GEOGRAPHY

Paper-I

Physical Geography

B. A. Part-I

Objective and Theoretical Question-Answers

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SYLLABUS

GEOGRAPHY

Paper I : Physical Geography

COURSE INPUTS

UNIT-I **Lithosphere :** Nature and Scope of Physical Geography : Geological Time Scale, Origin of the Earth, Interior of the Earth, Origin of Continents and Oceans, Isostacy, Earthquakes and Volcanoes, Geosynclines, Mountain Building with special reference to folded mountains, Concept of Plate Tectonics.

UNIT-II **Rocks :** Their origin, classification and characteristics, Earth movements—Folding, Faulting and Wrapping, Weathering and Erosion, Cycle of Erosion by Davis and Penk, Drainage Pattern, Evolution of Land forms by River, Wind, Glacier and Underground water.

UNIT-III **Atmosphere :** Composition and Structure of atmosphere : Insolation, Horizontal and Vertical distribution of temperature, Atmospheric pressure and winds, Airmasses and Fronts, cyclones and anti-cyclones, Humidity, precipitation and rainfall types, Major climate types—Equatorial, Monsoon, Mediterranean, West European and Hot Desert.

UNIT-IV **Hydrosphere :** Ocean Bottoms, composition of marine water-temperature and salinity, Circulation of Ocean water—Waves, Currents and Tides, Ocean deposits, Corals and atolls, oceans as storehouse of resources for the future.

UNIT-V **Biosphere :** Components of Biosphere, Plants and animals evolution, dispersal and distribution : Biotic succession, Biome types and Zoo-geographical regions of the world, Biosphere as a global Eco-System.

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UNIT-I

LONG ANSWER TYPE QUESTIONS

Q. 1. Explain the scope of Physical Geography.

Ans. SCOPE OF PHYSICAL GEOGRAPHY

We have now learned that physical geography examines and investigates natural phenomena spatially. In the previous section, we identified some of the key elements studied by physical geographers. Combining these two items, we can now suggest that physical geography studies the spatial patterns of weather and climate, soils, vegetation, animals, water in all its forms, and landforms. Physical geography also examines the interrelationships of these phenomena to human activities. This sub-field of geography is academically known as the **Human-Land Tradition**. This area of geography has seen very keen interest and growth in the last few decades because of the acceleration of human induced environmental degradation. Thus, physical geography's scope is much broader than the simple spatial study of nature. It also involves the investigation of how humans are influencing nature.

Academics studying physical geography and other related earth sciences are rarely generalists. Most are in fact highly specialized in their fields of knowledge and tend to focus themselves in one of the following well defined areas of understanding in physical geography :

Geomorphology studies the various landforms on the Earth's surface.

Pedology is concerned with the study of soils.

Biogeography is the science that investigates the spatial relationships of plants and animals.

Hydrology is interested in the study of water in all its forms.

Meteorology studies the circulation of the atmosphere over short time spans.

Climatology studies the effects of weather on life and examines the circulation of the atmosphere over longer time spans.

The above fields of knowledge generally have a primary role in introductory textbooks dealing with physical geography. Introductory physical geography textbooks can also contain information from other related discplines including :

Geology studies the form of the Earth's surface and subsurface, and the processes that create and modify it.

Ecology the scientific study of the interactions between organisms and their environment.

Oceanography the science that examines the biology, chemistry, physics, and geology of oceans.

Cartography the technique of making maps.

Astronomy the science that examines celestial bodies and the cosmos.

Q. 2. What do you mean by Geosyncline ?

Ans. In geology, **geosyncline** is a term still occasionally used for a subsiding linear trough that was caused by the accumulation of sedimentary rock strata deposited in a basin and subsequently compressed, deformed, and uplifted into a mountain range, with attendant volcanism and plutonism. The filling of a geosyncline with tons of sediment is accompanied in the late stages of deposition by folding, crumpling, and faulting of the deposits. Intrusion of crystalline igneous rock and regional uplift along the axis of the through generally complete the history of a particular geosyncline. It is then transformed into a belt of folded mountains. Thick volcanic sequences, together with graywackes (sandstones rich in rock fragments with a muddy matrix), cherts, and various sediments reflecting deepwater deposition or processes, are deposited in *eugeosynclines,* the outer deepwater segment of geosynclines.

