CHAPTER 1

Kshamayaa Dharithri

(Oh Tolerant Mother Earth! Forgive Me)

O'MY SILENT INNER VIBES (O'M S I V – 1)

The mother Earth has greatest tolerance that she bears all our mistakes and misdeeds. She gives us everything such as minerals, food, shelter etc. But she can smash everything if we cross our limits. So,.....

I bow to Mother Earth to save the mankind!
I pray to mankind to save the mother Earth!
Oh! Mother Earth... Forgive us and give us your blessings!

Though ploughed through your belly, you fill our stomachs fully
Though cared never gratefully, you fulfil our needs gracefully,
I stand before Thee! Maa... with folded hands
Forgive us and give us your blessings!

Even when your body is split parts and parts, you never move apart
Though made you victim of our party, But you never leave our party
I kneel down! Maa... eyes filled with tears
Forgive us and give us your blessings!

Even if your heart's 'mine' is broken, you give us gold and diamonds
Even if garbage is thrown on you! You grab in your lap and garb us
I lay down on thee! Maa... to prostrate with stretched hands
Forgive us and give us your blessings!

Despite being kicked always with our feet!
Yet, you make us walk thousands and thousands of feet!
Touching thy feet! Maa...I salute you with these words
Forgive us and give us your blessings!

Kshamayaa Dharithri! Rakshathu! Samrakshathu!! Parirakshathu!!!

Namo Prithvee Matha! – Namo Prithvee Natha!!

The God (**Prithvee Nath)** created **Prithvee Matha,** 'The Earth' as the most beautiful planet! No other planet has all the requisites for living-hood except the Earth. It has abundant water at ambient temperature; amiable atmosphere, amicable humidity and pressure conditions and what not! All 'the optimal' conditions for life are available. However, when any of these conditions go to their uncontrollable extreme level, it becomes a disaster. What a wonder! The God not only created good living conditions, but also gave right self-resisting mechanism to adjust itself to the situations.

There is a small garden which has some cats and rats. One day suddenly, one wild cat came from a nearby forest (like a disaster) and ate many rats. Then, suddenly the rat population came down drastically. The cats could not get food and even starved to death (like famine/draught to cats). Thus the cats count fell down and thence the rat hunt reduced. This favoured the raise in rat population, which in turn the cats got abundant food. Now cats started hunting more and got food. Slowly cat population went up. This is called ecological balance, which nature by itself adjusts to a natural-ecological equilibrium. So we need to maintain the status-quo and/or allow the nature to balance by itself. If we go against this principle, there is every chance that we have to pay for its fury.

Similarly, for instance, if there is a high temperature at a place, the air at the region gets heated up and creates a depression. Then the dense air from nearby place rushes toward the depression. Thus a balance will be maintained. If this goes in a larger scale, it may become a disaster (cyclone). Thus, any disaster is for ecological balancing. If we don't let it go imbalance, or we balance it, there won't be any disaster. Thence, ...

The Ecological Balance is the Key to Disaster Prevention

1.1 THE EARTH – AN OVERVIEW

Earth, the densest planet in the solar system is the 3rd planet from the Sun. It is the only planet in the universe known to harbor life. According to radio-metric dating, the Earth is about 4.54 billion years old. But,

How safe are we on this Earth?

Are we safe on the surface of earth? What is above and below the earth?

Do we have safe environment in the air above the earth? What is inside the earth? Can we have safe environment inside the earth?

To answer the above questions, we should first know the geography and the anatomy of the earth also in addition to the ecology. Let's have a quick look on it.

Earth is revolving about its own axis and the time taken for one rotation is assumed as one day (24 hours). The Earth is oblate spheroidal and its rotation flattened along the geographic axis and bulged around the equator. Further it also rotates around the sun in an elliptical orbit due to gravitational interactions and takes 365.26 days for each rotation, called a year. The Moon is its natural satellite that rotates around the earth once in every 27.32 days (relative to the background stars) or 29.53 days (new moon to new moon), called a month approximately. Earth's axis is tilted about 23.44° from the perpendicular to the Earth–Sun plane (the ecliptic), and the Earth–Moon plane tilted up to ±5.1° against the Earth–Sun plane. Without this tilt, there would be an eclipse every 2 weeks, alternating between lunar and solar. Earth's rotation about its own axis causes day and night, Earth's rotation around Sun produces Seasonal variations and the Moon's rotation around the Earth causes ocean tides.

Chemical composition of the earth crust

Compound	Formula	Composition	
		Continental	Oceanic
Silica	SiO_2	60.2%	48.6%
Alumina	Al_2O_3	15.2%	16.5%
Lime	CaO	5.5%	12.3%
Magnesia	MgO	3.1%	6.8%
Iron(II) oxide	FeO	3.8%	6.2%
Sodium oxide	Na_2O	3.0%	2.6%
Potassium oxide	K_2O	2.8%	0.4%
Iron(III) oxide	Fe_2O_3	2.5%	2.3%
Water	H_2O	1.4%	1.1%
Carbon dioxide	CO_2	1.2%	1.4%
Titanium dioxide	TiO_2	0.7%	1.4%
Phosphorus pentoxide	P_2O_5	0.2%	0.3%
Total		**99.6%**	**99.9%**

O My God!

The diameter of the Earth at the equator is 43 km (27 mi) larger than the pole-to-pole diameter. Thus the point on the surface farthest from Earth's center of mass is the summit of the equatorial Chimborazo volcano in Ecuador. The average diameter of the reference spheroid is 12,742 km (7,918 mi). The maximum deviations of radius of sphere: 0.17% at the Mariana Trench 10,911 m (35,797 ft) below SL, while 0.14% at Mt. Everest 8,848 m (29,029 ft) above SL.

About 71% of Earth's surface is covered with water, mostly by its oceans namely, Pacific, Atlantic, Indian, Arctic and Antarctic. The remaining 29% is land consisting of seven continents, namely Asia, Europe, Africa, North America, South America, Australia, Antarctic and islands that together have many lakes, rivers and other sources of water that contribute to the hydrosphere. The Earth's poles are covered in ice (Antarctic Ice sheet and sea ice of the Arctic ice pack). Earth's interior with a solid iron inner core and a liquid outer core generates the magnetic field. Earth's lithosphere has several rigid tectonic plates that migrate across the surface driven by mantle over periods of many millions of years.

1.2 EARTH AND GEOGRAPHY

Before knowing the anatomy of earth (basic geology), what is known as 'in and out' of the earth, we now need to know a little geography to understand the earth.

For the ease of study, Earth is divided by 180^{o} (90^{o} on either side are poles) horizontal imaginary lines called latitudes. The middle one, called equator (0^{o}) divides into two halves as Northern Hemisphere (NH) and Southern Hemisphere (SH). At 23° (Approx.) on either side we call Tropic of Cancer (N) and Tropic of Capricorn (S) respectively.

1.2.1 Axial Tilt: The Reason for Season

The Earth is axially tilted by 23.44° (approx.) with the axis of its orbit plane, always pointing towards the celestial poles. Due to this tilt, the amount of sunlight falling on any point on the surface changes over the year, thereby causing the seasonal change as summer in the NH when the Tropic of Cancer faces the Sun, while winter to Tropic of Capricorn in SH, and reverse in other half of the year. During the summer, the day lasts longer, and the Sun appears to move higher in the sky. In winter, the climate becomes cooler and the days are shorter. In northern temperate latitudes, the Sun rises north of true east during the summer solstice, and sets north of true west, reversing in the winter. The Sun rises south of true east in the summer for the southern temperate zone and sets south of true west.

