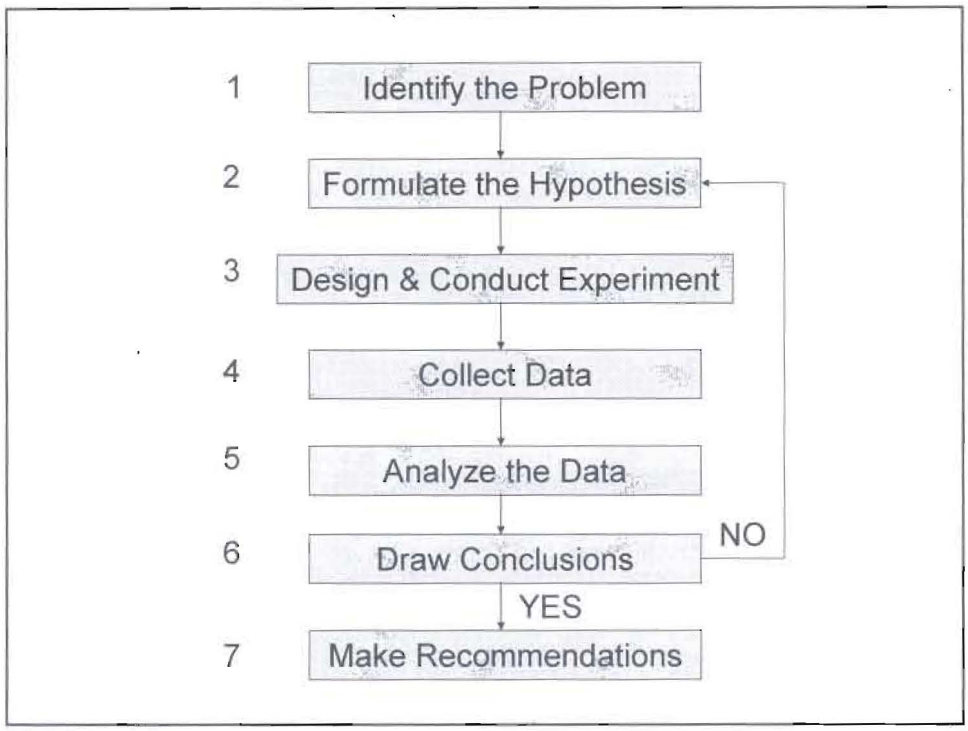
"The Scientific Method"

- The scientific method of inquiry is based on three main concepts:
- Observation
- Experimentation
- The development of theories or natural laws.



- Hypothesis: an unproved theory tentatively accepted to explain certain facts.
- Theory: a formulation of apparent relationships or underlying principles of certain observed phenomena which has been verified to some degree.

- Law: a sequence of events in nature or in human activities that has been observed to occur with unvarying uniformity under the conditions(Law of nature).
- One of the most important aspects of the scientific method is experimentation.

- An experiment allows scientists to prove or disprove a hypothesis.
- Conducting experiments follows an organized patterns, which include stating the purpose of the experiment, creating a hypothesis, writing out step-by-step procedures, collecting and analyzing data, and formulating a conclusion.

- Carefully conducting an experiment in an organized way ensures that scientific discovery can be well documented and recreated.

- The general goal of science has been to try to understand how the natural world works.

- The goal of technology is to take the knowledge gained by scientific inquiry and apply it in a practical way.

- Today many of the technologies that our society uses are the direct result of scientific inquiry and research. These include technologies like the airplane, the telephone, radio, computers, satellites, the light bulb, lasers and countless more inventions.

- The role of science and technology will play an important role in the future of the human race.

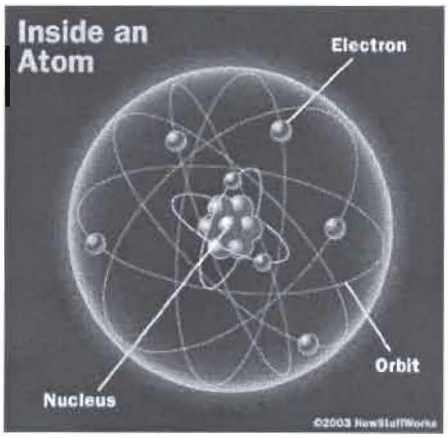
"Matter and Energy"

- All substances that exist on the Earth consist of matter.
- Matter is made up of fundamental particles called atom (ατωμωσ)

- Atoms are extremely small particles that possess unique physical and chemical properties.
- All atoms are composed of three subatomic particles: protons, electrons, and neutrons.