Overview

The **geosyncline hypothesis** is an obsolete concept involving vertical crustal movement that has been replaced by plate tectonics to explain crustal movement and geologic features.

Geosynclines are divided into *miogeosynclines* and *eugeosynclines*, depending on the types of discernible rock strata of the mountain system. A miogeosyncline develops along a continental margin on continental crust and is composed of sediments with limestones, sandstones and shales. The occurrences of limestones and well-sorted quartzose sandstones indicate a shallow-water formation, and such rocks form in the inner segment of a geosyncline. The eugeosynclines consist of different sequences of lithologies more typical of deep marine environments.

Eugeosynclinal rocks include thick sequences of greywackes, cherts, slates, tuffs and submarine lavas. The eugeosynclinal deposits are typically more formed, metamorphosed, and intruded by small to large igneous plutons. The eugeosynclines often contain exotic flysch and melange sediments.

An *orthogeosyncline* is a linear geosynclinal belt lying between continental and oceanic terranes, and having internal volcanic belts (eugeosynclinal) and external nonvolcanic belts (miogeosynclinal). Also known as geosynclinal couple or primary geosyncline. A miogeosyncline is the nonvolcanic portion of an orthogeosyncline, located adjacent a craton. A zeugogeosyncline is a geosyncline in a craton or stable area within which is also an uplifted area, receiving clastic sediments, also known as yoked basin. A parageosyncline is an epeirogenic geosynclinal basin located within a craton area. A exogeosyncline is a parageosyncline that lies along the cratonal border and obtains its clastic sediments from erosion of the adjacent orthogeosynclinal belt outside the craton. Also known as delta geosyncline; foredeep; or transverse basin.

Several types of 'mobile' geosynclinal zones have also been recognized and named. Among the more common of these are the taphrogeosyncline, a depressed block of the Earth's crust that is bounded by one or more high-angle faults and that serves as a site of sediment accumulation; and the paraliageosyncline, a deep geosyncline that passes into coastal plains along continental margins.

History of the Concept

The geosyncline concept was first developed by the American geologists James Hall and James Dwight Dana in the mid-19th century during the classic studies of the Appalachian Mountains. Dana was first to use the term *geosynclinal* in reference to a gradually deepening and filling basin resulting from his concept of crustal contraction due to a cooling and contracting Earth. The geosynclinal hypothesis was further developed in the late 19th century and early 20th century and at that time was widely accepted as an explanation for the origin of most mountain ranges until its replacement by the subduction zone and continental collision orogenies of plate tectonics in the 1960s. Although the usage varied over the following 100 years, a geosyncline is still basically a large linear deepening basin along a continental margin which becomes deformed and then uplifted in parts as a mountainous region.

Q. 3. Describe the Earth's Lithosphere.

Ans. EARTH'S LITHOSPHERE

In the Earth the lithosphere includes the crust and the uppermost mantle, which constitute the hard and rigid outer layer of the Earth. The lithosphere is underlain by the asthenosphere, the weaker, hotter, and deeper part of the upper mantle. The boundary between the lithosphere and the underlying asthenosphere is defined by a difference in response to stress :

the lithosphere remains rigid for very long periods of geologic time in which it deforms elastically and through brittle failure, while the asthenosphere deforms viscously and accommodates strain through plastic deformation. The lithosphere is broken into tectonic plates. The uppermost part of the lithosphere that chemically reacts to the atmosphere, hydrosphere and biosphere through the soil forming process is calld the pedosphere.

The concept of the lithosphere as Earth's strong outer layer was developed by Joseph Barrell, who wrote a series of papers introducing the concept. The concept was based on the presence of significant gravity anomalies over continental crust, from which he inferred that there must exist a strong upper layer (which he called the lithosphere) above a weaker layer which could flow (which he called the asthenosphere). These ideas were expanded by Harvard geologist Reginald Aldworth Daly in 1940 with his seminal work 'Strength and Structure of the Earth' and have been broadly accepted by geologists and geophysicists. Although these ideas about lithosphere and asthenosphere were developed long before plate tectonic theory was articulated in the 1960s, the concepts that a strong lithosphere exists and that this rests on a weak asthenosphere are essential to that theory.

There are two types of lithosphere :

1. Oceanic lithosphere, which is associated with Oceanic crust and exists in the ocean basins.
2. Continental lithosphere, which is asscoaited with Continental crust.