Above the Arctic region (N. Pole), an extreme case i.e., no daylight at all for 6 months, called a polar night. In the SH, the situation is exactly reversed,

with the S. Pole. Six months later, this pole will have a midnight sun, a day of 24 hours, again reversing with the S. Pole.

By astronomical convention, the 4 seasons can be determined by the solstices. In the NH, winter occurs around 21 December; summers near 21 June, spring is around 20 March and autumn is about 22 or 23 September. In the SH, the situation is reversed, with the summer and winter solstices exchanged and the spring and autumnal equinox dates swapped.

O My God!

1. Earth orbits around Sun about 150 million km (93 million mi)
2. Earth rotates in 365.2564 mean solar days, or 1 Sidereal Yr.
3. Orbital speed is about 29.78 km/s (107,200 km/h; 66,600 mph)
4. Earth's diameter is about 12,742 km (7,918 mi)
5. Solar System in Milky-way orbits about 28,000 LY from its center
6. It is about 20 LY above the Galactic plane in the Orion Arm
7. During the Devonian period (410 Mya) a year had 400 days & each day was 21.8 hrs.

1.2.2 Geographic History

It is believed that Earth's atmosphere and oceans were formed by volcanic activity and out-gassing which included water vapor. The oceans originally formed by condensation augmented by water and ice delivered by asteroids, proto-planets, and comets. By 3.5 Gya (Billion years ago), magnetic field was established that prevented the atmosphere stripping away. Continents formed by plate tectonics along with continuous loss of heat from Earth's interior. About 750 Mya (million years ago) supercontinents broke and recombined. The present pattern began about 40 Mya. High-latitude regions undergo repeated cycles of glaciations (every 40,000–100000 yrs) and the last continental glaciations occurred 10,000 years ago.

Do You Know?

The orientation (rather than the angle) of Earth's axis also changes over time, with precision in around 25,800 yr cycle due to which a sidereal year is differing from a tropical year. Both of these motions are due to variations in attraction of the Sun, Moon and Earth's equatorial bulge. The poles also migrate a few meters across Earth's surface. In addition to this motion, there is a 14-month cycle called the Chandler Wobble. Earth's rotational velocity also varies, known as length-of-day variation. Further, Earth's perihelion occurs around 3 Jan, and its aphelion around 4 July subject to the precession and other orbital factors following the cyclical patterns called Milankovitch cycle.

1.2.3 Internal Structure and Composition

The mass of Earth is approximately 5.97×10^{24} kg (5,970 Yg), mostly composed of iron (32.1%), oxygen (30.1%), silicon (15.1%), magnesium (13.9%), sulphur (2.9%), nickel (1.8%), calcium (1.5%) and aluminum (1.4%) and 1.2% trace elements. The core is composed of iron (88.8%) with small amounts of nickel (5.8%), sulfur (4.5%) and less than 1% trace elements. Mostly rock constituents are oxides of chlorine, sulfur, and fluorine along with silica, alumina, iron oxides, lime, magnesia, potash and soda.

Earth's outer layer is silicate solid crust along with tectonic plates upon a highly viscous solid mantle (called lithosphere) separated by the Moho. The thickness of the crust varies from about 6 km (under the oceans) to 30–50 km (for lands). Under this, a relatively low-viscosity layer, the asthenosphere consists

of the upper and lower mantle at 410-660 km below the surface. Below this, there is an extremely low viscous liquid outer core underlain by a solid inner core. The detailed study is given in the section 1.5 of this chapter.

Earth gets external heat from sun and other celestial bodies while it gets internal heat from a combination of residual heat from planetary accretion (about 20%) and radioactive decay (80%), mainly of isotopes K-40, U-238 and Th-232. At the center, the temperature may be up to 6,000 °C (10,830 °F), and the pressure could reach 360 GPa.

1.3 ENVIRONMENT–ATMOSPHERE–WEATHER– CLIMATE

Environment of a region refers to its surroundings or conditions in which a person, animal, or plant lives or operates. It speaks about the natural world, as a whole or in a particular geographical area, especially as affected by human activity. Thus environment is a broader term that includes not only atmosphere, but also the surroundings and their states and conditions. The **natural environment** includes complete ecological functions of all living and non-living things such as all vegetation, microorganisms, soil, rocks, water, atmosphere in all forms and states occurring as natural phenomena (not artificial) and covers all the interaction of all living species, climate, weather and natural resources that affect human survival and economic activity. The term is most often applied to the Earth (or planets or celestial bodies such as stars) or some parts of Earth.

Atmosphere (in Greek, atmos means 'vapour', and sphaira, means 'sphere') is a layer of gases surrounding a planet or a material body due to gravity. Atmosphere is a subset of environment.

The atmosphere of the Earth is mostly composed of Nitrogen (about 78%), Oxygen (about 21%), Argon (about 0.9%) with carbon dioxide and other dust and gases traces. Oxygen is mainly used by most organisms for respiration, nitrogen by bacteria and to produce ammonia used in the construction of nucleotides and amino acids and carbon dioxide is used by plants, algae and cyano-bacteria for photosynthesis. The atmosphere helps protect living organisms from genetic damage by solar UV radiation, solar wind and cosmic rays.

Weather is the state of the atmosphere, to the degree of hotness or coldness, wet or dry, calm or stormy, clear or cloudy etc., and mostly occurs in the lowest level of the atmosphere i.e., the troposphere, below the stratosphere. It also refers to day-to-day temperature and precipitation, while climate is the term for the averaging of atmospheric/weather conditions over longer periods of time.

Weather is governed by differences of air pressure, temperature and moisture between places which occur due to the sun's angle, latitude and other reasons discussed in the above paragraphs of this chapter.

Climate is the statistics of weather assessed the variation patterns of temperature, humidity, pressure, wind, precipitation, atmospheric particle count and other meteorological variables in a given region over long periods. A region's climate is described by five components, viz. atmosphere, hydrosphere, cryosphere, lithosphere and biosphere. Climate differs from weather in terms of time frame i.e. weather refers to short-term conditions of these variables in a given region while climate refers long term conditions. The following table distinguishes between weather and climate clearly.

The climate of a location is affected by its latitude, terrain, altitude and water bodies and their currents. Climates are classified based on the average ranges of temperature and precipitation. The most common classification is given by Koppen-Gieger. Paleoclimatology is the study of ancient climates.

Distinction between Weather and Climate		
No	**Weather**	**Climate**
1.	It is a short-term phenomenon	It is long-term phenomenon
2.	The state of the atmosphere, to the degree of hotness or coldness, wet or dry, calm or stormy, clear or cloudy etc.	The statistics of weather assessed by variation patterns in temperature, humidity, pressure, wind, precipitation, atmospheric particle count etc., in a region over long period.
3.	Described by temperature, pressure and humidity due to sun's angle, latitude and other reasons	Described by changes of temperature and pressure in 5 components, viz., Atmosphere, hydrosphere, cryosphere, lithosphere and biosphere.
4.	Study of weather is Meteorology	Study of climate is climatology
5.	It is an information of instantaneous conditions	It is an information of averaging conditions

1.3.1 Classification of Climate

Koppen-Gieger classified the climates in five broad groups as given below. However, these may be further divided into more specific subtypes based on temperature and precipitation.

