The Earth & the Universe

- Universe – Endless space – Includes → galaxies, stars, Planets, Other form of Matter & Energy.
  - Born with Big Bang
    - unimaginably Hot, dense point.
- Early stages – entire universe compressed – Infinitely small point [singularity]

ORIGIN OF UNIVERSE

- approx. 13·787 Billion years old.
- Widely accepted Theory → Big Bang Theory [Expanding Universe Hypothesis]

BIG BANG THEORY

- According to this Theory,

Universe → started with huge explosion & Matter [Dust & Gases] filled the entire space

↓

Matter from universe thrown out → All directions expanding outwards

↓

From this matter, Many groups of stars are formed, known – Galaxies.

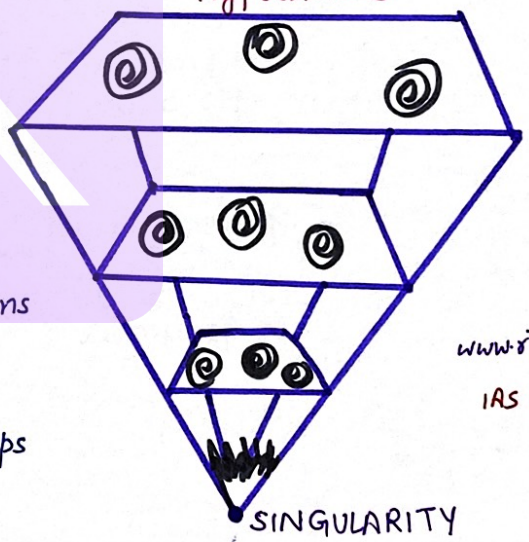

Fig:- Big Bang Theory

Stages in development of Universe

- Singular atom – All universe – tiny ball [singular atom] – Atom – small volume, infinite Temp & infinite density → Explosion – Tiny ball violently exploded [Tremendous expansion] → Cooling down Period – After 300,000 years, Temp. dropped 4500K ⇓ universe Transparent → Expansion universe ↓ Means inc. in space b/w galaxies

FORMATION OF GALAXIES & STARS

- Universe – Distribution of Matter & energy – Not uniform.
- Variations in density → variation in gravitational forces → causes Matter to be drawn Together
  - → Foundation for formation of galaxies.

GALAXY – comprise multitude of stars
- Vast distances, measured in thousands of light years.
- Individual galaxies diameter – 80,000 to 150000 light years.

FORMATION –

Accumulation of Hydrogen Gas in form of Massive cloud → known as Nebula → Nebula undergo growth & develop localised clumps of gas

MAJOR FORMS – a) SPIRAL GALAXIES
b) ELLIPTICAL GALAXIES
c) IRREGULAR GALAXIES.

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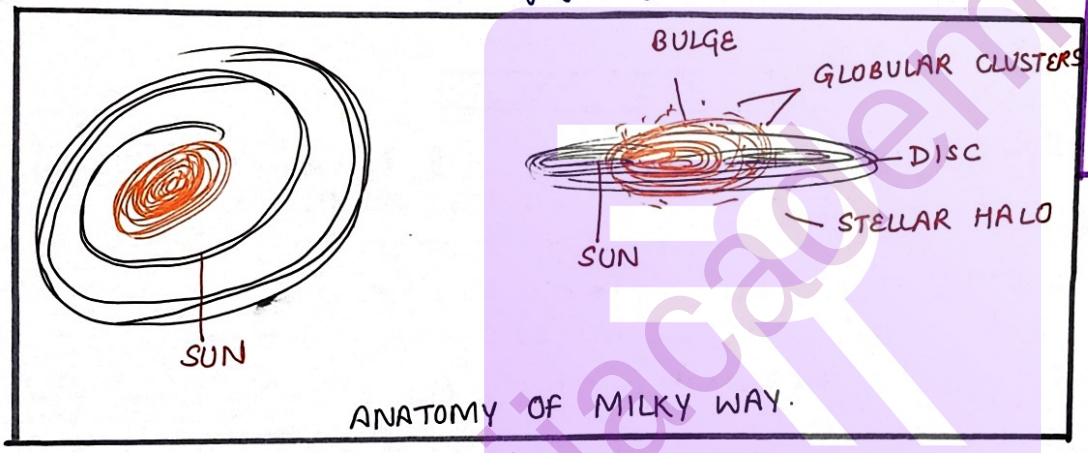
MILKY WAY GALAXY – Galaxy in which solar system – located

- Shaped like flat disc with central Bulge.
- Diameter – b/w 1,50,000 – 2,00,000 Light years.
- estimated – contain 100–400 Billion stars.
- Supermassive Black Hole – Sagittarius A* – centre.
- Andromeda – closest Big galaxy to Milky way.

