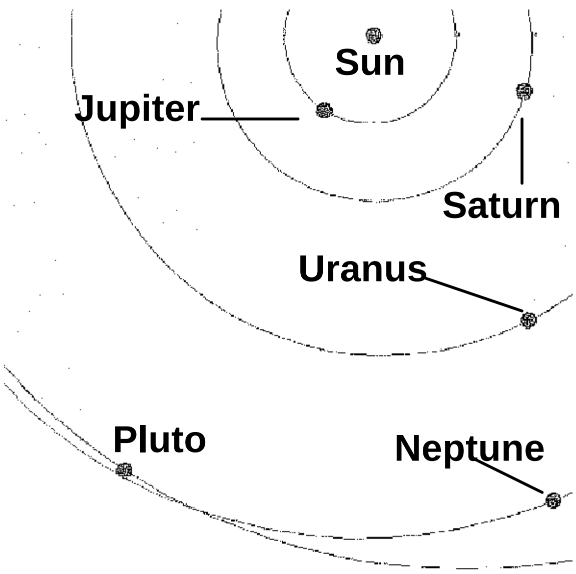



**Motion of a planet around the Sun.**

**Planetary motion is elliptical.**

**This means that distance from the Sun is not constant.**

**Drawn on a small scale the orbits of most planets appear as circles**




This shows the outer planets of the solar system.

Pluto crossed inside the orbit of Neptune in 1980,and will remain inside Neptune's orbit until 1999.

Fig.4

Newton's Third Law states

**" If a body A exerts a force on body B,then body B exerts an equal and opposite force on body A"**

This means that if the Sun is exerting a force on Earth,then Earth must be exerting a force on the Sun.The two forces are equal in size,but opposite in direction.

The time taken for one complete orbit of a planet around the Sun is called a **YEAR**.

Different planets have different times for one orbit (different years), This is shown in Table 2.

| | **Distance from the Sun** (million km) | | | **Mass of Planet** compared with Earth (=1) | **Orbit Time** (length of Year) |
|---|---|---|---|---|---|
| | **Maximum** | **Minimum** | **Average** | | |
| **Mercury** | 69.700 | 45.900 | 57.800 | 0.060 | 87.97d |
| **Venus** | 109.000 | 107.400 | 108.200 | 0.820 | 224.7d |
| **Earth** | 152.100 | 147.100 | 149.600 | 1.000 | 365.26d |
| **Mars** | 249.100 | 206.700 | 227.900 | 0.110 | 1.88y |
| **Jupiter** | 815.700 | 740.900 | 778.300 | 317.830 | 11.86y |
| **Saturn** | 1507.000 | 1347.000 | 1427.000 | 95.160 | 29.46y |
| **Uranus** | 3004.000 | 2735.000 | 2869.500 | 14.500 | 84.01y |
| **Neptune** | 4537.000 | 4456.000 | 4496.600 | 17.200 | 164.79y |
| **Pluto** | 7375.000 | 4425.000 | 5900.000 | 0.003 | 248.54y |

Notes : Mass of Earth = 5.97 x $10^{24}$ kg
d = Earth day y =Earth year

Table 2

Table 2  shows the further the planet is from the Sun the greater the time for one year of a planet. The order of the planets, from the Sun  can be remembered in the following way *:*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **M**y | **V**ery | **E**asy | **M**ethod | **J**ust | **S**peeds | **U**p | **N**aming | **P**lanets |
| **M**ercury | **V**enus | **E**arth | **M**ars | **J**upiter | **S**aturn | **U**ranus | **N**eptune | **P**luto |

## 3. The Seasons

Earth has <u>seasons</u> because of the **tilt** of the Earth's axis.