- Protons and neutrons form an atom's nucleus, around which revolves electrons.

- The Bohr model has become the most popular model of the atom; however ,today it is believed the atomic nucleus is surrounded by an electron "cloud", which is composed of electrons possessing different energy levels.



- A model of an atom which shows the nucleus surrounded by an electron cloud.

- Protons are a subatomic particle that have a positive electric charge, whereas the electron possesses a negative charge, the neutron has no charge.

- Recent research has demonstrated that these subatomic particles are made up of even smaller basic particles called quarks, which form protons and neutrons when combined.

- Together the mass of the particular number of protons and neutrons in an atom's nucleus creates its atomic mass.
- The atomic number of an atom helps to classify the different atoms that exist, which are also known as elements.

- There are 109 different atoms or elements that have been identified based on their atomic numbers.
- The 109 elements are arranged in an organized chart called the periodic table of elements.

- Among these 109 elements: 90 elements exist by nature, the rests are synthetic elements.
- The number of protons in a nucleus called the atomic number.
- The total number of protons and neutrons in a nucleus is called the mass number.

- Scientific symbol

Mass No. ⟶ 4
Atomic No. ⟶ 2 He ⟵ Element

He = Helium

H = Hydrogen

O = Oxygen

Pb = Lead

- Atoms of the same element may differ in the number of neutrons in the nucleus called isotopes.
- $^{4}He_2$ and $^{3}He_2$ are isotopes also called helium-4 and helium-3.

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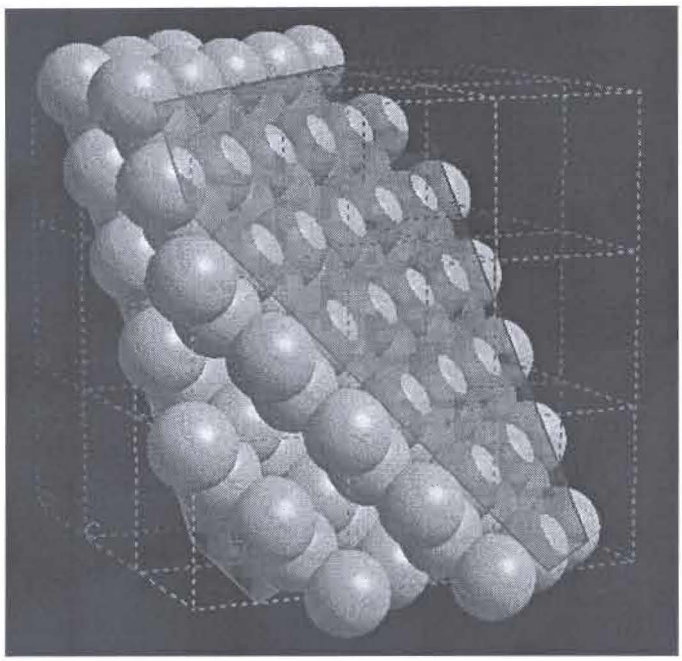
Element	Mass no.	Relative Abundance(%)
U(Uranium)	234	0.0057
	235	0.72
	238	99.27
Pb(Lead)	204	1.48
	206	23.6
	207	22.6
	208	52.3

- Isotopes usually have the same chemical properties.

"States of Matter"

- All matter in the universe exists in 4 distinct states that possess unique physical properties.
- The 4 states of matter: solids, liquids, gasses and plasma.

- The solid form of matter is the state in which atoms most tightly packed together and are most restricted in their movement.
- Many solids are composed of atoms organized into a crystal pattern, which is an orderly, reocurring arrangement of atoms.



- Atoms in a solid state posses the least amount of atomic movement and tends to have a definite shape.
- The next state of matter is liquid.
- Liquids are composed of atoms that are more loosely arranged.

- The atoms in a liquid have more freedom of movement, which gives liquid a more fluid property that has no definite shape.
- The third state of matter is gaseous state.

- The gaseous state of matter provides atoms with the highest degree of movement.

- The fourth state of matter is called plasma, which is not as common as the other three.
- Plasma forms when the atoms that compose a gas become exposed to such high energy that they begin to ionize, or lose their electrons.

- Plasma got its name from a Greek word □πλασμα□ which means "moldable substance", or "jelly".
- Stars are composed of plasma.

- The relationship between matter and energy in the universe is the fundamental cause for the existence of the living and non-living world.
- Albert Einstein revealed that energy and mass have a mutual relationship.