LIGHT YEAR

- Measure of distance Not time.
- light travel – speed. 300,000 km/second
- Mean distance b/w sun & earth – 149598000 km
- In terms of light years, 8.311 Minutes



ANATOMY OF MILKY WAY.

STARS – Localised clumps of Gas → continue to condense → Become denser → Formation of stars.

- FORMATION – occured approx. 5–6 Billion years ago
- Giant Balls – Hot Gas – Mainly → Hydrogen, Helium, Trace amount [other elements]
- Fundamental Building Blocks → Galaxies.
- Proxima centauri – closest star to Earth.

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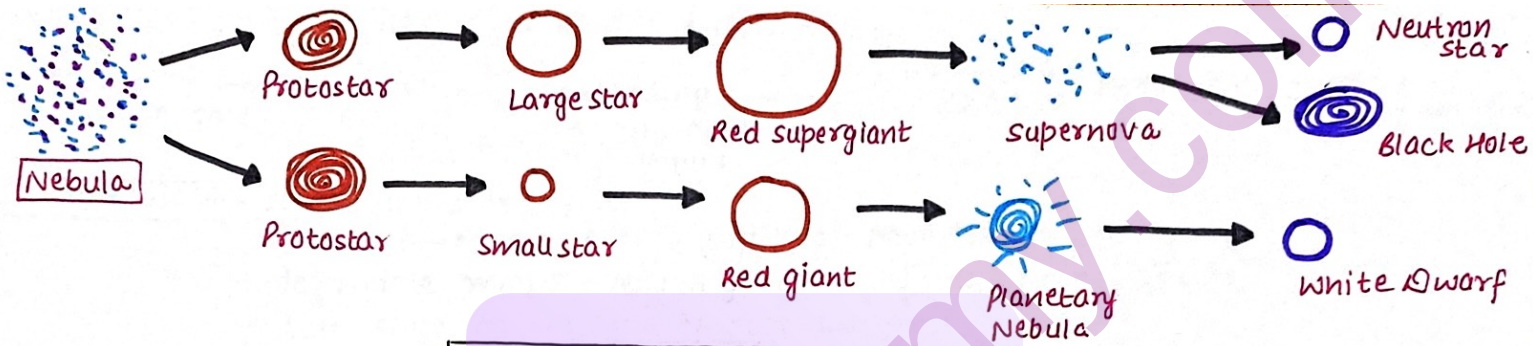


STELLAR EVOLUTION

NEBULA – • Cloud of gas [Mostly hydrogen & Helium] & dust in space.
• Birthplace of stars.

PROTOSTAR – Looks like star, but its core is not enough hot – for Nuclear fusion.
- surrounded by dust → Blocks the light they emit
- difficult to observe - visible spectrum.

RED GIANT
• Diameter = 10 to 100 times that of sun
• very bright
• formed during later stages of evolution
↳ Runs out of Hydrogen fuel at its center — fuses Hydrogen into Helium

RED SUPERGIANT – Red star condenses → Heats up further → Burning last of its Hydrogen → causing stars outer layer to expand outward
• star → Becomes Large Red Giant

PLANETARY NEBULA - outer layer of gas & dust → lost
- End of its lifetime → sun will swell up Red Giant — expanding beyond orbit of Venus.
  - ↳ when star changes Red Giant → White Dwarf.

WHITE DWARF - small, Hot star
- ↳ Nuclear energy supplies - Have been used up
- degenerate matter - very High density [gravitational effects]
- Last stage in life cycle of star like sun.

BLACK DWARF - Last stage - stellar evolution.
- White dwarf sufficiently cooled - No longer emits → Heat, Light.
- No Black dwarf expected to exist in Universe Yet.

SUPERNOVA - explosive death of star
- Great proportion - primary cosmic Rays → comes from supernovae.

NEUTRON STAR - Mainly composed of Neutrons
- produced after supernova.
- forcing protons & electrons → combine to produce Neutron star
- Very dense
- If mass greater, its gravity will be strong → shrink further → Become Black Hole.

Chandrasekhar Limit - Max. mass at which star Near the end of its life cycle
- ↳ Becomes White Dwarf
- ↳ above which - Star collapse to form → Neutron Star, Black Hole.

BLACK HOLE - form from Massive Stars at end of their lifetimes.
- Density of Matter - cannot be Measured.
- Gravitational pull - great - Nothing can escape from it, Not even light
- distort space around them.