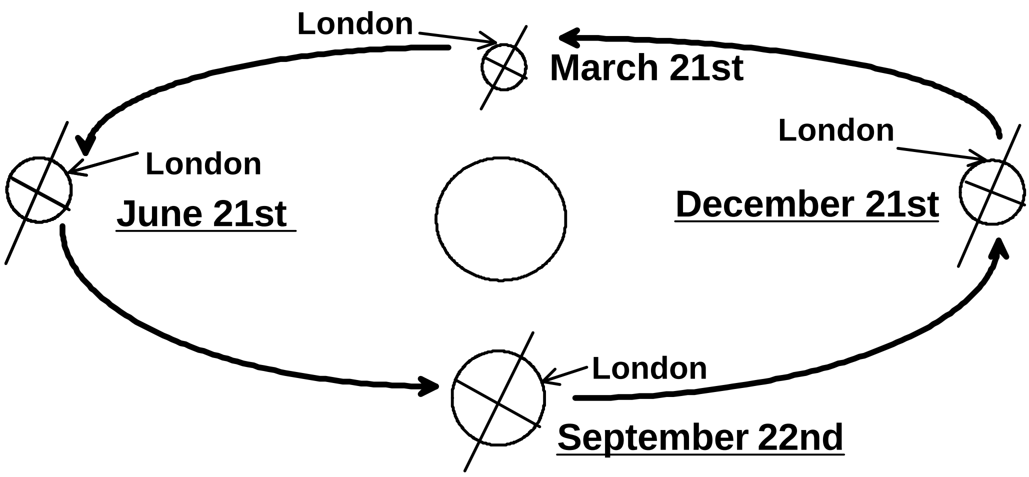
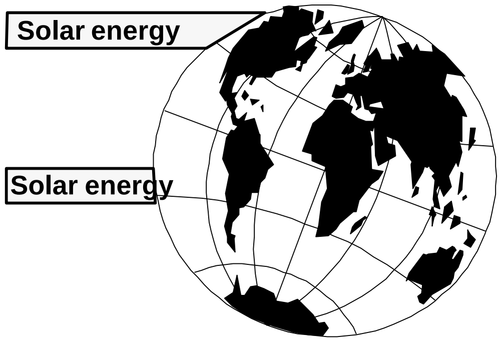



Fig . 5

The  <u>half</u> of  the Earth which has the tilt  towards the Sun will receive a greater concentration of Sun's energy on each square metre , and so it will be hotter (Summer) .This is shown  in Fig. 6.

Fig.6




***December 21st***

Notice that on December 21st the energy beam from the Sun is spread out over a much greater <u>area</u> in the northern hemisphere,so it will be winter.The southern hemisphere will have summer, because of the greater concentration of solar energy on each square metre of Earth.

## 4. Mass ,Force and Weight

(a) Mass

* An object taken anywhere in the Universe will not change its mass.
* Mass is measured in **kg.**

(b) Weight

Weight is the *force of gravity* acting on an object.
Weight is measured in newtons (N)

The **weight** of an object will depend on the **gravitational force acting on 1kg**. This is given the symbol g , called the *gravitational field strength.*

On Earth there is 10N of gravitational force acting on each kg.

**Weight = m x g**

where **m** = mass of the body (in kg)
**g** = gravitational field strength (N/kg)

**Eric in Space**

**Mass** of Eric = 80 kg
Nothing to attract him so g = 0
**Weight** = m x g =80 x 0 =0 N

**Eric on an Asteroid**

**Mass** of Eric = 80 kg
g=Force of gravity on 1kg , = 0.1 N
**Weight** = m x g = 80 x 0.1 = 8 N

When an object is dropped from a height above a planet's surface, the **force of gravity** (weight) causes the object to <u>accelerate</u> towards the planet.

In the absence of air friction the velocity of an object dropped above the surface of Earth would increase by 10m/s every second of the fall.The acceleration due to gravity does vary with latitude, but we normally take the value of the acceleration due to gravity (g) as 10 $m/s^2$ for most calculations.

Fig. 7 shows that different planets have different gravitational forces on a body of the same mass.