$E = mc^2$

E = energy

m = mass

c = speed of light in vacuum = 2.998×10^8 m/s

- Energy is defined as the ability to do work or cause change.
- Matter that is exposed to energy is said to be in motion.
- Energy is classified in two basic forms: kinetic energy and potential energy.

- Kinetic energy is the energy of motion.
- The movement of the Earth around the Sun is kinetic energy.
- Potential energy is stored energy.

- The gasoline in the tank of your car is a type of potential energy.
- The Law of the Conservation of Energy.

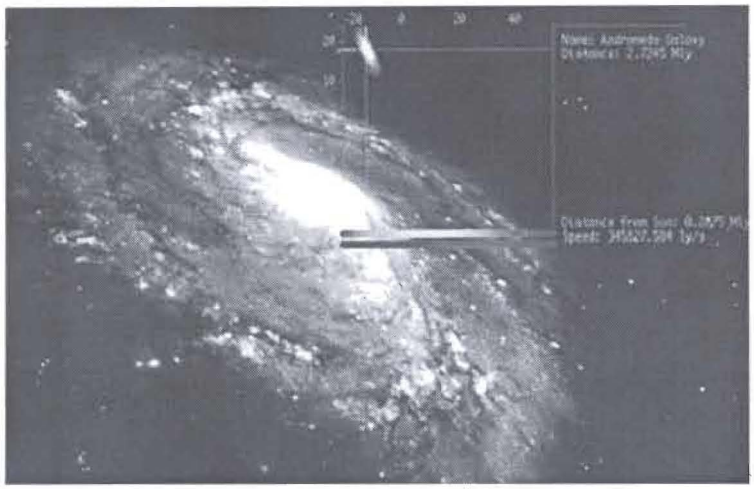
"Human and the Universe"

- What is universe?
- Let imagine that we are now the space travelers.
- The first thing to see is galaxy.

- The universe is composed of enormous number of galaxies.

- On the average, a galaxy is composed of 100,000 million stars (or 10^{11} stars).

- The distance between galaxies is about 150,000 light years (ly).



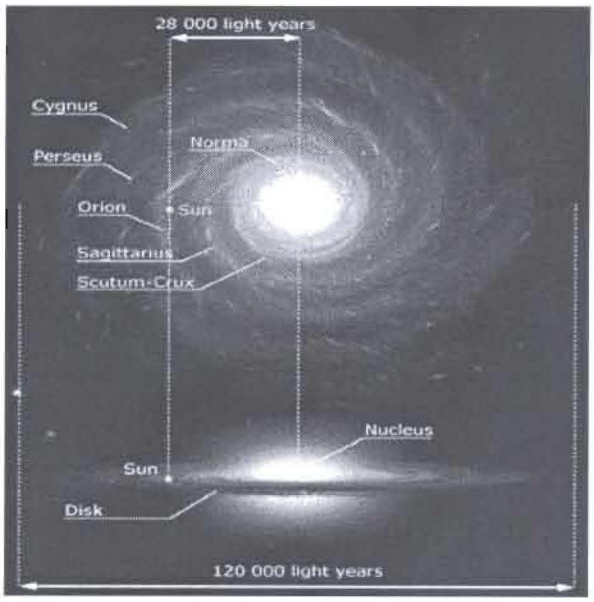
- Light year is an astronomical unit for measuring distance between celestial objects.
- 1 light year is the distance that light can travel in one year.
- The speed of light in vacuum is $3x10^5$ km/s.

- In one second, light can make a round-trip between BKK-Chiang Mai about 200 trips.
- 1 ly = 9.5×10^{15} m
- Astronomical Distance Units:
  1AU = 150×10^{6} km
  (AU = Astronomical Unit)
  1 ly = 9.5×10^{12} km
  1 parsec = 3.26 ly = 3.09×10^{13} km

- The galaxy that our sun belongs to is called "the Milky Way".
- How does the Milky Way look like?
- From the radio signal (wavelength 21 cm), astronomer concluded that the Milky Way looks like a galaxy called the Andromeda galaxy.