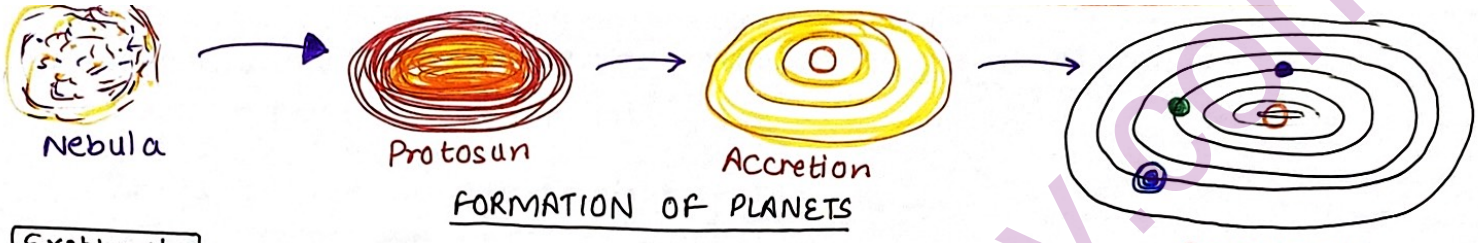
CONSTELLATIONS

- Stars forming group → Recognisable shape - constellation.
- Famous constellations - Great Bear [Big Dipper or Saptarshi or Ursa Major] - Moves around Pole star
  - Orion [Hunter] - seen during winter
  - Cassiopeia - Northern sky
  - Leo Major.

POLE STAR - star or star system - situated in direction [earth axis]
- Polaris or North star - earths pole star
- visible only from Northern Hemisphere.

Formation of Planets

- Within Solar Nebula → dust particles in gas occasionally collided & clumped Together → Accretion process, Microscopic particles - form larger Bodies, eventually become planetesimals.
- Disc continue to cool → plantesimals grew through accretion - form protoplanets
  - They got larger & larger, → sweeping up all leftover dust, other protoplanets & plantesimals → until they grew into planets



FORMATION OF PLANETS

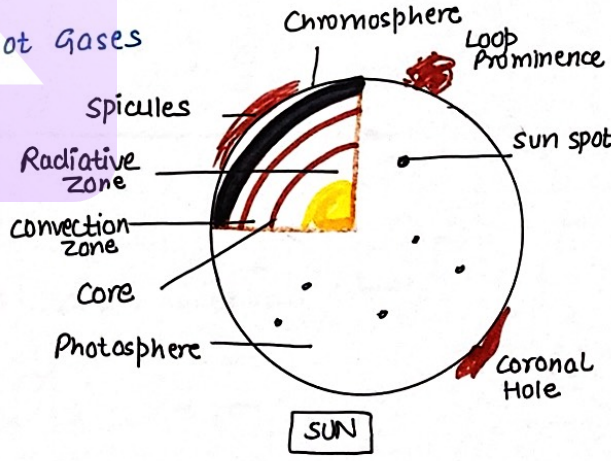
Exoplanets

- Any planet outside of our solar system.
- Majority exoplanets orbit other stars
  - ↳ But freefloating exoplanets – Rogue planets (Not Bound to any star)

The Solar System

Sun

- Sun is Ball of Hot Gases mainly Hydrogen
- Shining surface of Sun → Photosphere.
- outer layer of sun's atmosphere → Thin Hot Gases
  - ↳ Corona
    - ⇓
    - Visible only during full eclipse.

