Earth - Origin & Evolution [Geography Notes For UPSC]

NCERT notes on important topics for the UPSC civil services exam. These notes will also be useful for other competitive exams like banking PO, SSC, state civil services exams and so on. This article talks about the Geography syllabus for IAS exam as an assimilating discipline as a science of spatial characteristics and Divisions of geography and significance of physical geography.

Early Theories of Origin of Earth

The major early theories of the earth's origin are discussed below.

- **Nebular Hypothesis** - This theory was developed by Immanuel Kant and modified in 1796 by Pierre Laplace. According to this hypothesis, the planets were formed out of a cloud of material associated with a youthful sun, which was slowly rotating.
- In 1900, Chamberlain and Moulton considered that a wandering star approached the sun which resulted in the formation of a cigar-shaped extension of material that got separated from the solar surface. This separated material continued to revolve around the sun and slowly got condensed into planets.
- The binary theories considered a companion to be coexisting with the sun.
- In 1950, the Nebular Hypothesis was revised by Otto Schmidt (in Russia) and Carl Weizascar (in Germany). According to them, the sun was surrounded by a solar nebula consisting mainly of hydrogen and helium along with dust. The friction and collision of particles led to the formation of a disk-shaped cloud and planets were formed through the process of accretion.

Origin of Earth Modern Theories

Big Bang Theory

- The Big Bang Theory explains the origin of the universe. It is also called the expanding universe hypothesis.
- In 1927, Abbe Georges Lemaitre, a Belgian astronomer was the first to provide a theory on the origin of the Universe. It was Edwin Hubble who provided evidence that the universe is expanding.
- According to this theory, all matter that formed the universe existed in one point (tiny ball) called singularity having an unimaginable small volume, infinite temperature and infinite density.
- The great event of the big bang happened some 13.7 billion years ago. The tiny ball exploded which led to a huge expansion and this expansion continues even today. There was rapid expansion within fractions of a second after the bang. Thereafter, the expansion slowed down. With the expansion some of the energy was converted into matter. Within the first three minutes from the big bang event, the first atom began to form.

- Within 300,000 years from the big bang, temperature dropped down to 4500 K and gave rise to atomic matter. The majority of atoms formed were hydrogen, along with helium and traces of lithium. Huge clouds of these elements fused through gravity to form stars and galaxies.
- Once there were two theories for explaining the origin of the universe - the Big Bang theory and the Hoyle's concept of steady state.
    - The steady state theory considered the universe to be roughly the same at any point of time.
    - However, with greater evidence becoming available about the expanding universe, the Big Bang theory was confirmed which proposes that the universe originated from a single violent explosion of a very minute amount (tiny ball) of matter of high density and temperature.

Formation of Stars

Star formation is the process by which dense regions within molecular clouds in interstellar space called star forming regions or stellar nurseries collapse under their own gravitational attraction and form stars. The formation of stars is believed to have taken place some 5-6 billion years ago.

Stages in the Formation of Stars:

1. Nebula - It is a cloud of gas (mainly hydrogen and helium) and dust in space. It is a star's birth place.
2. Protostar - It is an early stage of a star formation where nuclear fusion is yet to begin. It looks like a star but its core is not yet hot enough for nuclear fusion to take place.
3. T Tauri Star - It represents an intermediate stage between a protostar and a low mass main sequence star like the sun. It is a young, low weight star, less than 10 million years old that is still undergoing gravitational contraction.
4. Main Sequence Star - At this stage, the core temperature is enough to start the fusion reactions i.e, fusing hydrogen atoms to form helium atoms. The sun is the main sequence star.
5. Red Giant - A red giant is formed during the later stages of the evolution as the star runs out of hydrogen fuel at its centre. However, it still fuses hydrogen into helium in a shell surrounding a hot, dense degenerate helium core. This fusion of hydrogen into helium around the core releases much greater energy and pushes much harder against gravity and expands the volume of the star.
6. Fusion of Heavier Elements - As the star expends, helium molecules fuse at the core which prevents the core from collapsing. When the fusion of helium ends, the core shrinks and begins fusing carbon. This process repeats until iron appears at the core. The iron fusion reaction absorbs energy, which causes the core to collapse. This implosion transforms massive stars into supernovae and smaller stars (sun) into white dwarfs.
7. Supernovae and Planetary Nebulae - Planetary nebula is an outer layer of gas and dust that is lost when the star changes from Red Giant to White Dwarf. This white dwarf becomes black dwarf when it stops emitting light.

Supernova is the explosive death of a bigger star and it obtains the brightness of 100 million suns for a short time. Neutron stars are produced after a supernova (protons and electrons combine to produce neutron stars).

Our Solar System

Our solar system consists of the sun (the star), eight planets, 63 moons, asteroids, comets and huge amounts of dust-grains and gases. The solar system is believed to have been formed about 5 - 5.6 billion years ago and the planets were formed about 4.6 billion years ago. The eight planets namely Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune revolve around the sun in fixed elliptical orbits.

