Topic 3 - Earth and Universe

Vocabulary

Asteroid – solid rocky objects orbiting the sun that are large and irregularly shaped.

Big Bang theory – Universe started as a big explosion containing all matter 15 – 17 billion years ago.

Celestial object – objects outside of the Earth's atmosphere such as the moon, stars, sun, planets, etc …

Comet – a low density celestial object that orbits the sun made up of ices that vaporizes

Doppler Effect – the apparent change in wavelength as an object moves in relation to the observer.

Eccentricity – the degree of ovalness of an ellipse, either flat or round with a value between 0.000 to 1.000.

Ellipse – a closed circle around an object(s) called foci. Describes orbits of celestial objects with values between 0.000 to 1.000.

Focus – plural foci. The two points real and imaginary, in an orbit that a celestial object orbits orbit either a star or planet.

Galaxy – a large grouping of millions or more stars held together by gravitational attraction, such as our galaxy the Milky Way.

Jovian planet – the planets that are furthest from the sun; large, gaseous and low densities.

Luminosity – the measure brightness of a star compared to the sun.

Moon – the natural satellite that orbits the Earth.

Nuclear fusion – the smashing of atoms in a star that makes their light and energy.

Red shift – the movement of the wavelength to the red part of the spectrum, used to determine object moving away from Earth, used to determine object in universe are moving away from each other.

Revolution – an objects movement in an orbit around another larger object, such as the Earth – Moon orbit or the Earth – Sun orbit.

Rotation – the spinning on abject on its axis.

Solar system – a group of objects that orbit a star under the influence of gravity. Earth is part of the Solar System.

Star – a large ball of gas producing tremendous amounts of energy, the sun.

Terrestrial planet – rocky planets closest to the sun; small and high density. Earth is a terrestrial planet.

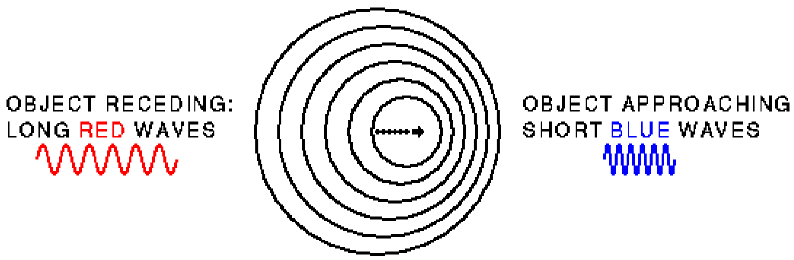
Universe – everything that exists in totality. We are part of the universe.

Overview of Topic

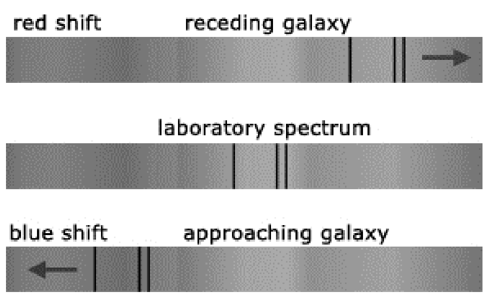
I. Origin and Age of the Universe

- Estimated to be 12 -14 billion years old.

a. Evidence for the Big Bang
    i. Determined from red shift in the spectra
        1. Red shift indicates objects are moving away from the observer.
        2. Blue shifted means moving towards an observer



        3. Spectral lines in laboratory spectrum will either move to the red (away) or the blue (towards)



        4. Majority of objects are red shift indicating expansion of universe.

II. Stars including our Sun

- Many sizes, many ages and many types are found in you galaxy, the Milky Way and other galaxies in the universe.

a. Energy production
    i. Nuclear fusion combines hydrogen into helium.

ii. Energy produced is in the form of electromagnetic radiation
    1. Page 14 ESRT – Electromagnetic Spectrum

b. Characteristics of stars
    i. Based on Luminosity
        1. Bigger is more luminous
        2. Hotter is more luminous

c. Star types
    i. Page 15 ESRT – Characteristics of Stars
        1. Horizontal axis
            a. Surface temperature
                - Increases left to right
            b. Color