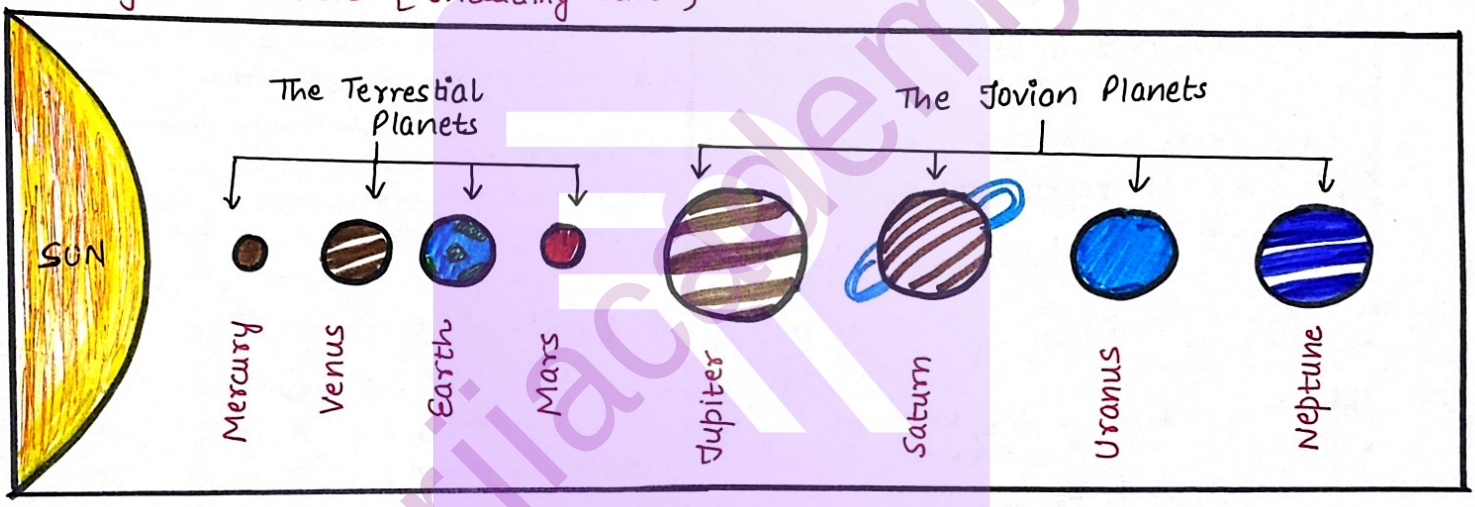


Goldilocks Zone

- Habitable zone
- Region around star where orbiting planets similar to Earth – can support liquid water
- Neither too Hot, Nor too cold

PLANETS

- solid Heavenly bodies → Revolve around Star — in closed elliptical paths.
- Planet → Made of Rock & Metal
- No light of its own.
- Shines because it reflects light of sun.
- Move around sun [west to east]
- Major 8 Planets [including earth]



CASE OF PLUTO - International Astronomical Unit,

Characteristics Required to Qualify Planet:
- celestial Body Has to be in orbit of sun.
- Sufficient Mass — assume Hydrostatic equilibrium
- 'cleared Neighbourhood' — around orbit [Pluto lacked this] — So, Pluto - Dwarf planet

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TERRESTIAL PLANETS [EARTH LIKE OR INNERMOST PLANETS]	JOVIAN PLANETS [JUPITER LIKE OR OUTERMOST PLANETS]
• 4 Innermost planets Mercury, Venus, Earth, Mars	• 4 Outermost planets [Gas planets] Jupiter, Saturn, Uranus, Neptune
• Formed close vicinity of parent star — Too warm for gases to condense to solid particles	• Formed at quite distant location.
• Solar winds - Most intense Nearer to sun, so, it blew off lots of gases & dust from Terrestial planets	- Solar winds - Not all that intense [To cause Removal of gases]
• Smaller & lower gravity → could Not Hold Escaping gases	• Larger & High gravity ↳ Hold Gases - gaseous planets
• compact, Rocky surface.	• All of them → planetary magnetic field → Rings → lots of satellites.
• None - Have Rings, Earth → Does have Belts [Trapped Radiation]	
• Only Earth → substantial planetary Magnetic field.	
• very less Number or No Natural satellite	• Large Number - Natural satellites
• Thin atmosphere	

MERCURY - closest to the sun
- Temp. Range -427°C on side facing sun, 270°C - dark side
- No atmosphere

VENUS - closest Neighbour of earth.
- extremely Hot planet — Temp. = 480°C
- Atmosphere - 96% carbon dioxide [CO_2]
- poisnous gases → sulphur dioxide [SO_2]
  → carbon Monoxide [CO]

Venus & Uranus - only planets Rotation East to West

EARTH - only planet sustain life
- 1 Moon

MARS - Red Planet
- 95% CO & Reddish dust
- Relatively cold planet, Two small moons → Phobos, Deimos

JUPITER - Largest planet of solar system
- Mainly Rapid spinning Ball of Gas - especially clouds of ammonia
- No Solid surface.

SATURN - consist of Mainly Hydrogen & Helium
- 90% Nitrogen & Temp [-184°C]
- Made of Hydrogen cyanide — poisnous Gas.
- Characterised by Ring that surrounds it

URANUS - very cold Planet
- Highly tilted Rotational axis

NEPTUNE - Cold & dark with its surface coated with frozen methane.

Satellites [Natural Moon]

- Heavenly Body that Revolves around Planet
- except Mercury & Venus – all planets have satellites
- No light of their own
- Shine because they Reflect the light of sun.
- Biggest Moon of solar system = Ganymede [Jupiter]
- Titan = Moon of Saturn.