(i) Humid tropics (ii) Arid

(iii) Humid middle latitudes (iv) Continental

(v) Cold polar

Since the amount of solar energy reaching Earth's surface decreases with increasing latitude, perhaps, the simplest way of classifying the climates is

based on the latitudes of the region. At higher latitudes, the sunlight reaches the surface at lower angles, and it must pass through thicker columns of the atmosphere. As a result, the mean annual air temperature at Sea Level (SL) decreases by about 0.4°C (0.7°F) per degree of latitude from the equator. Earth's surface can be subdivided into specific latitudinal belts (equator to the poles) with nearly homogeneous climate as; these are

- Tropical (or equatorial) climate
- Subtropical climate
- Temperate climate
- Polar climate

1.3.2 Factors Influencing Climate (in addition to latitude factor)

Undoubtedly, climate is largely influenced by the latitude and the tilt of the earth and the climate of a region is characterized by the latitudinal aspects and features as discussed above. Though the climate can be described based on the latitudes, yet there are several anomalies, which may attributed to the local conditions and other reasons. The following are a few:

- **Nearness to oceans:** Proximity to oceans moderates the climate e.g., Scandinevian region has more moderate climate than at similar northern latitudes of N.Canada.
- **The wind direction effect:** The windward side of land gets more moderation than the leeward side. In the N. Hemisphere; the wind is west-to-east, and so western coasts would be milder than eastern. In the S. Hemisphere, wind is east-to-west, and so eastern coasts are milder.
- **The distance from the Earth to the Sun variation:** The Earth is closest to the Sun (at perihelion) in January, which is summer in the S. Hemisphere; winter for N. Hemisphere. Similarly, it is furthest away (at aphelion) in July, and so is summer in the N. Hemisphere and winter in South. Only 93.55% solar radiation of Sun falls on a given square area of land than at perihelion.
- **The heat transfer variation between land and ocean regions:** Land gets heated faster and cools faster while water gets heated slower and cools slower. This heat transfer variation makes a lot of difference in the climate. We know that there is larger land mass in the N. Hemisphere, and thence easier to heat than the seas. Consequently, summers are 2.3 °C (4 °F) warmer in the N. Hemisphere than in the Southern Hemisphere under similar conditions.
- **Altitude from Sea Level (SL):** The climate is colder at high altitudes than at sea level because of the decreased air density.
- **Tilted Earth and angle of incidence of sun rays:** Since the Earth is slightly tilted, the sun rays will not be at same angle at all places. This also, influences the climate considerably.

The highest air temperature ever measured on Earth was 56.7 °C (134.1 °F) in Furnace Creek, California in Death Valley, in 1913. The lowest air temperature measured on Earth was –89.2 °C (–128.6 °F) at Vostok Station in 1983, but satellites records read lowest at –94.7°C (–138.5 °F) at 81.8°S 59.3°E, along a ridge between Dome Argus and Dome Fuji, at 3,900 m elevation.

Above the troposphere, the atmosphere up to Karman line (supposed as boundary between atmosphere and outer space) about 100 km up is usually divided into the stratosphere, mesosphere, thermosphere exosphere and magnetosphere. These are described at length in the sections 1.4 and 1.5 of this chapter to follow.

SELF ASSESSMENT INTERMISSION (SAI – 1.1)

1. What do you understand by the terms 'Ecological System' and 'Ecological Balance'? Discuss what happens if ecological imbalance occurs?
2. Give a brief account of Geography and Ecology of Earth.
3. Do you think ecological balance is the key to disaster control? Justify.
4. Describe briefly, the formation of Earth and its geography and its environment.
5. Define and distinguish the terms environment, atmosphere, climate and weather.
6. What are the effects of axial tilt of the Earth in its rotation?
7. Give briefly, the internal structure of the Earth.
8. Distinguish between Climate and Weather.
9. What are the five components of climate? Give brief notes.
10. What are the factors influencing climate of a region? Explain briefly.
11. What is meant by atmosphere? How is it different from weather?

1.4 THE SPHERES OF EARTH

No doubt, the Earth is big sphere, but there are many big spheres on the Earth, virtually revolving around it. To get an overview of the Earth, we should understand these spheres listed below.

1. Pedosphere – concerned with the surface of Earth
2. Hydrosphere – related to the waters on Earth
3. Cryosphere – speaks about the icy regions on Earth
4. Atmosphere – connected to the weather, climate and all about air on Earth
5. Magnetosphere – means the magnetism of the Earth
6. Biosphere – The Life on the Earth

We shall now discuss about the above spheres in brief.

1.4.1 Pedosphere – The Superficial Earth

The Earth's TSA is about 510 million km^2 (197 million sq mi) of which 70.8%, i.e. 361.13 million km^2 (139.43 million sq mi), is under (sea/ocean) water containing continental shelf, mountains, volcanoes, oceanic trenches, submarine canyons, oceanic plateaus, abyssal plains, and a globe-spanning mid-ocean ridge system. The remaining 29.2% (148.94 million km^2, or 57.51 million sq mi) varies greatly from place to place and consists of mountains, deserts, plains, plateaus, and other productive and non-productive landforms. However, the tectonics, erosion, volcanic eruptions, flooding, weathering, glaciations, the growth of coral reefs, and meteorite impacts are those some of which reshape the Earth's surface over geological time.

The continental crust consists of lower density material such as the igneous rocks granite and andesitic with some basalt (a denser volcanic rock), sedimentary and metamorphic rock while the pedosphere (surface) is most abundant with soil containing silicate minerals such as quartz, feldspar, mica, etc along with carbonates like lime stone (calcite), dolomite etc.

The elevation of the land surface varies from the low point of –418 m at the Dead Sea, to a maximum altitude of 8,848 m at the top of Mount Everest while the mean height is 840 m above SL.

The total arable land is 10.9% of the land surface, with 1.3% being permanent cropland. Close to 40% of Earth's land surface is used for cropland and pasture, or an estimated 1.3×10^7 km^2 of cropland and 3.4×10^7 km^2 of pastureland.

1.4.2 Hydrosphere – The Wet Globe

The abundance of water distinguishes the Earth as "Blue Planet" from other planets of the Solar System. Earth's hydrosphere is composed of oceans (major portion-nearly 1.35×10^{18} MT i.e. 1/4400 of total Earth's mass) along with inland seas, lakes, rivers, creeks and underground waters such as wells and springs down to a depth of 2,000 m. The deepest (10,911.4 m) underwater location is Challenger Deep of the Mariana Trench in the Pacific Ocean. The oceans cover an area of 3.6×10^8 km^2 with a mean depth of 3682 m, resulting in an estimated volume of 1.332×10^9 km^3. About 97.5% of the water is saline and only 2.5% is fresh water. Most fresh water, about 68.7%, is present as ice in ice caps and glaciers. The average salinity of oceans is about 35 g/kg of sea water (3.5% salt) most of which was released from volcanic activity or cool igneous rocks. Shifts in the oceanic temperature distribution can cause significant weather shifts, such as the El-Nino (Southern shift) and La-Nino (Northern shift).

1.4.3 Cryosphere – The Cool World

The **cryosphere** (cryo refers to "cold, frost or ice" and sphere means "globe or ball") refers to those portions of Earth's surface where water is in solid form, such as sea/lake/river ice, snow cover, glaciers, ice caps/sheets, and frozen ground including permafrost. Thus, it is an integral part of the global climate system that widely overlaps with the hydrosphere. It influences surface energy and moisture fluxes, clouds, precipitation, hydrology, atmospheric and oceanic circulation. Cryology is the study of cryospheres.

1.4.4 Atmosphere – The Sphere of Air

The Earth's surface has an atmosphere averaging 101.325 KPa with a scale height of about 8.5 km. It has a composition of 78% N_2 and 21% O_2, with traces of H_2O and CO_2, and other gaseous molecules. The height of the troposphere varies with latitude, ranging between 8 km at the poles to 17 km at the equator, with some variation resulting from weather and seasonal factors. The detailed discussion is given in section 1.5 of this chapter. However, an overview is given here below.