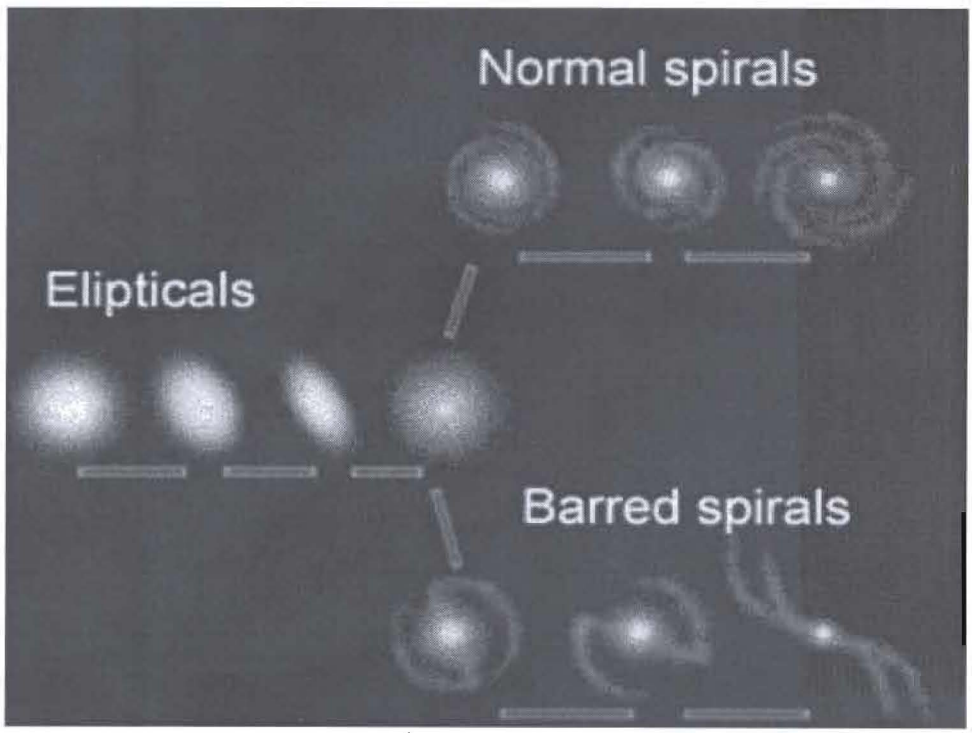
- The Andromeda galaxy is about 2×10^6 ly away.
- We are looking at the past of the Andromeda two million years ago.

•Structure of the Milky Way



- Galaxy Classification
  (by physical appearance)