Saturn → largest Number of satellites [146], whereas Jupiter = 95 Moons [satellites]

Earth Moon

- Natural satellite of Earth.
- Revolves around Earth – in definite Regular path
- about 1/4th size of Earth in diameter & 1/8th in weight
- Moon doesnot have air or water
- Its surface is covered with → Hard & Loose dirt, craters & Mountains.
- Days are extremely Hot & Nights are very cold on Moon.

Theories of formation of Moon:

① Darwin – Both Earth & Moon – formed a single Rapidly Rotating Body.
– Whole Mass → Dumb-Bell shaped → eventually Broke out.

② Material forming → The Moon was separated from what we have at present the depression occupied by Pacific ocean.

③ GIANT IMPACT OR THE BIG SPLAT

- Body of size of 1-3 times that of Mars
  - ↳ collided into earth shortly → after earth was formed.
- Blasted Large part of earth into the space.
- Blasted portion → started Revolving around earth
  - ↳ eventually formed – present Moon [after 4.4 Million Years ago].
- Most accepted Theory.

OTHER OBJECTS IN SKY

① **Asteroids** – Belt of debris composed of Rocks & Metals
- keep revolving b/w orbits – Mars & Jupiter – asteroid Belt.
- as many as 1,00,000 asteroid.
- Biggest asteroid – ceres [Diameter = 800 km]
- smallest asteroid – size of pebble.
- Asteroids can collide with earth.
- Believed that extinction of dinosaur – due to collision.
- Lonar Lake [Maharashtra] – filled up crater
  - ↳ formed after asteroid collision.

② **COMETS** – celestial objects formed of Ice & dust
- formed very early from same gas clouds
  - ↳ from which other members – Solar system formed
- orbit around the sun.
- Path disturbed, start moving towards sun → Ice sublimates into Gas → Bright outflowing atmosphere around comet Nucleus [COMA]

- Comet may also form two tails → Ionised molecules & Radicals
  → Other of dust.
- Tails of comet
  ↳ always point away from sun.
- Study of Tails of comet – shows presence → carbon, Hydrogen, Nitrogen, oxygen.

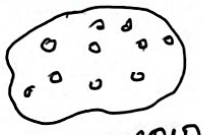
COMET

③ METEORS –

- small celestial Bodies – enter into earth's atmosphere
  ↳ Burns as a bright streak of light
  ⇓
  Due to heat → produced by friction.
- shooting stars.
- Meteorite – If Meteor is big enough
  ↳ doesnot gets burnt up completely → lands on earth [like stone from sky]

METEOR

METEORITE



METEOROID

- Meteoroid – Rock [asteroid fragment]
  ↳ Bigger than grain of sand & orbits the sun.
  – Object before it enters the atmosphere.

④ KUIPER BELT – Great Ring of debris like asteroid Belt
  ↳ But consist mainly of objects → composed of Ice.
– Pluto – Largest known object.

Evolution of Earth

- Early earth - planet earth — Barren, Rocky, Hot object } with a thin atmosphere
  Hydrogen, Helium.
- Transformation & evolution of earth -
  - period b/w 4600 Million Years to present
  - Makes planet with → ample amount of water
    → conducive atmosphere
- Earth layered structure
- Matter of atmosphere → least density
- Earth interior different zones → CORE, MANTLE, CRUST.

Formation of Lithosphere

- Lithosphere — solid, outer part of earth.

Earth in volatile state during primordial stage → with gradual increase in density, inner Temp. increases. → Differentiation Based on densities
- Heavier sinks @ core
- Lighter moves towards surface

↓ with passage of Time

Solidified & condensed → Outer layer CRUST → During formation of moon, earth further Heated up → Differentiation Based on densities

- CRUST
- MANTLE
- CORE → Inner, Outer

Evolution of Hydrosphere & Atmosphere

- Present composition – Earth Atmosphere → Nitrogen, Oxygen

3 Stages in Evolution of earth present atmosphere

- Loss of primordial Atmosphere
- Hot Interior → evolution of earth atmosphere
- composition of atmosphere → modified by living world ⇓ Process of photosynthesis

EVOLUTION OF HYDROSPHERE

With cooling of Earth, water vapour started condensing. → Atmospheric CO_2 dissolved in rain → Decreased Temperature → More condensation, more Rainfall → Rainfall collected in depression → FORMATION OF OCEANS

EVOLUTION OF ATMOSPHERE

Loss of primordial atmosphere due to solar winds → Cooling of Interior released gases & water vapour → Early atmosphere contained H_2O, CO_2, CH_4, NH_4 & less free O_2 → Degassing – Process through which gases were outpouring from Interior → continuous volcanic eruption contributed water vapour & Gases into atmosphere → PRESENT ATMOSPHERE

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