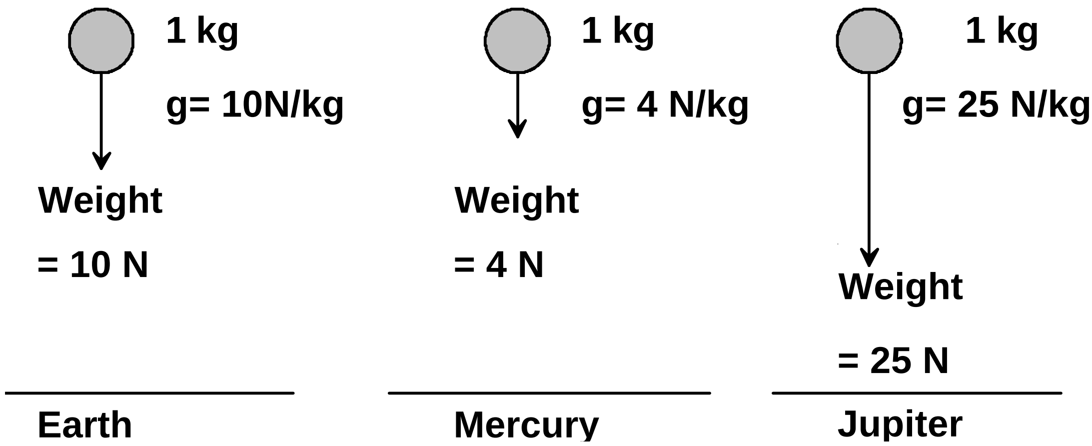


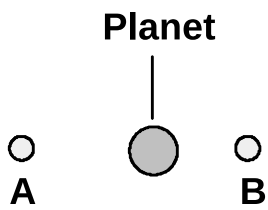

Fig. 7

**<u>5. Planets and Moons</u>**

Some planets have moons.Moons are natural satellites which **orbit** planets. The Earth's moon makes one complete orbit around the Earth every 28 days. The moon is attracted to the planet by the force of gravity,just like a planet is attracted to the Sun.The force of gravity keeps the moon in orbit around the planet. The size of the gravitational force depends on

(i) *<u>the mass of the planet and the moon,</u>*
(the greater the masses,the greater the force)

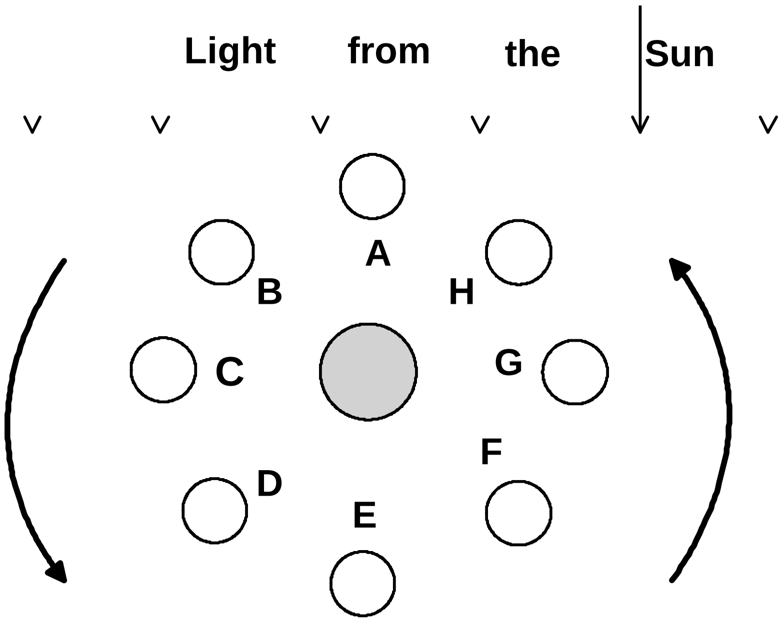
(ii) *<u>distance between a planet and a moon.</u>*
(The greater the distance,the smaller the force)



The moons in the diagram have the same mass, but the force of gravity on B will be greater,because it is closer to the planet.

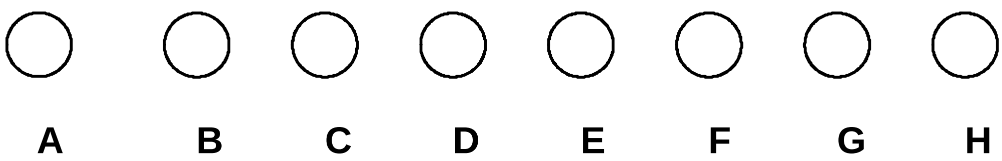
<u>Phases of the Earth's Moon</u>

Fig. 8  shows  8 positions of the Moon as it orbits  Earth.
This gives different views , or phases of the Moon, during 28 days.
(Students to complete the shading of the Moon ! )