        2. Vertical axis
            a. Luminosity
                - Increase towards top
                - Largest stars at top Smallest stars bottom

    ii. Main sequence
    90% of all stars located here
        - Our Sun
        - Fusing hydrogen
        - Can be small red dwarf to large blue giants
        - Blue is hot, burning fuel fast, short lived
        - Red is cool, burning fuel slow, long lived

    iii. Giants
        - Late stage star – dying
        - Main sequence star that is no longer fusing hydrogen
        - Our sun will follow the path
        - Become white dwarfs

    iv. Super giants
        - Late stage star – dying massive star
        - Massive main sequence stars that is no longer fusing hydrogen.
        - Become black holes or neutron stars

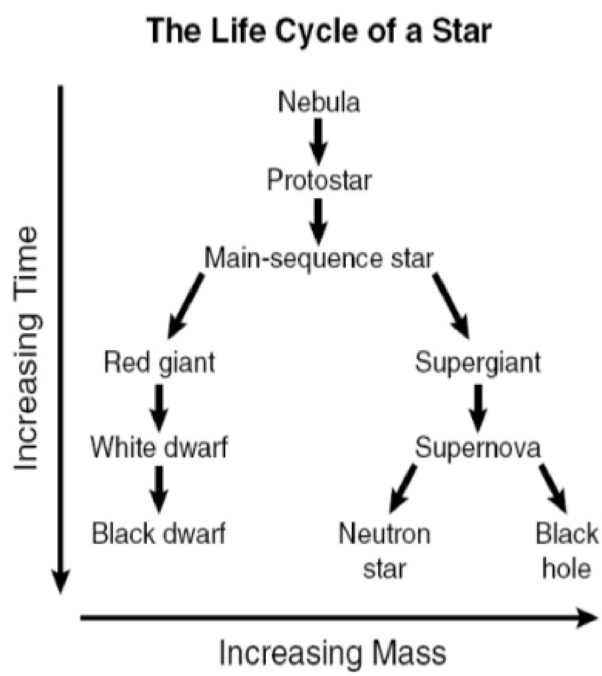
    v. White dwarfs
        - Very small

- Remains of a star core.
- Our sun will become a white dwarf

d. Star origin and evolution

i. Nebula

- Space dust that forms a star becomes very dense Protostar
  - Baby star not dense enough to give of light



III. Solar System

a. Sun

- A star
- Source of energy for Earth and the other objects of solar system.

b. Planets

- Terrestrial planets (page 15 ESRT)
  - Mercury, Venus, Earth and Mars
  - Means rocky

- Jovian planets (page 15 ESRT)
  - Jupiter, Saturn, Uranus, Neptune
  - Means gas – The Gas Giants

c. Moons – natural satellites
    - Orbit Planets
    - Earth has one moon
    - More than 175 moons in solar system

d. Asteroids
    - Large rocky group orbit between Mars and Jupiter
    - Can impact other planets
    - Can cause extinction - Dinosaurs

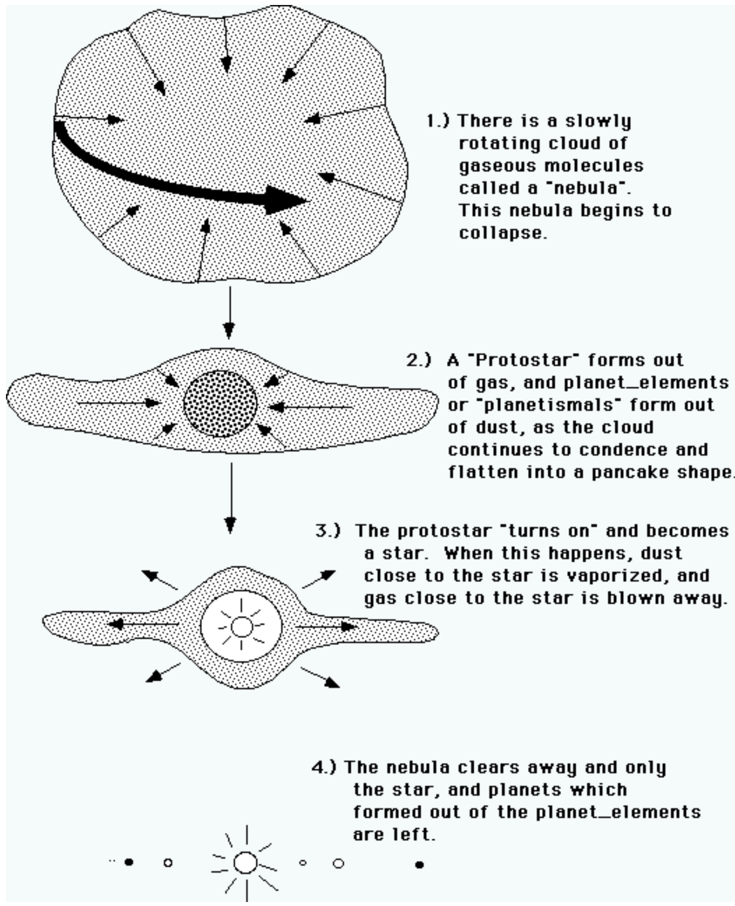
e. Comets
    - Orbit sun in very elliptical orbits
    - Come close to sun