1. Elliptical galaxy
2. Spiral galaxy can be divided into two subclasses:
   2.1 Normal Spiral
   2.2 Barred Spiral

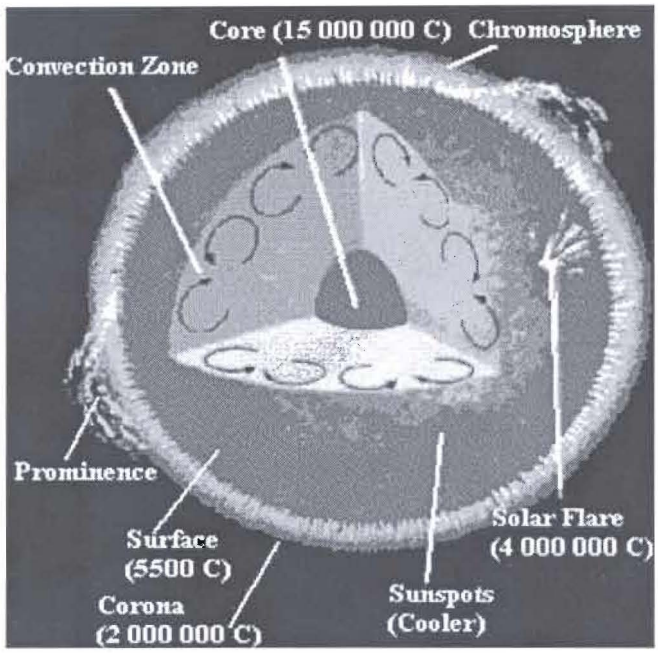


3. Irregular galaxy

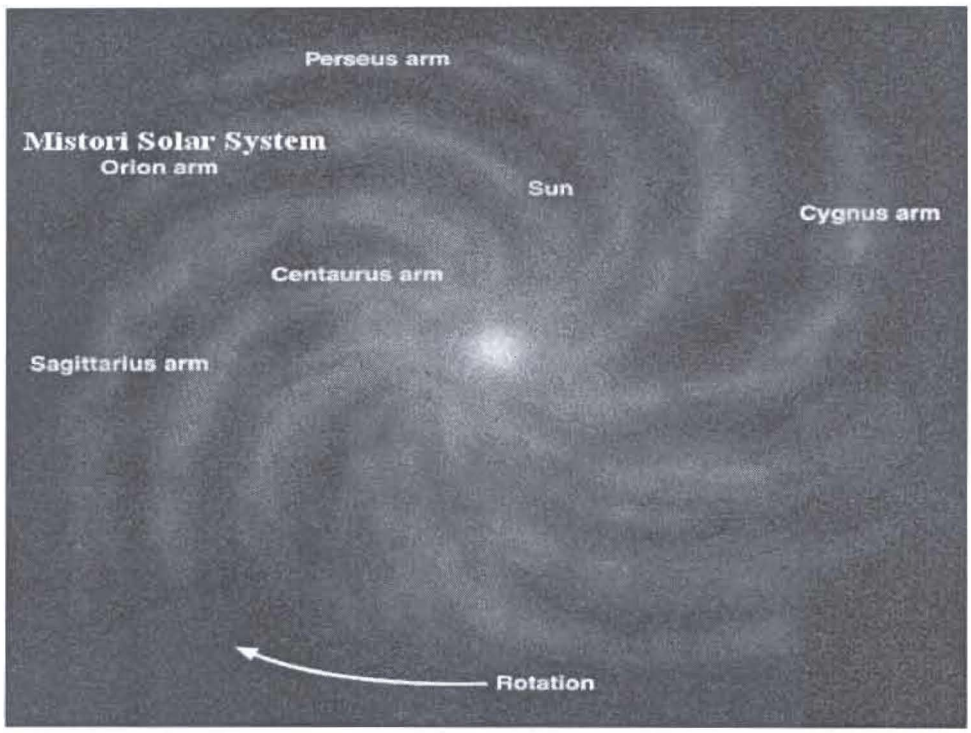
e.g. Large Magellanic Cloud (LMC)

- Nucleus consists of millions of stars (old stars).
- Spiral arms consist of young stars, interstellar gases, molecular clouds, and space dust.
- Stars are huge hydrogen gas in plasma state hold together by gravitational force.

Formic acid



- The Milky Way consists of about 10^{11} stars.
- The Sun is one of the stars in the Milky Way.
- The Sun is the average star (Mass, luminosity, temperature)



- The nearest star to the Sun is Proxima Centauri (about 4 ly away).
- So we are looking at the past of Proxima Centauri (about 4 years ago).
- The average distance between the Earth and the Sun is about 1.5×10^8 km.

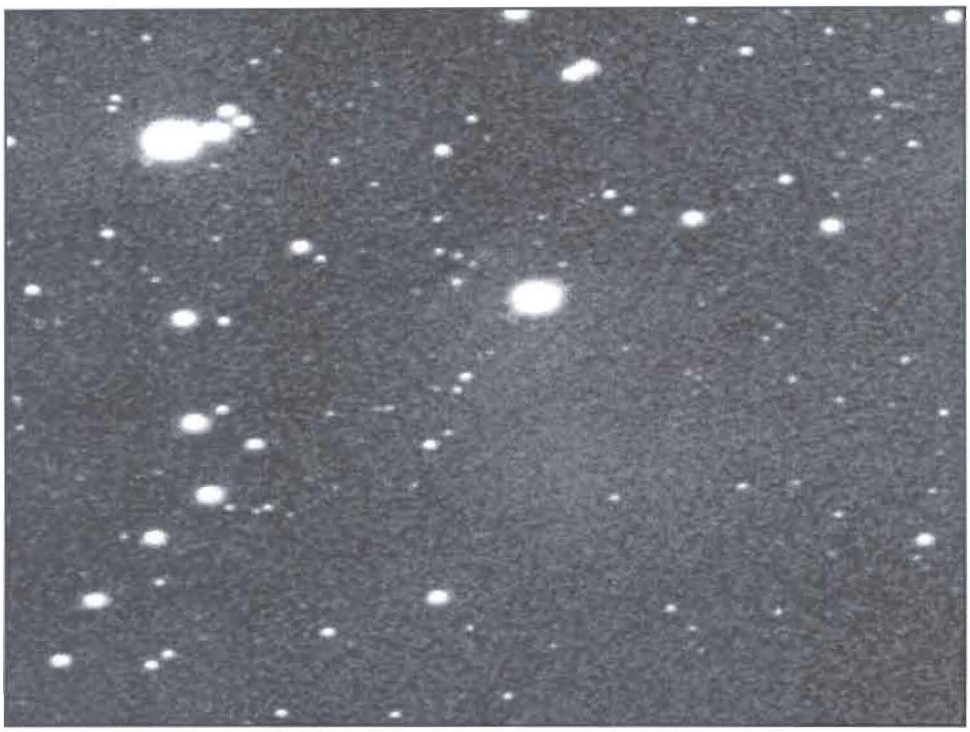
- Light needs 8 minutes and 20 seconds to reach the Earth (from the Sun).