**The moon takes 28 days for one orbit.**

**These are the views as seen by an observer on Earth:**




A= New Moon       C,G = half-moon      E= Full Moon

Fig.8

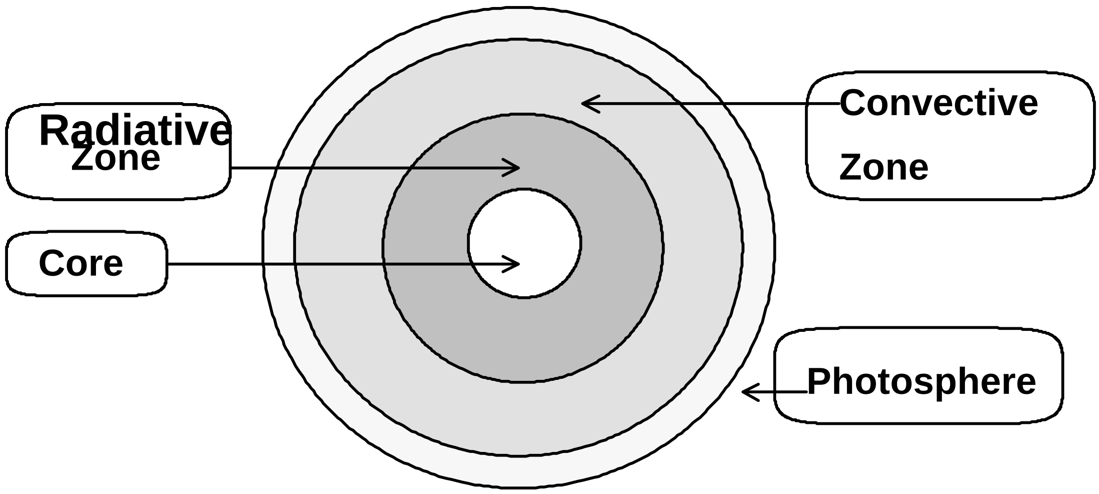
Remember that the Earth is also rotating on its own axis,so the Moon appears to move  quite quickly across the night sky. The moon orbits Earth ,the Earth spins, and they both  move  around the Sun.

## 6. Stars,Solar Systems,Galaxies,and the Universe

### (a) The Sun and Stars

* All stars release energy by a process called **nuclear fusion**.

Nuclear fusion involves the conversion of small atoms to larger ones.
This happens when *hydrogen* is converted into *helium* in great amounts,
This gives a massive release of energy. The Sun is the nearest star to Earth.
Fig.9  shows the structure of the Sun :




**The nuclear energy is produced in the core.**
**The temperature is about 15 million  C.**

**Energy  moves outwards from the radiative zone.**

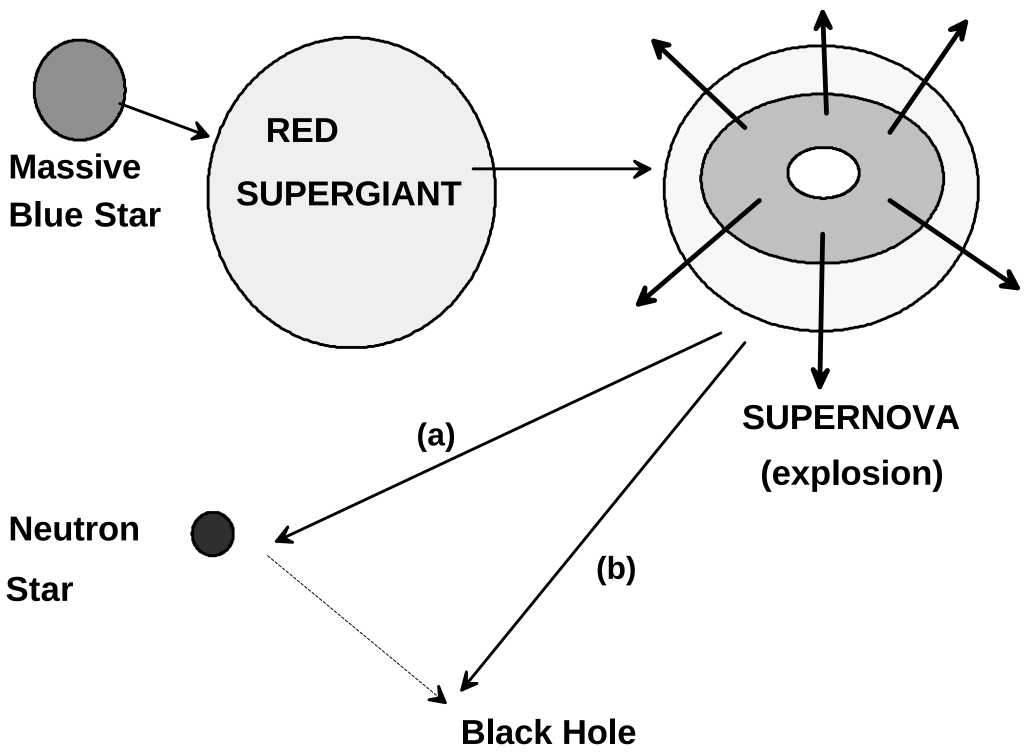
**Heat moves by convection currents in the convective zone**