f. Meteoroids
    - Very small fragments that orbit sun
    - Hit Earth and burn up as meteors (shooting stars)

IV. Evolution of the Solar System

a. Solar nebula

- Large dense patch of space dust
- Pulled together by gravity
- Material made stars, planets and other solar system objects.
- Solar system estimated to be 4.6 billion years old (page 8 ESRT).



V. Characteristics of planets (page 15 ESRT)

a. Terrestrial – Closest to sun

- Rocky
- High densities
- Small
- Few moons

b. Jovian – Further from Sun

- Gaseous
- Low densities
- Large
- Many moons and / or rings

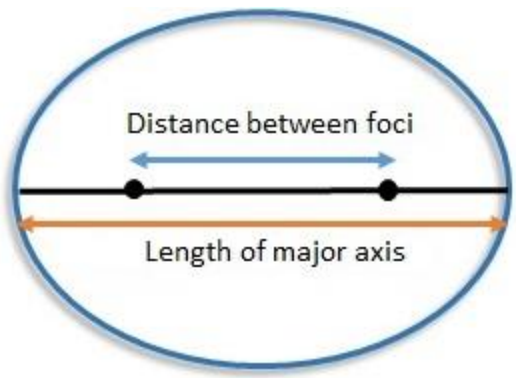
VI. Planet Motions

a. Rotation
   - Varies from planets to planet (page 15 ESRT)
   - Gas planets fast rotations

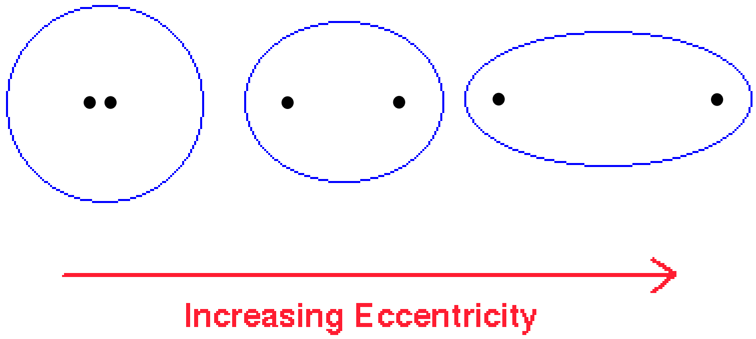
b. Revolution
   - Further form sun = longer periods of revolution (page 15 ESRT)
   - Travel in elliptical orbits around sun

c. Eccentricity of planets (page 15 ESRT)
   - Measure how flat an orbit is.
   - Formula (page 1 ESRT)

$$Eccentricy = \frac{distance\ between\ foci}{length\ of\ major\ axis}$$

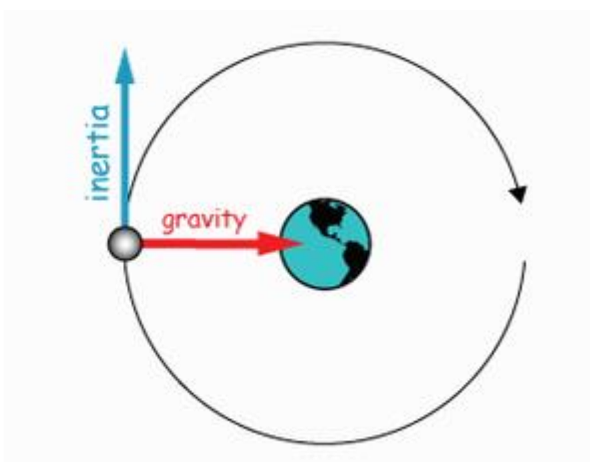


   - Foci or focal distance is the measure between the sun (star) and an imaginary point.
   - Major axis is the widest point of the orbit
   - Eccentricity has no units.
   - Always report to the thousandths.
     - Values are always between 0.000 and 1.000
     - A circle is 0.000
     - A flat orbit is 1.000