The thickness of the lithosphere is considered to be the depth to the isotherm associated with the transition between brittle and viscous behaviour. The temperature at which olivine begins to deform viscously (~ 1000°C) is often used to set this isotherm because olivine is generally the weakest mineral in the upper mantle. Oceanic lithosphere is typically about 50-100 km thick (but beneath the mid-ocean ridges is no thicker than the crust), while continental lithosphere has a range in thickness from about 40 km to perhaps 200 km; the upper ~ 30 to ~ 50 km of typical continental lithosphere is crust. The mantle part of the lithosphere consists largely of peridotite. The crust is distinguished from the upper mantle by the change in chemical composition that takes place at the Moho discontinuity.

Q. 4. Explain the Oceanic Lithosphere.

Ans. **OCEANIC LITHOSPHERE**

Oceanic lithosphere consists mainly of mafic crust and ultramafic mantle (peridotite) and is denser than continental lithosphere, for which the mantle is associated with crust made of felsic rocks. Oceanic lithosphere thickens as it ages and moves away from the mid-ocean ridge. This thickening occurs by conductive cooling, which converts hot asthenosphere into lithospheric mantle and causes the oceanic lithosphere to become increasingly thick and dense with age. The thickness of the mantle part of the oceanic lithosphere can be approximated as a thermal boundary layer that thickens as the square root of time.

$$h = 2\sqrt{\kappa t}$$

Here, h is the thickness of the oceanic mantle lithosphere, κ is the thermal diffusivity (approximately 10^{-6} m^2/s), and t is time.

Oceanic lithosphere is less dense than asthenosphere for a few tens of millions of years but after this becomes increasingly denser than asthenosphere. This is because the chemically-differentiated oceanic crust is lighter than asthenosphere, but thermal contraction of the mantle lithosphere makes it more dense than the asthenosphere. The gravitational instability of mature oceanic lithosphere has the effect that at subduction zones, oceanic lithosphere invariably sinks underneath the overriding lithosphere, which can be oceanic or continental. New oceanic lithosphere is constantly being produced at mid-ocean ridges and is recycled back to the mantle at subduction zones. As a result, oceanic lithosphere is much younger than continental lithosphere : the oldest oceanic lithosphere is about 170 million years old, while parts of the continental lithosphere are billions of years old. The oldest parts of continental lithosphere underlie cratons, and the mantle lithosphere there is thicker and less dense than typical; the relatively low density of such mantle 'roots of cratons' helps to stabilize these regions.

Subducted Lithosphere

Geophysical studies in the early 21st century posit that large pieces of the lithosphere have been subducted into the mantle as deep as 2900 km to near the core-mantle boundary, while others 'float' in the upper mantle, while some stick down into the mantle as far as 400 km but remain 'attached' to the continental plate above, similar to the extent of the 'tectosphere' proposed by Jordan in 1988.

Mantle Xenoliths

Geoscientists can directly study the nature of the subcontinental mantle by examining mantle xenoliths brought up in kimberlite, lamproite, and other volcanic pipes. The histories of these xenoliths have been investigated by many methods, including anlayses of abundances of isotopes of osmium and rhenium. Such studies have confirmed that mantle lithospheres below some cratons have persisted for periods in excess of 3 billion years, despite the mantle flow that accompanies plate tectonics.

Q. 5. What do you mean by Plate Tectonics ?

Ans. The tectonic of the world were mapped in the second half of the 20th century. Plate motion based on Global Positioning System (GPS) satellite data from NASA JPL. The vectors show direction and magnitude of motion.

Remnants of the Farallon Plate, deep in Earth's mantle. It is thought that much of the plate initially went under North America (particularly the western United States and southwest Canada) at a very shallow angle, creating much of the mountainous terrain in the area (particularly the southern Rocky Mountains).

Plate tectonics (from the Late Latin *tectonicus*, from the Greek : τεκτονικός "pertaining to building") is a scientific theory that describes the large scale motions of Earth's lithosphere. The theory builds on the concepts of continental drift, developed during the first decades of the 20th century, and accepted by the majority of the geoscientific community when the concepts of seafloor spreading were developed in the late 1950s and early 1960s.

The lithosphere is broken up into tectonic plates. In the case of the Earth, there are currently seven or eight major (depending on how they are defined) and many minor plates. The lithospheric plates ride on the asthenosphere. These plates move in relation to one another at one of three types of plate boundaries : convergent, or collisional boundaries; divergent boundaries, also called spreading centers; and conservative transform boundaries. Earthquakes, volcanic activity, mountain-building, and oceanic trench formation occur along these plate boundaries. The lateral relative movement of the plates typically varies from 0-100 mm annually.