**The photosphere is the outer surface of the Sun.**
**The temperature is about 6000  C**

Fig. 9

The life of a star begins when large clouds of gas and dust in the Universe collect together , by the attractive force force of gravity, to form **protostars**. The remaining stages in the life of a star depend very much on thre original mass of the protostar. There are two main types of stars .

Type I stars (Very large mass)

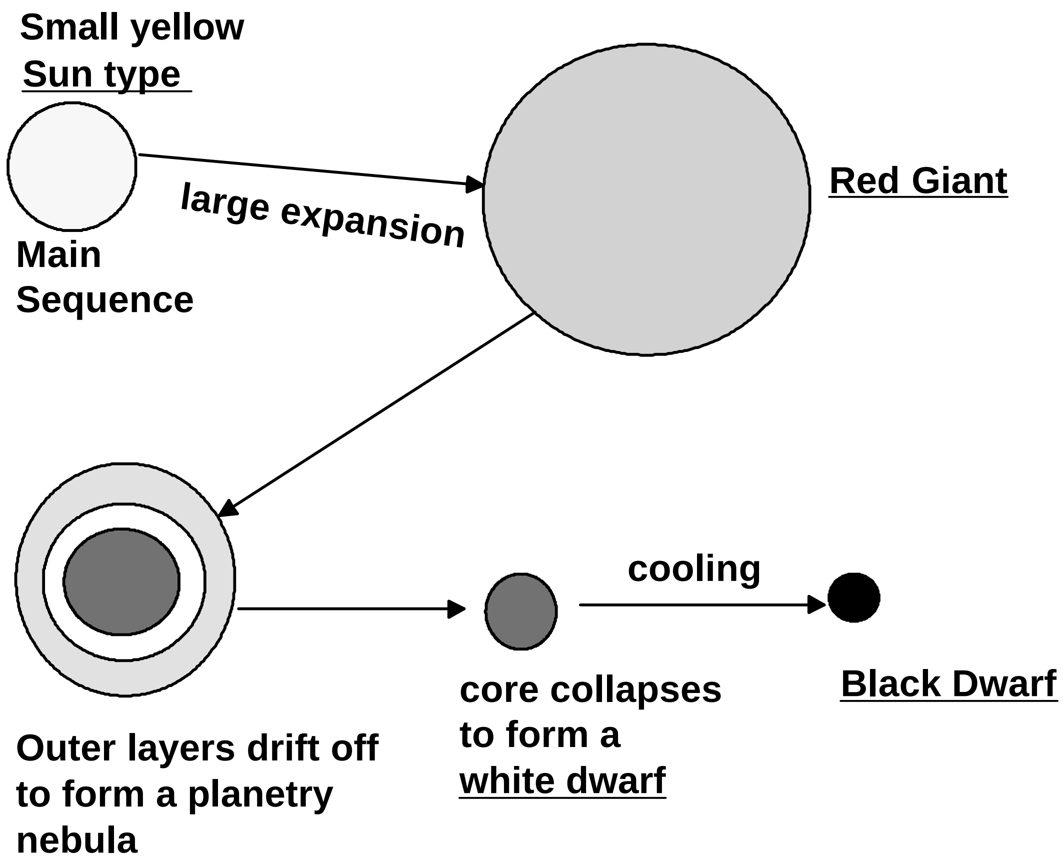



**(A) If the mass remaining is between 1.4 and 3 solar masses**

**(B) If the mass remaining is much greater than 3 solar masses**
**(a Solar mass is the mass of our star..the sun )**

**If the neutron star has a very large mass,and a very small volume,the inward gravitational force can become so great that it continues to collapse into a black hole. The black hole has a force of gravity so great that not even light can escape....so you can't see it ! the chances of finding a black hole is improved .if it is part of a binary system, with a close star as its companion.. The force of gravity of the black hole pulls gas from the nearby star.. this gas then forms a disc around the black hole,which spirals around the black hole...This action gives x-rays which we can detect using special instruments..There is some evidence that a black hole might be at the centre of our own galaxy (the Milky Way)**

Type II Stars  (Low mass ...Sun type stars.. up to 1.4 solar masses)