- Star clusters

1. Globular Clusters
2. Open Clusters

- Globular Clusters: A gravitationally bound group of stars, symmetrical shaped.
- Consists of 10^5-10^7 stars
- 100 parsec (or ~ 300 ly) in diameter
- Old stars
- Found in the halo of the galaxy and orbiting the galactic center.

- Open cluster: A small group of gravitationally bound stars.
- Consists of about ten to a few hundred stars.
- Young stars.
- Found in or near the plane of the galaxy.
- E.g. Pleiades, in the constellation Taurus, lie about 400 ly away (contains ~ 100 stars within a diameter of 10 ly.)



- Interstellar Matter (ISM): All the gas and dust found between stars.
- Composition of ISM

  Hydrogen ~ 90%

  Helium
  Nitrogen
  Oxygen+ } ~10%
  Carbon
  Sulphur

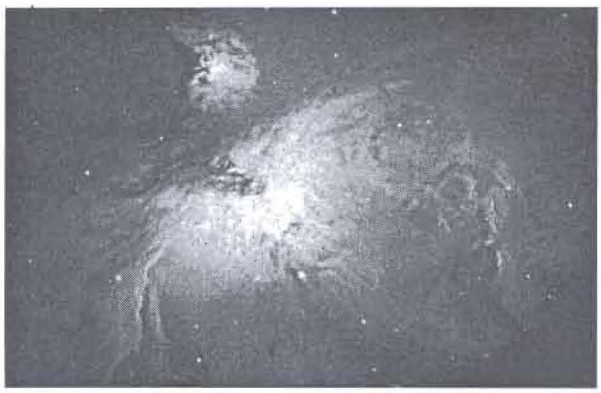
- ISM that can be seen by the naked eyes or by small telescope is called "nebula" which means "cloud".

- Nebula can be classified into 3 groups:

1. Emission nebula
2. Reflection nebula
3. Dark nebula

- Emission nebula: A cloud of hot ionized gas, mostly hydrogen, with an emission-line spectrum.

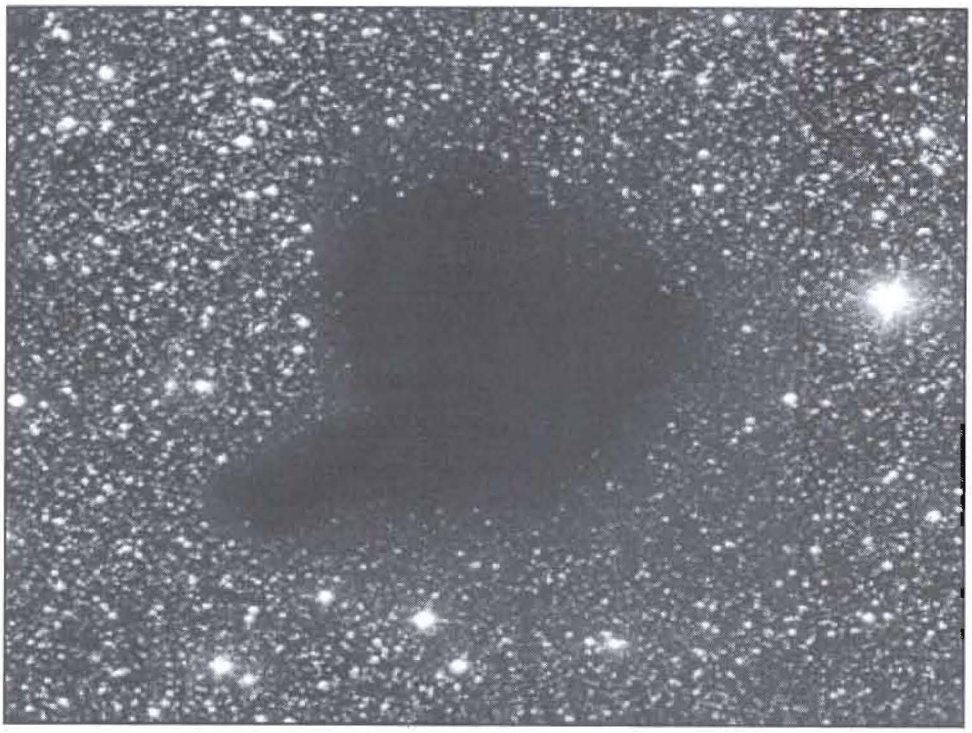
- Emission-line spectrum is produced by the radiation from a hot star (Temp >= 20,000 K) embedded in the nebula.