Strictly speaking, there is no definite boundary to Earth's atmosphere as it slowly becomes thinner and fades into outer space. About ¾ of the atmosphere's mass is within the first 11 km (6.8 mi) of the surface, called the troposphere (lowest layer). Energy from the Sun heats this layer (and the surface below) causing expansion of the air. Obviously, this lower-density air rises up replaced by cooler, higher-density air, which is known as atmospheric circulation that governs the weather and climate through redistribution of thermal energy. These circulation bands are known to be trade winds in the equatorial region below 30° latitude and the westerlies in the mid-latitudes (30°–60°). In addition to this the weather and climate is characterized by Ocean currents and particularly the thermohaline circulation (distribution of thermal energy from the equatorial oceans to polar oceans).

Water vapor through surface evaporation moves up into atmosphere in circulatory patterns and as the conditions favour for an uplift of warm, humid air, this water condenses and precipitates to fall on the surface. This precipitation fall depends on atmospheric circulation, topographic features, and temperature differences of the given region. Most of the fallen water is then flows down by river systems and usually returned to the oceans or lakes. This water cycle is a vital for life on land and at the same time a chief factor of erosion.

1.4.5 Magnetosphere – The Attractive World

The extent to which Earth's magnetic field is felt can be termed as the magnetosphere. Since the solar rays are electromagnetic waves, the ions and electrons of the solar wind are deflected by the magnetosphere. So, the solar wind pressure compresses the dayside of the magnetosphere, while extends the night-side magnetosphere into a long tail. This considerably changes the climatic conditions in several ways.

During magnetic storms, the charged particles get deflected from the outer magnetosphere (magneto-tail), directed along field lines into Earth's ionosphere, where atmospheric atoms can be excited and ionized, causing the Aurora.

Magnetic field

The Earth's magnetic field is generated in the core and extends outwards through the mantle, and up to Earth's surface, where it is, approximately, a dipole located close to Earth's geographic poles (The Earth's Geographic North is its Magnetic South and vice-versa). At the equator of the magnetic field, the magnetic-field strength at the surface is 3.05×10^{-5} T, with global magnetic dipole moment of 7.91×10^{15} T-m^3.

Gravitational field

The gravity of Earth causes the acceleration to objects due to the distribution of mass within the Earth. On the surface of Earth the acceleration due to gravity is about 9.81 m/s^2 or 32 ft/s^2 which may vary according to the height, depth, latitude, topographic and geological conditions. However, the gravitational constant described by Newton's law of universal gravitation (the force of attraction between any two bodies is directly proportional to their product of masses and is inversely proportional to the square of the distance between their centers) is given by $G = 6.674 \times 10^{-11}$ m^3 kg^{-1} s^{-2}.

1.4.6 Biosphere – The Lively World

A planet is said to be habitable if it can sustain life, even though life did not originate there. The total of the planet's life inhabit ecosystems is often called "biosphere". Earth provides liquid water environment where complex organic molecule can assemble and interact with metabolism on getting sufficient energy. Great the God's creation! The distance of Earth from the sun, its orbital eccentricity, rate of rotation, axial tilt, geological history, cycling hydrosphere,

sustaining atmosphere, and magnetic field all together contribute to the current living climatic conditions (habitable) at the surface.

Estimation of human land use (2000)	
Land use	**Mha**
Cropland	1,510–1,611
Pastures	2,500–3,410
Natural forests	3,143–3,871
Planted forests	126–215
Urban areas	66–351
Unused, productive land	356–445

The air on the earth has large influence on its biosphere while the life on Earth's has a significant impact on its atmosphere. Earth's biosphere is believed to have started about 3.5 Gya.

It is believed that the outcome of Oxygenic photosynthesis about 2.7 Gya is today's nitrogen–oxygen atmosphere, creation of aerobic organism and also the Ozone layer that permits living-hood by stopping UV radiation as well as burning up small meteors before they strike the surface, and moderating temperature. This last phenomenon is known as the Greenhouse Effect. The trace molecules such as water vapor, carbon dioxide, methane, nitrous oxide (precisely called greenhouse gases) in the atmosphere capture thermal energy emitted from the ground and thence raise the mean temperature. Without this heat-retention effect, the mean surface temperature would have been "18 °C, instead of today's +15 °C, and life on Earth probably would not exist like what is today.

The biosphere is divided into a number of biomes, inhabited by broadly similar plants and animals. On land, biomes are separated primarily by differences in latitude, height above SL, humidity and so forth. About 7½ billion humans survive on Earth and depend on its biosphere and minerals. Humans have developed diverse societies and cultures. Politically, the globe has about 200 countries.

Humans discovered the Earth's natural non-renewable resources (which can only renew over geological timescales) such as fossil fuels in the form of solids (coal), liquids (petroleum), and gases (natural gas). Also humans found mineral bodies on the earth crust for various applications. Earth's biosphere produces many useful biological products for humans, like food, fuel, wood, medicines and the recyclable organic wastes. The land-based ecosystems depend on topsoil and fresh water, while the oceanic ecosystems depend on dissolved nutrients washed down from the land.

SELF ASSESSMENT INTERMISSION (SAI – 1.2)

1. What do you understand by the terms 'Pedosphere' and 'Biosphere'? Discuss.
2. Distinguish between Hydrosphere and Cryosphere of the Earth. Describe the significance of their existence on the earth.
3. What is atmosphere? What are its components? How is useful to the livelihood?
4. What is magnetosphere? What is its significance on the earth?
5. What do you understand by the term 'Biosphere'? Explain in detail.

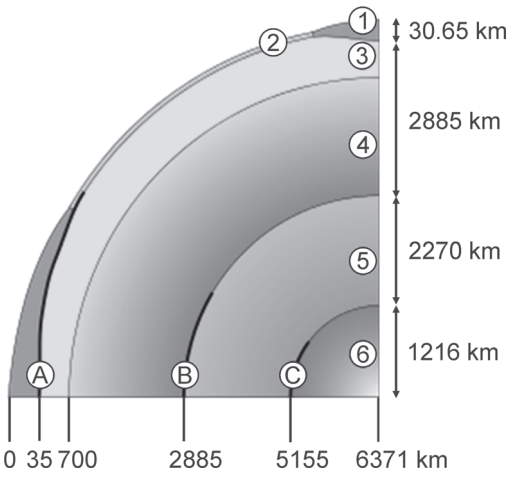
1.5 THE ANATOMY OF THE EARTH

The sequence of the principal layers is as shown in the following figure:

Above From Earth	Below From Earth
1. Crust	1. Crust
2. Troposphere	2. Lithosphere
3. Atmosphere	3. Aesthenosphere
4. Stratosphere	4. Upper Mantle
5. Mesosphere	5. Mantle
6. Thermosphere	6. Outer Core
7. Exosphere	7. Inner Core

A: Mohorovic discontinuity – B: Gutenberg discontinuity – C: Lehmann–Bullen discontinuity.

1.5.1 Principal Layers



The earth is made up of several layers in spherical shells like an onion or cabbage, with distinguishable structure characterized by their physical/chemical or rheological properties. Let us understand these layers starting from the space toward the centre of the Earth.