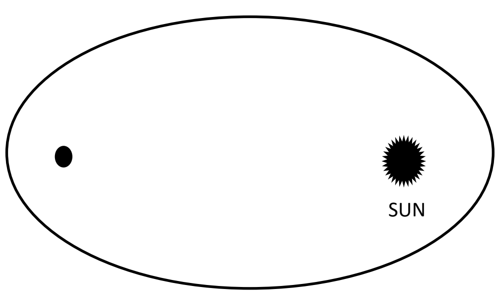
- Planets have a round orbit (left diagram)
- Comets have a flat orbit (right diagram

VII. Inertia, orbital velocity and gravitation.
- Object wants to move in a straight path (inertia)
- Velocity speed of object orbiting
- Gravity pulls orbiting object towards center



a. Without gravity there would be no orbit.
b. Greatest velocity = greatest gravitational attraction

Greatest gravity and velocity at perihelion or perigee.



Least gravity and velocity at aphelion or apogee.

Earth Science Reference Table – (ESRT)

Pages from ESRT used in Topic 3. (1, 8 and 15)

Eccentricity page 1

Calculating eccentricity is a simple calculation using the formula on page 1 of the ESRT.

You must reinforce that eccentricity has NO UNITS. If units are included on the final answer the response will be incorrect.

You must also reinforce that the answer must be to the thousandths and rounded correctly.

Examples of proper reporting to the thousandths with rounding:

0.0169 → 0.017

0.4999 → 0.500 yes this is correct. 0.5 would be incorrect.

The formula for eccentricity is below:

Equations

$$\text{Eccentricity} = \frac{\text{distance between foci}}{\text{length of major axis}}$$

$$\text{Gradient} = \frac{\text{change in field value}}{\text{distance}}$$

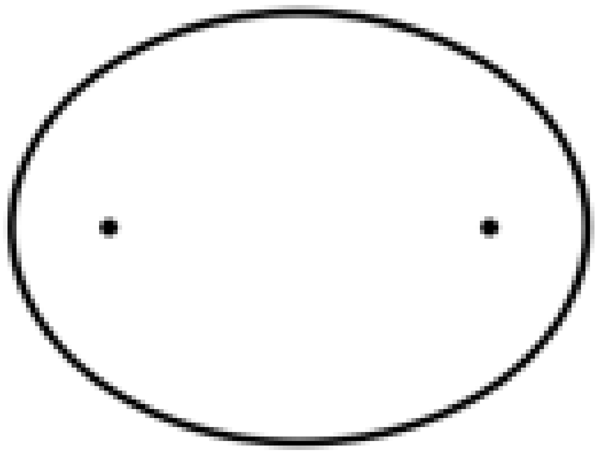
$$\text{Rate of change} = \frac{\text{change in value}}{\text{time}}$$

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

Eccentricity problems can use direct measurement and word problems. Let's begin with direct measurement. You must use a ruler and it is necessary to use centimeters.

For example:

Find the eccentricity of the following orbit.



Write your formula:

$$Eccentricy = \frac{distance\ between\ foci}{length\ of\ major\ axis}$$

actual measurements may not be represented below

Measure the distance between the foci (the dots). 5.0 cm

Measure the major axis (widest distance) on ellipse. 7.6 cm

Eccentricity $= \frac{5.0\ cm}{7.6\ cm}$ = 0.6578 = 0.658

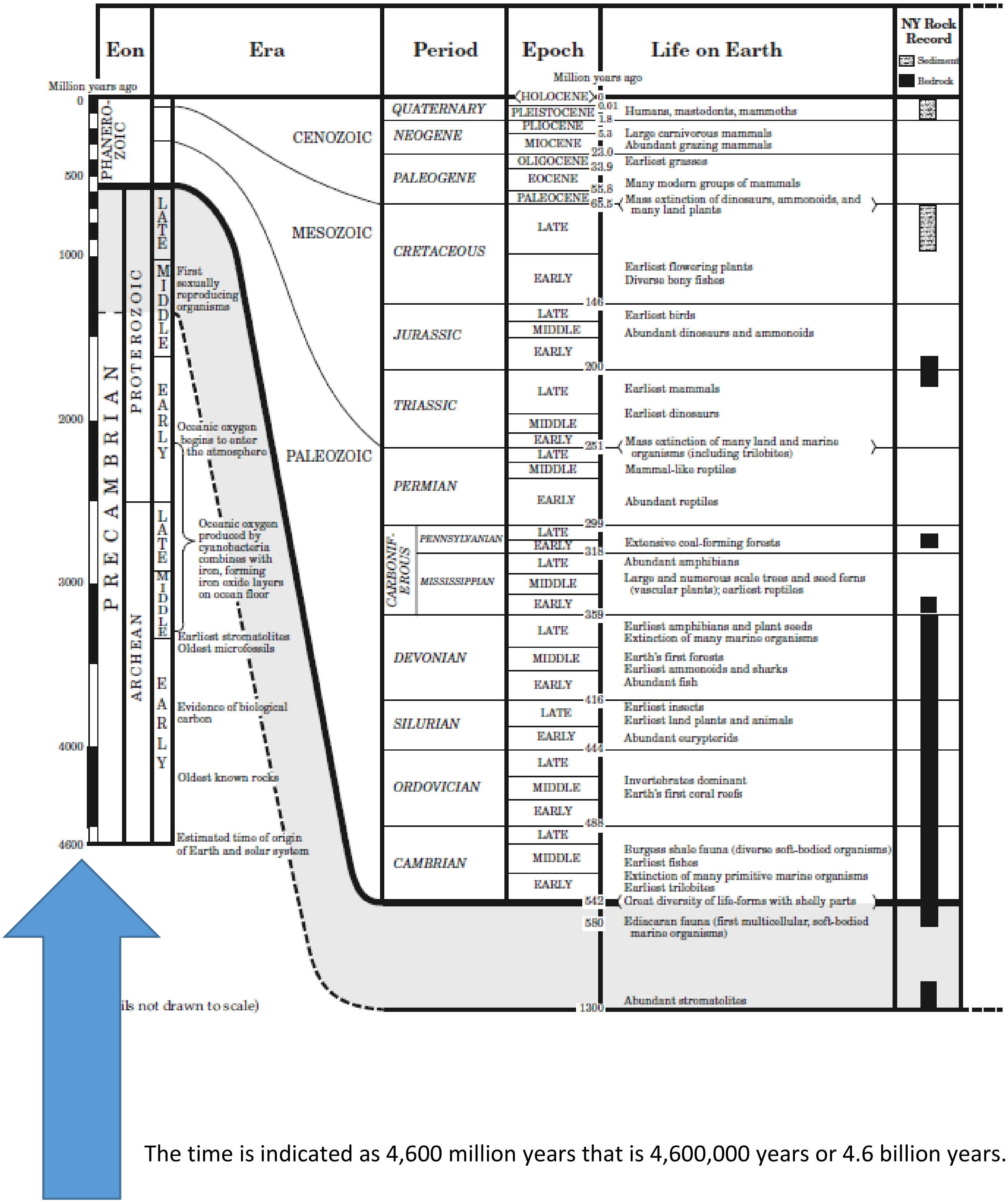
Another example is a word problem.

Calculate the eccentricity of orbit if the focal distance is 39,200,000 km and the major axis is 139,000,000 km.