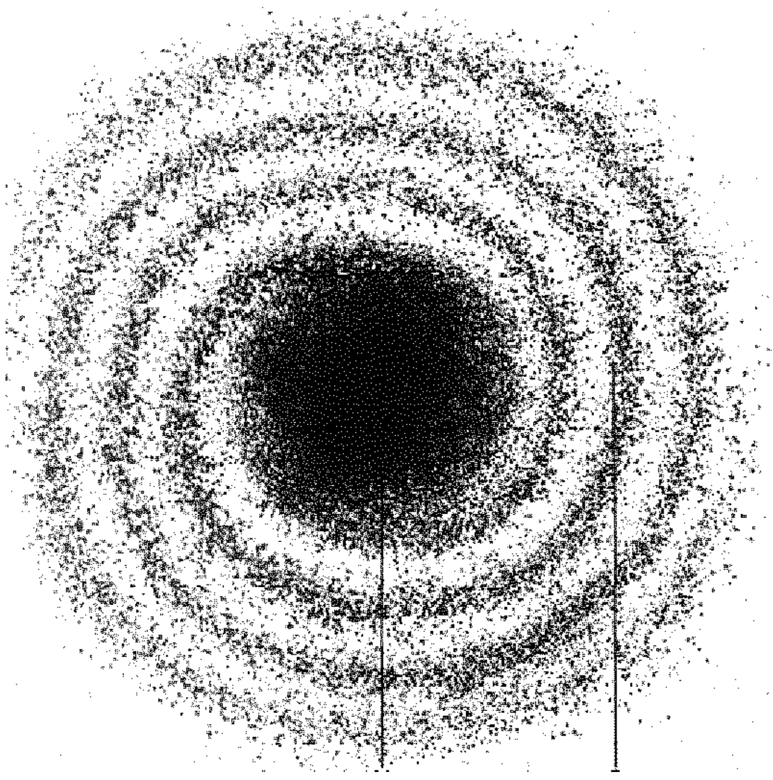

**A star of about one solar mass remains in the main sequence for about 10 million years.After all the hydrogen has been converted into helium the star swells to become a RED GIANT.When the helium in the core runs out,the outer layers drift away into space to become a planetary nebula,and the core collapses to form a WHITE DWARF Th star then cools to become a BLACK DWARF.**

(b) Solar Systems

A solar system consists of a star and one or more planets which orbit the star. Our solar system consists of a star (the Sun) and nine planets.
The order of the planets is given in Table 2. It is almost certain that there are other planets in the Universe. Stars are easy to find, because they give off their own light energy. The search for planets and other solar systems is proving to be very difficult, because planets do not give off their own light, and they are usually very much smaller than stars.

(c) Galaxies

Galaxies are very large collections of stars and solar systems.
Our solar system is part of a galaxy called the MILKY WAY, which contains about 1000,000 million stars, Fig.10 shows one view of our galaxy.



The galaxy rotates about the centre. It takes about 225 million years for our solar system to complete one orbit. It is impossible to see through the galaxy because of the gas and matter in the way, but we can use a picture taken using x-rays, because x -rays travel straight through this material.