The region above the Earth's surface, up to the space, is filled with the air having a set of spherical layers is often referred to as the atmosphere. Generally, air pressure and density decrease with altitude in this atmosphere. Of course, the temperature has a complicated profile with altitude, and may remain relatively constant or even increase with altitude in some regions. With reference to these changes, the Earth's atmosphere can be classified (called atmospheric stratification) into five main layers from highest to lowest, as given below:

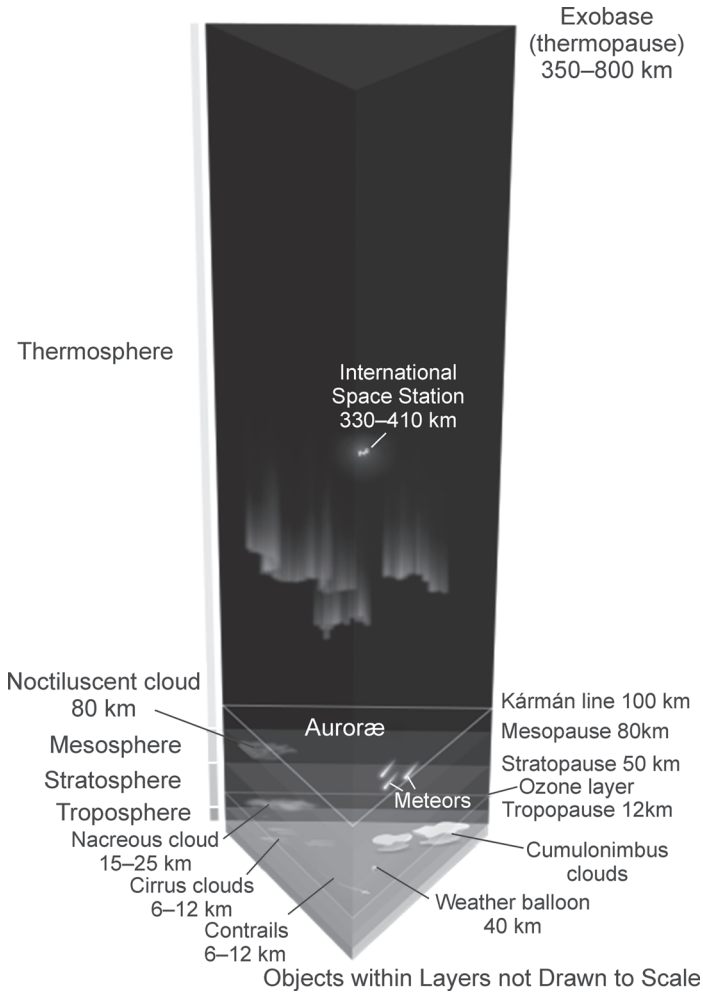
1. Exosphere: 700 to 10,000 km (440 to 6,200 miles)
2. Thermosphere: 80 to 700 km (50 to 440 miles)
3. Mesosphere: 50 to 80 km (31 to 50 miles)
4. Stratosphere: 12 to 50 km (7 to 31 miles)
5. Troposphere: 0 to 12 km (0 to 7 miles)

Do You Know?

14 Lokas according to Hindu Myths

As per Hindu myths there are 14 Lokas, 7 on upper side of the Earth while 7 on downside. The seven upper lokas are Bhulok, Bhuvarlok, Suvarlok, Maharlok, Thapolok, and Sathyalok. The lower seven are Athala, Vithala, Suthala, Mahaathala, Thalaathala, Rasathala and Pathaala lokas.

Perhaps! These are the seven layers on either sides (above and below) the earth crust.



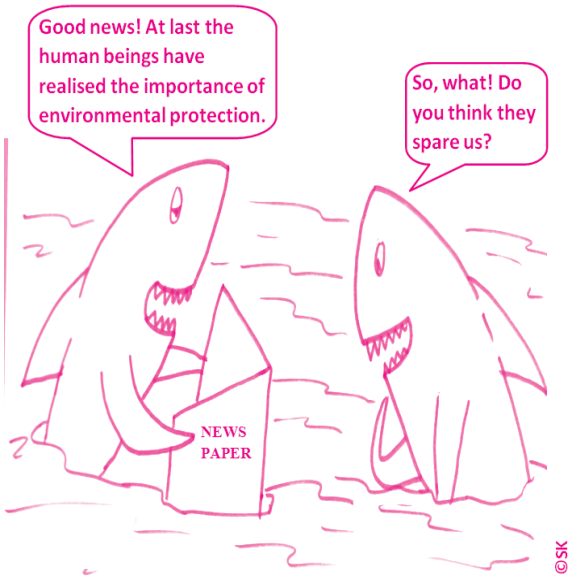
1.5.2 Exosphere

The exosphere is the outermost layer (i.e. the upper limit) extends from the exobase located at the top of the thermosphere at a height of about 700 km above SL, to about 10,000 km (6,200 miles; 33,000,000 ft). The exosphere merges with the vacuum of outer space, where there is no atmosphere.

Do You Know?

The exosphere is located too far above Earth for any meteorological phenomena to be possible. However, the aurora borealis and aurora australis sometimes occur in the lower part of exosphere, when they overlap into the thermosphere. The exosphere contains most of the satellites orbiting Earth.

This layer chiefly consists of very low densities of hydrogen, helium and some heavier molecules including nitrogen, oxygen and carbon dioxide closer to the exobase. Strictly speaking, the exosphere does not behave like a gas, and the particles constantly escape into space, because the atoms and molecules are so far apart that they can travel hundreds



of kilometres without colliding with one another. These free-moving particles follow ballistic trajectories and may migrate in and out of the magnetosphere.

1.5.3 Thermosphere and Ionosphere

The thermosphere is the second-highest layer of Earth's atmosphere extending from the mesopause (which separates it from the mesosphere) at a height of about 80 km (50 miles; 260,000 ft) up to the thermopause (also called exobase as it is lower boundary of exosphere) at a height range of 500–1000 km (310–620 miles; 160,000–330,000 ft). The lower part of the thermosphere, from 80-550 km (50-342 miles) above Earth's surface, contains the ionosphere.

Gradual increase in temperature (as high as 1500°C or 2700 °F) with height is seen in this layer. Unlike the stratosphere, (temperature inversion is due to the radiation absorption by ozone), the inversion in the thermosphere occurs due to the extremely low density of its molecules. The air is so rare fied that an individual molecule can travel an average of 1 km (0.62 mile; 3300 ft) without collisions. This layer is completely cloudless and free of water vapour. However the aurora borealis and aurora australis are occasionally seen in the thermosphere. The International Space Station orbits in this layer, between 320 and 380 km (200 and 240 mi).

Do You Know?

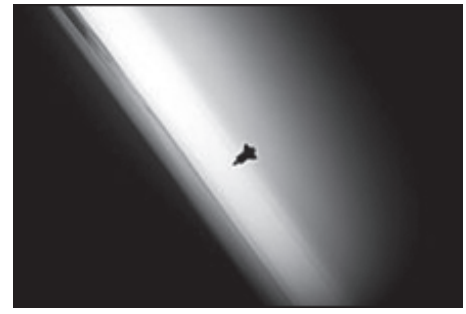
Even though the thermosphere has a very high proportion of molecules with immense amounts of energy, it would not feel hot to a human skin because the low density in the thermosphere would not be able to conduct a significant amount of energy to or from the skin. In other words, a person would not feel warm because of the thermosphere's extremely low pressure.

1.5.4 Mesosphere

The mesosphere is the third highest layer of Earth's atmosphere, occupying the region above stratosphere and below thermosphere i.e., from the stratopause at a height about 50 km (31 miles; 160,000 ft) to the mesopause at 80–85 km (50–53 miles; 260,000–280,000 ft) above sea level.

Temperatures drop with increase in height to the mesopause that marks the top of this middle layer of the atmosphere. It is the coldest place on Earth (an average temperature around "85°C; "120°F; 190 K). These are the highest

clouds in the atmosphere visible to the naked eye if sunlight reflects off them about an hour or two after sunset or before sunrise (i.e. when Sun is around 4° to 16° below the horizon). This type of lightning referred to as either SPRITES or ELVES occasionally form far above tropospheric thunderclouds. The mesosphere is mainly accessed by sounding rockets. Be happy! The mesosphere is also the layer where most meteors burn up upon atmospheric entrance.