Eccentricity $= \frac{39{,}200{,}000\ km}{139{,}000{,}000\ km}$ = 0.282

Calculating eccentricity is part of the lab practical- Part D of the Regents

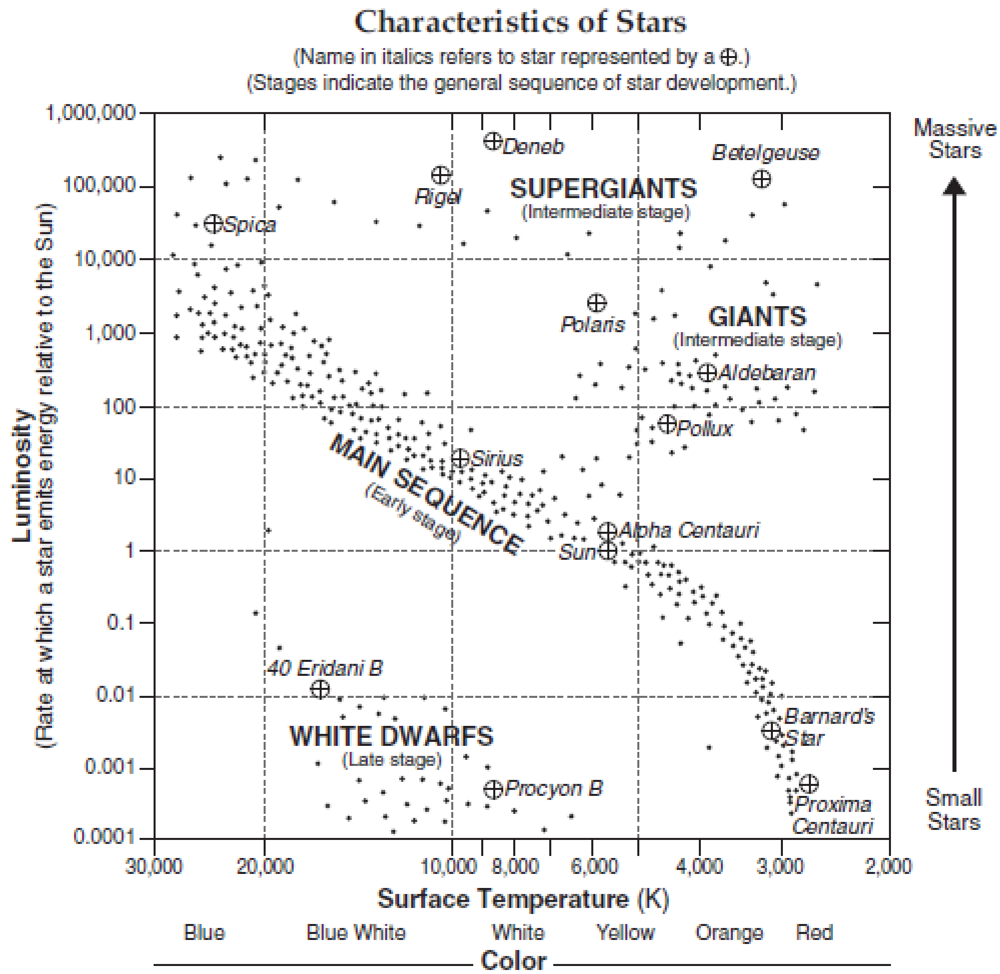
Determining Age of Earth and Solar System page 8



The time is indicated as 4,600 million years that is 4,600,000 years or 4.6 billion years.

Characteristics of Stars and Solar System Data page 15

These tables are self-explanatory.



This table gives a lot of useful information about stars. Notice the color and the temperature are together on the x-axis. This is useful when questions refer to color instead of temperature.

Solar System Data

Celestial Object	Mean Distance from Sun (million km)	Period of Revolution (d=days) (y=years)	Period of Rotation at Equator	Eccentricity of Orbit	Equatorial Diameter (km)	Mass (Earth = 1)	Density (g/cm^3)
SUN	—	—	27 d	—	1,392,000	333,000.00	1.4
MERCURY	57.9	88 d	59 d	0.206	4,879	0.06	5.4
VENUS	108.2	224.7 d	243 d	0.007	12,104	0.82	5.2
EARTH	149.6	365.26 d	23 h 56 min 4 s	0.017	12,756	1.00	5.5
MARS	227.9	687 d	24 h 37 min 23 s	0.093	6,794	0.11	3.9
JUPITER	778.4	11.9 y	9 h 50 min 30 s	0.048	142,984	317.83	1.3
SATURN	1,426.7	29.5 y	10 h 14 min	0.054	120,536	95.16	0.7
URANUS	2,871.0	84.0 y	17 h 14 min	0.047	51,118	14.54	1.3
NEPTUNE	4,498.3	164.8 y	16 h	0.009	49,528	17.15	1.8
EARTH'S MOON	149.6 (0.386 from Earth)	27.3 d	27.3 d	0.055	3,476	0.01	3.3

Notice that eccentricity in the Solar System Data is to the thousandths with no units.

A common mistake students make is include the sun and the moon as planets. Remind them the sun is a star and the moon is not a planet.