Fig.11 shows the side view impression of the Milky Way (students to complete the shape of the galaxy ....)

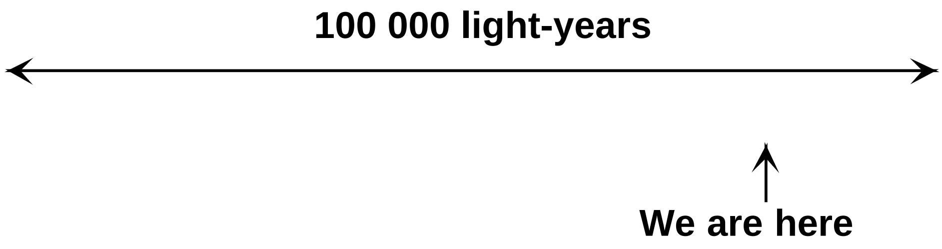



Fig. 11

The **Universe** is made up of many different types of galaxies, with very large distances between them. Fig. 12 shows a diagram of our local group of galaxies in the Universe. (Students to complete the shapes of the galaxies)

**Milky Way**

**Andromeda**

Fig.12

**Triangulum**

## 7. Conditions on the planets/Visiting other planets

Table 3 shows some information about conditions on the planets of our solar system.

| Planet | Force of Gravity (compared with Earth) | Average Surface temperature ($^0$C) | Number of Moons | Atmosphere |
|---|---|---|---|---|
| Mercury | 0.380 | -170 to 430 | 0.000 | none |
| Venus | 0.860 | 464.000 | 0.000 | thick,carbon dioxide,sulphuric acid |
| Earth | 1.000 | 15.000 | 1.000 | nitrogen and oxygen |
| Mars | 0.380 | -40.000 | 2.000 | thin,,carbon dioxide |
| Jupiter | 2.500 | -120.000 | 16+1 ring | hydrogen,helium, ammonia,methane |
| Saturn | 1.100 | -180.000 | 18+ 7rings | hydrogen,helium, ammonia,methane |
| Uranus | 1.100 | -210.000 | 15+ 11rings | hydrogen,helium, ammonia,methane |
| Neptune | 1.100 | -220.000 | 8+4 rings | hydrogen,helium, methane |
| Pluto | unknown | -220.000 | 1.000 | none: frozen |

Notes:

1. The force of gravity given is the value at the equator
2. The value of g Earth can be taken as 10 N/kg for GCSE work
3. Mercury rotates very slowly on its axis , taking almost 59 Earth days to complete one rotation.

Source : The Visual Dictionary of the Universe (Dorling Kindersley)

Table 3

Table 3 shows that there is a decrease in the average temperature with increasing distance from the Sun.This is because the Sun's energy spreads out over a greater areas, and is less concentrated. Venus does not fit into this pattern, because the large concentration of *carbon dioxide* gas gives a Greenhouse effect, which traps solar energy arriving at the planet.

Mercury, Venus, Earth, and Mars are called the **rocky dwarf** planets, because of their high densities.Mars has been of special interest to space travel. It is the planet which comes closest to Earth, it has the least hostile environment than other planets. If we wanted to live on Mars we would need to take our own oxygen supplies, and build special (pressurised) stations on the planet. Heating and cooling systems would be needed , to keep ourselves and plants alive. Mars could provide Earth with precious minerals/rock supplies.

Jupiter,Saturn,Uranus and Neptune are called the **gassy giants** because they have very low densities.

A knowledge of the force of gravity on a planet is important for future space explorations. It is needed to find the weight of rockets and space probes landing on the planets, and for engineers to calculate the fuel needed to land and take-off from planets. A space probe landing on a planet with a high gravitational field strength (g) would need very strong thruster rockets for take-off and landing. This would need more fuel, so the engineers would need to calculate how much they needed from a knowledge of g.

Gravitational pull from planets has helped space probes to reach distant planets in the solar system. Voyager I and Voyager II were able to reach the distant planets much more quickly by gaining kinetic energy as they travelled close to other planets on their journeys. They used the gravitational pull of the planets to increase their speed as they travelled past the planets. This is sometimes called the sling-shot effect.