1.5.5 Stratosphere

The stratosphere is the second-lowest layer of Earth's atmosphere, above the troposphere (about 12 km; 7.5 miles; 39,000 ft above Earth's surface) separated by the tropopause to the stratopause at a height about 50 to 55 km (31 to 34 miles; 164,000 to 180,000 ft).

The pressure at the top of the stratosphere is around 1/1000 of that at sea level. It consists of the ozone layer, which is the part of Earth's atmosphere. In this layer also temperatures rise with increasing height. But, this rise is due to the absorption of ultraviolet radiation (UV) radiation from the Sun by the ozone layer, which restricts turbulence and mixing. What a wonderful Earth!

Although the temperature may be "60°C" ("76°F; 210K") at the tropopause, the top of the stratosphere is much warmer, and may be near 0 °C. The stratosphere is almost free of clouds rarely nacreous clouds are seen in the lower part where the air is coldest. Perhaps! This is the highest layer that can be accessed by an aircraft.

1.5.6 Troposphere

The troposphere is the lowest layer of Earth's atmosphere, distributed from Earth's surface to an average height of about 12 km; this height actually varies from 9 km (30,000 ft) at the poles to 17 km (56,000 ft) at the equator, with some variation due to weather. The troposphere is bounded above by the tropopause, a boundary marked in most places by a temperature inversion (i.e. a layer of relatively warm air above a colder one), and in others by a zone which is isothermal with height.

Although variations occur, the temperature usually declines with increasing altitude in the troposphere because the tropospheric heat is through energy transfer from the surface. Thus, the lowest part of the troposphere (i.e. Earth's surface) is typically the warmest section of the troposphere. This promotes

vertical mixing. The troposphere contains roughly 80% of the mass of Earth's atmosphere. The layer is denser than all its atmospheric layers because a larger atmospheric weight sits on top of the troposphere and causes it to be most severely compressed. Fifty percent of the total mass of the atmosphere is located in the lower 5.6 km (18,000 ft) of the troposphere. It is primarily composed of nitrogen (78%) and oxygen (21%) with only small concentrations of other trace gases. Most of Earth's weather is due to the water vapour or moisture that comes from the surface and is basically all the weather-associated cloud genus by active wind circulation. Most conventional aviation activity takes place in the troposphere, and is the only layer accessed by propeller-driven aircraft.

Fig: Space Shuttle Endeavour orbiting in the thermosphere. Because of the angle of the photo, it appears to straddle the stratosphere and mesosphere that actually lie more than 250 km below. The orange layer is the troposphere, which gives way to the whitish stratosphere and then the blue mesosphere.

1.5.7 Other Layers

Within the five principal layers that are largely determined by temperature, several secondary layers may be distinguished by other properties:

- The ozone layer about 2 to 8 ppm, at the lower portion of the stratosphere from about 15–35 km (9.3–21.7 miles; 49,000–115,000 ft), being about 90% in the stratosphere.
- The ionosphere is ionized by solar radiation, is responsible for auroras. During daytime hours, it stretches from 50 to 1,000 km (31 to 621 miles; 160,000 to 3,280,000 ft) and includes by the mesosphere, thermosphere, and parts of the exosphere.
- The homosphere and heterosphere are defined by whether the atmospheric gases are well mixed. This relatively homogeneous layer ends at the turbopause i.e. at about 100 km (62 mi; 330,000 ft), which places it about 20 km (12 mi; 66,000 ft) above the mesopause. Above this height lies the heterosphere, which includes the exosphere and most of the thermosphere.
- The planetary boundary layer is the part of the troposphere closest to Earth's surface. The depth of this layer ranges from as little as about 100 meters on clear/calm nights to 3000 m or more during the afternoon in dry regions.

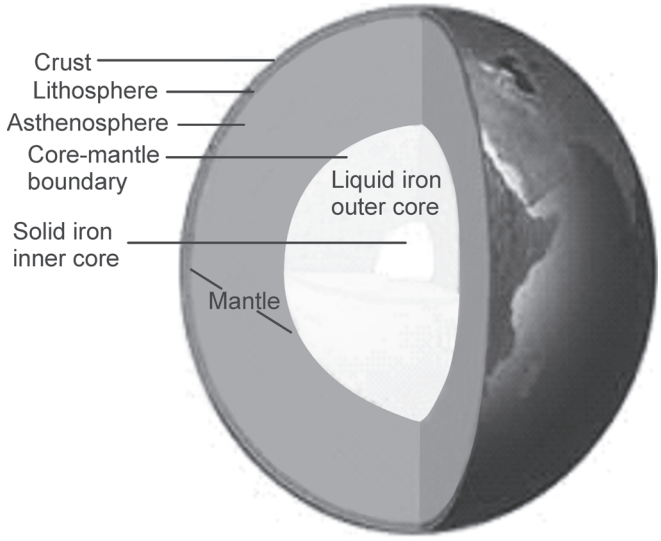
The average temperature of the atmosphere at Earth's surface is 14 °C (57 °F; 287 K) or 15 °C (59 °F; 288 K), depending on the reference.

SELF ASSESSMENT INTERMISSION (SAI – 1.3)

1. What do you understand by the terms 'Anatomy of Earth'? What are its constituents? Discuss.
2. What is "Earth's Atmosphere"? How do you classify it?
3. What is Stratification of Earth's atmosphere? Discuss briefly each layer.
4. What are mesosphere and stratosphere?
5. What are thermosphere and ionosphere? Brief out.
6. What are troposphere and exosphere? What differences do you observe between these two?
7. Distinguish between homosphere and heterosphere. Write a note on atmosphere of earth.
8. What are mesopause, tropopause, stratopause and exobase?
9. List out and briefly describe the principal layers of atmosphere above the earth.
10. Write short notes on (a) Mesosphere (b) Stratosphere (c) Thermosphere (d) Troposphere

1.6 STRUCTURE OF EARTH

Scientific understanding based on topography and bathymetry, observations of rock, volcanic material, analysis of the seismic waves, measurements of gravitational and magnetic fields and so forth, the Earth has an outer silicate solid crust, a highly viscous mantle, a liquid outer core (much less viscous than mantle), and a solid inner core.



The structure of Earth can be defined in two ways: by mechanical or chemical properties. Mechanically, it can be divided into lithosphere, asthenosphere, mesospheric mantle, outer core, and the inner core. Chemically, Earth can be divided into the crust, upper mantle, lower mantle, outer core, and inner core. We shall discuss about these in detail now.

1.6.1 Crust

The crust is the outermost layer ranging from 5–70 km (3–44 miles) in depth. The oceanic crust is thin underlying the ocean basins (5–10 km) and are

Depth		Layer
Kilometers	Miles	
0–60	0–37	Lithosphere (varies between 5 and 200 km)
0–35	0–22	… Crust (varies between 5 and 70 km)
35–60	22–37	… Uppermost part of mantle
35–2,890	22–1,790	Mantle
100–200	210-270	… Upper mesosphere (upper mantle)
660–2,890	410–1,790	… Lower mesosphere (lower mantle)
2,890–5,150	1,790–3,160	Outer core
5,150–6,360	3,160–3,954	Inner core

composed of dense iron, magnesium, silicate, igneous rocks (called mafic), like basalt. The continental crust is thicker but less dense and composed of sodium, potassium, aluminium, silicate rocks (called felsic), like granite. The rocks of the crust fall into two major categories – sial (**si**licon and **al**uminium) and sima (**si**licon and **ma**gnesium) that starts about 11 km below the Conrad discontinuity (2nd order discontinuity). The uppermost mantle along with the crust constitutes the lithosphere (rocky layer). The crust-mantle boundary occurs as two physically different events. First, there is a discontinuity in the seismic velocity, which is known as the Mohorovièiæ discontinuity or Moho due to change in rock composition from rocks containing plagioclase feldspar (above) to rocks that contain no feldspars (below). Second, in oceanic crust, there is a chemical discontinuity between ultramafic cumulates and tectonized harzburgites, at deep parts of the oceanic crust.