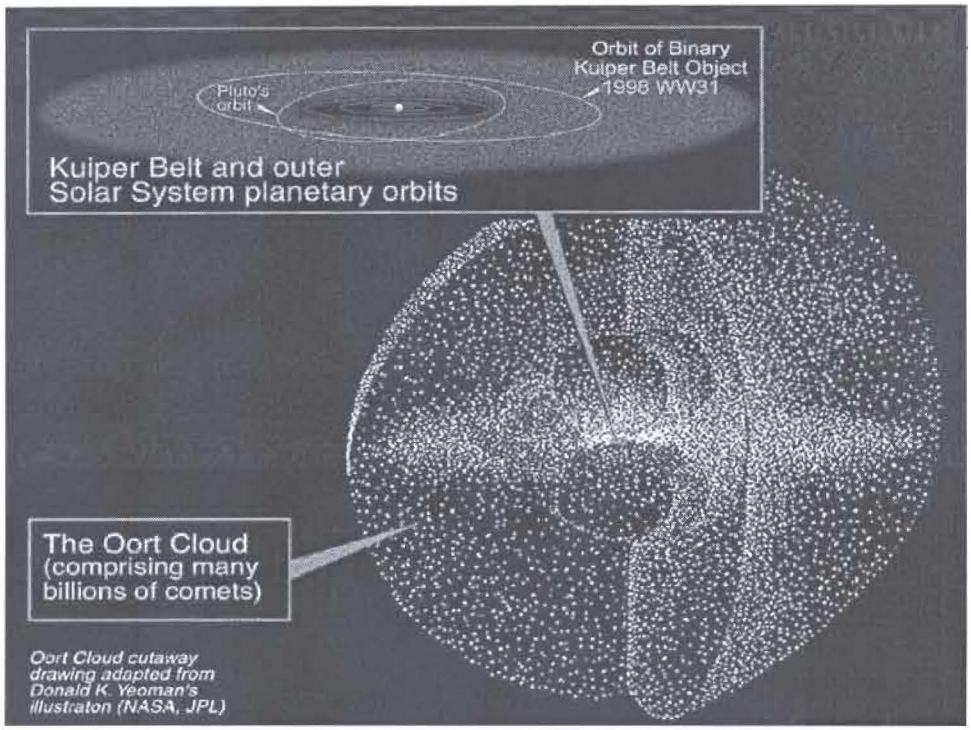


- Reflection nebula: A bright cloud of gas and dust that is visible because of the reflection of starlight by the dust.

- The temperature of the star is too low to produce fluorescence process.

- Dark nebula: An interstellar cloud of gas and dust that contains enough dust to blot out the light of stars behind it (as seen from the earth).