- Mercury, Venus, Earth and Mars are called the inner planets and also terrestrial planets, which means earth-like as they are made up of rocks and metals. The other four planets - Jupiter, Saturn, Uranus and Neptune are called outer planets as well as jovian (Jupiter-like) or Gas Giant planets. They are mostly larger than terrestrial planets and have a thick atmosphere mainly of helium and hydrogen.
- Pluto was earlier considered a planet, however it is now believed to be a “dwarf planet”.
    - Dwarf planets are tiny planets in our solar system. Any celestial body orbiting around the sun, weighing for self gravity and nearly round in shape is called a dwarf planet.
- Number of satellites of planets:
    - Mercury - zero
    - Venus - zero
    - Earth - one
    - Mars - two
    - Jupiter - about 53
    - Saturn - about 53
    - Uranus - about 27
    - Neptune - 13

Moon

- The moon is the only natural satellite of the earth. The word satellite means “companion”. The satellites move around a planet from west to east. They do not have their own light but reflect the light of the sun. The moon takes 27 days and 7 hours and 43 minutes for both its rotation and revolution around the earth. It is the fifth largest natural satellite of the solar system.
- It is believed that the formation of the moon is a result of a giant impact called ‘big splat’. A large body (somewhat one to three times the size of Mars) collided with the earth just after it was formed. Due to this heavy impact, a large part of earth got separated. This portion of blasted material continued to revolve around the earth and eventually formed the present moon (4.44 billion years ago).

Evolution of the Earth

The earth was a barren, rocky and hot object with a thin atmosphere of hydrogen and helium.

- **Lithosphere** - With the increasing density, the temperature inside the earth increased and the materials started getting separated depending on their densities. The heavier elements like iron moved towards the centre and lighter ones moved towards the surface. With the passage of time the earth cooled, solidified and condensed into a smaller size and formed the crust (the outer layer of the earth).
    - The different layers of the earth starting from the surface are crust, mantle, outer core and inner core. From crust to the core, density increases.
- **Atmosphere** - The solar wind was most intense nearer the sun; so it blew off lots of gas and dust from the terrestrial planets - Mercury, Venus, Earth and Mars. During the process of cooling of earth, gases and water vapour escaped from the interior of the earth thereby starting the evolution of the present atmosphere. The early atmosphere mainly had water vapour, carbon dioxide, nitrogen, methane, ammonia and small amounts of free oxygen. The process of release of gases from the interior of the earth is called “degassing”.
- **Hydrosphere** - The frequent volcanic eruptions provided the atmosphere with water vapour and gases. With the cooling of the earth, water vapours condensed and brought rain. The carbon dioxide in the atmosphere got dissolved in rainwater which further lowered the temperature leading to more condensation and more rain. The rain water got collected into depressions to give rise to oceans. Life was limited to oceans only for a long time. Oceans got saturated with oxygen through the process of photosynthesis and then some 2,000 million years ago oxygen began to flood the atmosphere.

Geological Time Scale

The summary of evolution of life from unicellular bacteria to the modern man is given in the **Geological Time Scale** below -

Eons	**Era**	**Period**	**Epoch**	**Age/Years before Present**	**Life/Major Events**
	Cainozoic (from 65 million years to the present times).	Quaternary	Holocene Pleistocene	0 - 10,000 Million 10,000 - 2 Million	Modern Man Homo Sapiens

		Tertiary	Pliocene		Early Human Ancestor.
			Miocene	2 - 5 Million	Ape: Flowering plants and Trees.
				5 - 24 Million	Anthropoid Ape.
			Oligocene		Rabbits and Hare.
	Mesozoic		Eocene	24 - 37 Million	Small Mammals: Rats and Mice.
	65 - 245 Million	Cretaceous	Palaeocene	37 - 58 Million	
		Jurassic			
		Triassic		57 - 65 Million	Extinction of Dinosaurs.
	Paleozoic				Age of Dinosaurs.
	240 - 570 Million	Permian		65 - 144 Million.	Frogs and Turtles.
		Carboniferous		144 - 208 Million.	Reptiles dominate - replace amphibians.
		Devonian		208 - 245 Million.	Fresh reptile: Vertebrates: coal beds.
		Silurian		245 - 286 Million	Amphibians.
		Ordovician		286 - 360 Million	Fresh trace of life on land; Plants.
		Cambrian			First fish.
					No terrestrial life: Marine

				360 - 408 Million. 408 - 438 Million. 438 - 505 Million 505 - 570 Million.	invertebrate.
Proterozoic Archean Hadean	Pre-Cambrian 570 - 4800 Million			570 - 2500 Million 2500 - 3800 Million 3800 - 4800 Million.	Soft bodied arthropods. Blue green algae: unicellular bacteria. Oceans and continents form: Oceans and atmosphere are rich in carbon dioxide.
Origin of Stars Supernova Big Bang	5000 - 13,700 Million.			5000 Million 12,000 Million 13,700	Origin of the Sun. Origin of the Universe.

				Million.	