[Many rocks now making up Earth's crust formed less than 100 million (1×10^8) years ago; however, the oldest known mineral grains are 4.4 billion (4.4×10^9) years old, scoping to estimate the age of the Earth].

1.6.2 Moho

Between the Earth's crust and the mantle is a boundary called the moho which portrays a major structural change. The **Mohorovièiæ discontinuity** (in short **moho**), discovered by Andrija Mohorovièiæ in 1909, is the boundary between the crust and the mantle of the Earth. He uncovered that there are two kinds of seismic waves produce earthquakes, the shallow slower wave arrives first, and a deep faster wave arrives second. This is due to the fact that the material of the mantle is different from that of the crust and deeper wave changed speed as it got just below the mantle. The discontinuity lies 30–40 km below the surface of continents, and less deep below the ocean floors.

1.6.3 Mantle

Earth's mantle is the thickest layer at a depth of 2,890 km. The upper mantle is divided into the lithosphere and asthenosphere. The upper and lower mantles are separated by the transition zone and the lowest part of the mantle next to the core-mantle boundary is known as the D3 layer where pressure is about 140 GPa (1.4 Matm). The mantle is composed of silicate rocks that are rich in iron and magnesium relative to the overlying crust. Though solid, due to the high temperatures within the mantle, the silicate material is sufficiently ductile to flow on very long timescales. As there is intense and increasing pressure the lower part of the mantle flows less easily than the upper mantle (chemical changes are also significant). The viscosity of the mantle ranges between 10^{21} and 10^{24} Pa·s, depending on depth.

1.6.4 Cores

The average density of surface material is about 3,000 kg/m^3 while that of the Earth is 5,515 kg/m^3. Hence, it can be concluded that denser matter exists within Earth's core. Seismic measurements show that the core is divided into two parts, a "solid" inner core with a radius of about 1,220 km and a liquid outer core up to a radius of about 3,400 km. The densities are between 9,900 and 12,200 kg/m^3 in the outer core and 12,600–13,000 kg/m^3 in the inner core.

The inner core, discovered by Inge Lehmann in 1936 is believed to be composed of iron and some nickel. According to his theory, in early stages of Earth's formation about four and a half billion (4.5×10^9) years ago, in a process called planetary differentiation, melting would have caused denser substances to sink toward the centre while less-dense materials would have migrated to the crust. The core is thus believed to largely be composed of iron (80%), along with nickel.

Thus, summarily, the Earth has an outer solid crust, a highly viscous mantle, a liquid outer core, and a solid inner core. The shape of the earth is an oblate spheroid, because it is slightly flattened at the poles and bulging at the equator. Further, the structure of the Earth has two distinct (physically and chemically different) separating layers. The boundaries between these layers were discovered by seismographs which showed the way vibrations bounced off the layers during earthquakes. The following are note worthy points.

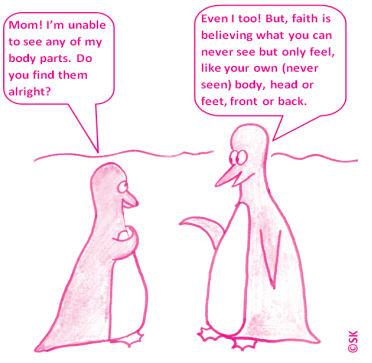
1. The **crust** is the outermost layer of the Earth mostly made of sial (silicon = Si; aluminium = Al) or felsic.
2. The **mantle** is the layer of the Earth right below the crust made of **sima** (Si + ma for magnesium) or mafic. The mantle itself is divided into layers as listed below.
   (a) The uppermost part of the mantle is solid, and is the base of the crust generally made of the heavy rock peridotite. The continental and oceanic plates together form the lithosphere plates floating on the semi-liquid asthenosphere
   (b) Upper asthenosphere: magma
   (c) Lower asthenosphere
   (d) Lower mantle
3. The **core** is made of solid iron and nickel, and is about 5000–6000°C.
   (a) **Outer core** is a liquid layer below the mantle,
   (b) **Inner core** the very center of the Earth, is very hot but solid due to the high pressure.
   With the increasing heat and pressure makes the changes in the crystallization of minerals, such that the composition might be a kind of changing mixture of liquid and crystals.
4. The change-over, called **discontinuities** between the layers are clearly distinguishable by boundaries
   (a) Moho: A boundary that separates the earth's crust and the mantle.
   (b) Guttenberg discontinuity: This is the boundary that separates the Earth's mantle and the outer core
   (c) Lehmann discontinuity: This boundary separates the inner and outer cores of the Earth.

1.7 ARE WE SAFE ON THE EARTH?

The God has created this Earth which seems to have all good conditions and climate for living. No other planet has the habitability. But at the same time, he has created the environment around capable of mass killing, large destruction and becoming disastrous. No land on the earth is 100% safe. And the five

natural forces earth, sky, water, air and fire can anytime move to extreme conditions.

1.7.1 The Present of The Earth



Large areas of Earth's surface have extreme weathers vulnerable to tropical cyclones, hurricanes/ typhoons that dominate life in those areas. (These events caused on average 11,800 human deaths per year during 1980-2000). Many places are subject to earthquakestsunamis, rockslides, mudslides, landslides, volcanic eruptions, tornados, blizzards, hot/cold waves, floods, hailstorms rainstorms, droughts, wild fires, and so on.

Many localized areas are subject to human-made air/water pollution, acid rain and toxic substances, loss of vegetation (due to overgrazing, deforestation, desertification etc.), loss of wildlife, species extinction, soil degradation, depletion, erosion and so forth. Universally agreed scientifically proven fact is global warming due to industrial (COx, SOx and NOx) emissions. Further, huge changes are predicted such as the melting of glaciersice sheets, extreme temperature ranges, significant weather fluctuation and changes in average Sea level (SL).

1.7.2 The Future of The Earth

In long-term, future of the earth, is expected to be disastrous with reference to the Sun. The following hazards are predicted (A 2008 simulation model).

- In next 1.1 Ga, solar luminosity increases by 10% and over the next 3.5 Ga by 40%.
- Surface temperature increase speeds up the inorganic CO_2 cycle,
- CO_2 concentration levels drastically go down for plants (10ppm for C4 photosynthesis) in approximately 500–900 Ma.
- Lack of vegetation leads to the loss of oxygen in the atmosphere, by which animal life becomes extinct.
- After another billion years all surface water disappear
- The mean global temperature will reach 70°C (158°F) in a billion years.
- The Earth may be habitable for another 500 Ma only.
- Nitrogen will be removed from the atmosphere in 2.3 Ga.
- Even if the Sun were eternal, 27% of the water in the oceans descends into the mantle in 1 billion years, due to reduced steam venting from mid-ocean ridges.

- The Sun becomes red giant in about 5 Ga.
- The Sun will expand to roughly 1 AU (150,000,000 km), i.e. 250 times its present radius.
- As a red giant, the Sun will lose about 30% of its mass, thence without tidal effects, Earth shifts to an orbit 1.7 AU from the Sun while the star reaches its maximum radius.
- The Sun's increased luminosity destroys life at the rate about 5,000 times of present level
- Earth's orbit will eventually decay due to tidal effects and drag, causing it to enter the Sun's atmosphere and be vaporized.