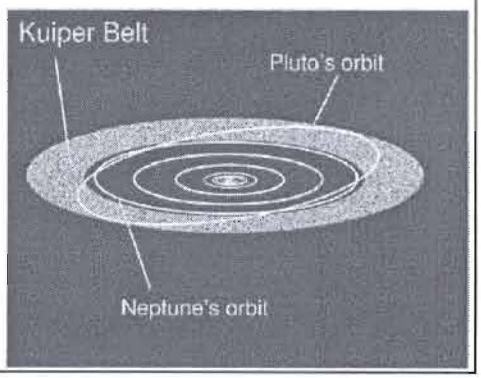


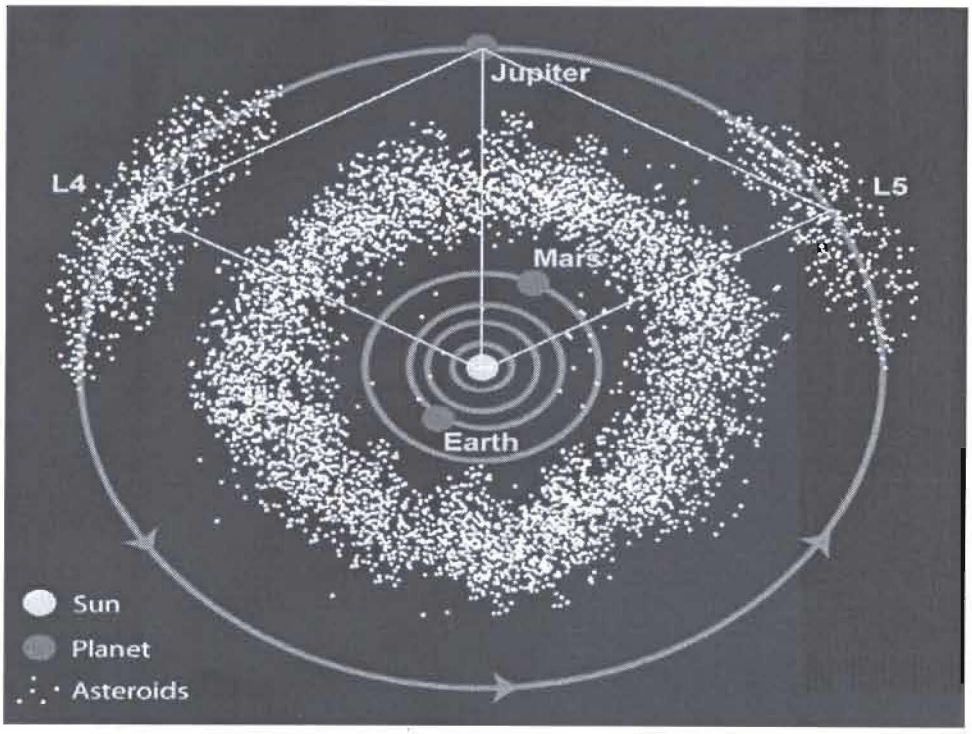


- Oort's cloud: A cloud of comet nuclei in orbit around the solar system,formed at the time the solar system formed; the reservoir for new comets.

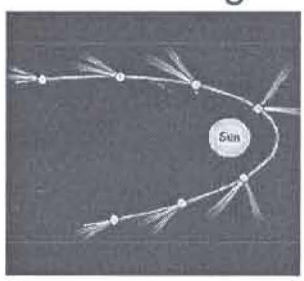
- Solar system
- The sun is at the center of the system.
- Eight planets orbiting around the Sun.
- Moons or satellites orbiting around planets.

- Asteroids: Minor planet; one of several thousand very small members of the solar system that revolve around the Sun, generally between the orbits of Mars and Jupiter.+

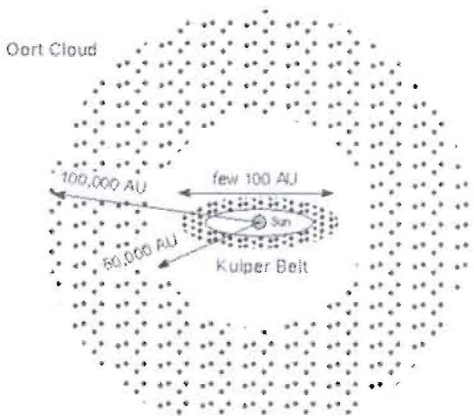




- Comets: Bodies of small mass that revolve around the sun, usually in highly elliptical orbits; in the dirty snowball model, comets consist of small, solid particles (probably of rocky material) embedded in frozen gases.



- Oort's cloud (named after a Dutch astronomer Jan Oort) has a diameter of about 100,000 AU.

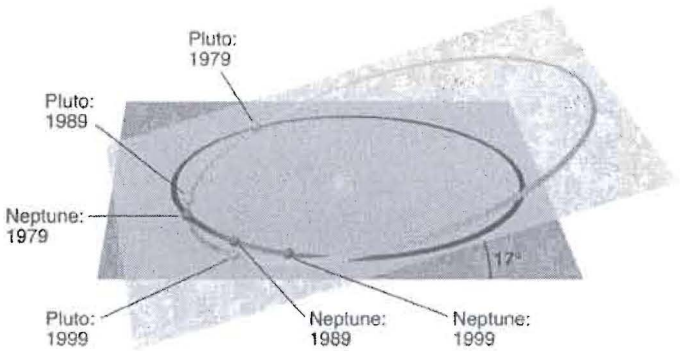


- The Oort cloud does not explain all comets, however, and in 1951, Gerard Kuiper proposed that a second, smaller band of comets must exist inside the Oort cloud. The first object in this Kuiper belt was discovered in 1992.

- Kuiper belt: A disk-shaped region beyond Neptune's orbit, 30-500 AU from the Sun, closer to the Sun than the Oort cloud and presumed to be the source of short-period comets.

- The comets with periods of less than 200 years are called the short-period comets

- The origin of these short-period comets is believed to be in the Kuiper belt.
- Pluto and charon are now classified to be the dwarf planets.



Orbital of Pluto