Whether the points stated in the above model are right or wrong, happen or not, it is certain that the situations predicted will very soon reach if we do not realize to save, conserve and preserve our present environment. It is high time to realize this fact and to act accordingly, otherwise our future generations will never forgive us. Of course! We cannot stop certain things which are not in our hands, but we can at least try to prevent their early arrival or postpone to the extent possible. We must set our hands together to fight against such evils and manage those aspects which are under our control.

SELF ASSESSMENT INTERMISSION (SAI – 1.4)

1. What is "the structure of the Earth"? How do you classify it?
2. What are Moho and Guttenberg and Lehmann discontinuities?
3. What are lithosphere and aesthenosphere? Briefly discuss.
4. What is mantle? What is it made up of? What differences do you observe between upper and lower mantle?
5. Distinguish between inner and outer core. Write a note on the cores of earth.
6. List out and briefly describe the principal layers below the earth's crust?
7. What are Crust, Moho, Mantles and Cores of the earth?
8. Where are Sima (or mafic), Sial (or felsic) and magma found inside the earth? What are these?
9. With reference to the earth structure write short notes on (a) Crust (b) Lithosphere (c) Discontinuities (d) Troposphere and their properties.
10. Discuss what could be the future of the Earth about a billion years later.

MINI-PROJECTS - CASE STUDIES

Search websites, books and all possible literature in print or audio/ video lectures etc., and prepare essays or presentations of the following. You discuss with your colleagues or classmates. You may conduct a competition of presentations or short-film or documentary etc.

Many natural disasters occurred in past 100 years. Search and browse them to list out the top ten. As a sample, three of the worst events of their kind are given below. Prepare a presentation for each of the following.

1. **Indian Ocean Tsunami:** The December 26, 2004 tsunami was triggered by a 9-magnitude quake under the Indian Ocean, near Sumatra. It had the energy of 20,000+ Hiroshima-type A-bombs. Across 15 countries over 230,000 were estimated to have lost their lives and 1.69 million displaced. Damages were estimated to be about $10 billion.
2. **Bhola Cyclone:** Considered to be the deadliest tropical cyclone ever, Bhola hit the then East Pakistan coast on November 12, 1970. Over 5 lakh people died. According to World Bank the estimated cost of rebuilding the ravaged areas was $188 million (1970 figure). Government mismanagement over relief operations was one of the reasons for the birth of Bangladesh.
3. **China Floods:** It was actually a series of floods that caused damage across central China during the summer months of 1931. Water levels in rivers had risen dangerously on the back of heavy rainfall. Regular cyclones worsened things. Western estimates suggest that the death toll reached 4 million.

DO YOU KNOW

The Birth of Earth...

Here is the story how mother earth was born...

Scientists believe that, we were once not alone in our orbit around the Sun – we had a "twin" planet, called Theia, (size of Mars) and was 60° away of the Big Blue Ball (Earth). About 4.533 billion years ago, Theia crashed into the Earth; most of the planet was absorbed, but a large chunk blew off and combined with materials from the planet to create the Moons. In fact, the Earth may once have had two moons. A teensy second moon, spanning ~1,200 km (750 mi) wide may have orbited Earth before it catastrophically slammed into the other one. This titanic clash can explain why the two sides of the surviving moon are so different from each other. That's the birth of the earth and now its age is above 4.5 Billion Years. **And...**

The Worth of Earth...

Here are some noteworthy points of earth.

1. For convenience of explanation, earth is assumed sphere but not exactly; it is a squashed sphere.
2. Do you have a desire of weight loss or weight gain, you don't need to do any exercise nor use any medicines, but just go to Equator to weigh less while go to Poles to weigh more.
3. Earth is 5th largest planet in terms of size and mass. Its circumference at equator is 40,075 km.
4. The diameter from the N to S pole is shorter than that across the Equator by 43 Km.
5. The point on equator moves fast, while that at N/S Pole will be perfectly still.
6. Like earthquake, there exist moonquakes also. Of course! They are less common and less intense.
7. The earth's hottest spot is in Libya at ***El Azizia*** that recorded 57.8 ^{0}C on Sept 13, 1922.
8. The coldest place on the earth is in Antarctica where the temperature falls to -73 ^{0}C.
9. Russia's Vostok Station as -89.2 ^{0}C on July 21, 1983 recorded the lowest temperature on earth.

10. Earth has uneven gravity. The Hudson of Canada has lower gravity than other regions.
11. The earth poles flip-flops about every 2,00,000 - 3,00,000 years.
12. Mt Everest is not the only tallest mountain. There's tie between Mt Everest and Mauna Kea.
13. Existence of water in liquid phase on earth is due to the temperature span on earth (0 – 100 ^{0}C).
14. Earth is the only planet where water can be present in all the three states or phases.
15. We are all travelling around the sun at an average velocity of 1,07,182 kmph.
16. Though earth is made up of >70% of water, it accounts for <1% of Earth's mass.
17. Earth has only one moon whereas Jupiter has highest number of (67) moons.
18. The same side of moon is always facing earth, means moon is synchronously rotating with earth.
19. Earth is the only planet not named after a Greek or Roman God.
20. Speed of rotation of earth is gradually slowing. After 140 million yrs, a day would be 25 hrs.
21. Earth is also known as Blue Planet due its bluish appearance from the outer space.
22. The extra 0.2564 day of a year (365.2564) is adjusted with an extra day in February of leap year.
23. Sea levels on Earth would rise about 60 m if all the ice in Antarctica were to melt.
24. Antarctica holds about 90% of the Earth's ice and 70% of Earth's fresh water.
25. Lake Baikal in Russia has 20% of Earth's unfrozen fresh water. It is the deepest and oldest lake.
26. The only man-made monument that is visible from the moon/space is The Great Wall of China.
27. The light that you are seeing or feeling now is approx. 8 min and 20 sec old at Sun.
28. Mawsynram, Meghalaya, India is the wettest on land of Earth with annual rainfall of 11,871 mm.
29. Dry Valleys in Antarctica is the driest on Earth, never saw rainfall from the past 2 million yrs.
30. Maldives is the flattest country.
31. Nile is the longest river (6,695 km) flowing from Burundi to Mediterranean Sea. Besides being widest, Amazon is the biggest river in terms of water flowing down. Congo River is the deepest.
32. About 1500 minerals are still undiscovered, though aware of >5000, many still unknown.
33. Some rocks on Earth move by themselves, of course minutely, but their movement is certain.
34. ***Perihelion*** (1.471X10^{11}m)/***Aphelion*** (1.521X10^{11}m) are min/max distance between Earth & Sun
35. An asteroid/comet may hit earth to devastate life, e.g. 65 million yrs ago, it wiped out dinosaurs.
36. Since recording began (1880), **2016 was the hottest year ever**, 1.69°F above mean of 20th century
37. There are 3 crater lakes – Nyos, Monoun, and Kivu, in Cameroon, on the border of Rwanda and Congo. They spit CO_2 at an enormous level and killed 100's of people in the past.
38. The peak of Ecuador's Mt Chimborazo, located just 1° S of equator and highest point on Earth.
39. **An ocean of water exists at a depth of 1,000 km under the surface of Earth.** This is important for volcanic activity, which in turn is responsible for generating soil.
40. Made of millions of tiny polyps, coral reefs are the largest living structures on Earth. But, the largest single living thing (apart from reefs) is mushroom fungus in Oregon, grew to 2,200 acres
41. The world's largest earthquake was with a magnitude of 9.5 mile in Chile on May 22, 1960. The most active eruption on Earth is Stromboli Volcano in Italy. For the past 2,000 years it has been erupting almost continuously, thence nicknamed "Lighthouse of the Mediterranean"