The tectonic plates are composed of two types of lithosphere : thicker continental and thin oceanic. The upper part is called the crust, again of two types (continental and oceanic). This means that a plate can be of one type, or of both types. One of the main points the theory proposes is that the amount of surface of the (continental and oceanic) plates that disappears in the mantle along the convergent boundaries by subduction is more or less in equilibrium with the new (oceanic) crust that is formed along the divergent margins by seafloor spreading. This is also referred to as the conveyor belt principle. In this way, the total surface of the globe remains the same. This is in contrast with earlier theories advocated before the Plate Tectonics paradigm, as it is sometimes called, became the main scientific model, theories and proposed gradual shrinking (contraction) or gradual expansion of the globe, and that still exist in science as alternative models.

Tectonic plates are able to move because the Earth's lithosphere has a higher strength and lower density than the underlying asthenosphere. Lateral density variations in the mantle result in convection. Their movement is thought to be driven by a combination of the motion of seafloor away from the spreading ridge (due to variations in topography and density of the crust that result in differences in gravitational forces) and drag, downward suction, at the subduction zones. A different explanation lies in different forces generated by the rotation of the globe and tidal forces of the Sun and the Moon. The relative importance of each of these factors is unclear, and is still subject to debate.

Q. 6. The outer layers of the Earth are divided into how many parts ?

Ans. The outer layers of the Earth are divided into lithosphere and asthenosphere. This is based on differences in mechanical properties and in the method for the transfer of heat. Mechanically, the lithosphere is cooler and more rigid, while the asthenosphere is hotter and flows more easily. In terms of heat transfer, the lithosphere loses heat by conduction whereas the asthenosphere also transfers heat by convection and has a nearly adiabatic temperature gradient. This division should not be confused with the chemical subdivision of these same layers into the mantle (comprising both the asthenosphere and the mantle portion of the lithosphere) and the crust : a given piece of mantle may be part of the lithosphere or the asthenosphere at different times, depending on its temperature and pressure.

The key principle of plate tectonics is that the lithosphere exists as separate and distinct *tectonic plates,* which ride on the fluid-like (visco-elastic solid) asthenosphere. Plate motions range up to a typical 10-40 mm/a (Mid-Atlantic Ridge; about as fast as fingernails grow), to about 160 mm/a (Nazca Plate; about as fast as hair grows). The driving mechanism behind this movement is described separately below.

Tectonic lithosphere plates consist of lithospheric mantle overlain by either or both of two types of crustal material : oceanic crust (in older texts called *sima* from silicon and magnesium) and continental crust (*sial* from silicon and aluminium). Average oceanic lithosphere is typically 100 km thick; its thickness is a function of its age : as time passes, it conductively cools and becomes thicker. Because it is formed at mid-ocean ridges and spreads outwards, its thickness is therefore a function of its distance from the mid-ocean ridge where it was formed. For a typical distance oceanic lithosphere must travel before being subducted, the thickness varies from about 6 km thick at mid-ocean ridges to greater than 100 km at subduction zones; for shorter or longer distances, the subduction zone (and therefore also the mean) thickness becomes smaller or larger, respectively.

Continental lithosphere is typically ~ 200 km thick, though this also varies considerably between basins, mountain ranges, and stable cratonic interiors of continents. The two types of crust also differ in thickness, with continental crust being considerably thicker than oceanic (35 km vs. 6 km).

The location where two plates meet is called a *plate boundary*, and plate boundaries are commonly associated with geological events such as earthquakes and the creation of topographic features such as mountains, volcanoes, mid-ocean ridges, and oceanic trenches. The majority of the world's active volcanoes occur along plate boundaries, with the Pacific Plate's Ring of Fire being most active and most widely known. These boundaries are discussed in further detail below. Some volcanoes occur in the interiors of plates, and these have been variously attributed to internal plate deformation and to mantle plumes.

As explained above, tectonic plates can include continental crust or oceanic crust, and many plates contain both. For example, the African Plate includes the continent and parts of the floor of the Atlantic and Indian Oceans. The distinction between oceanic crust and continental crust is based on their modes of formation. Oceanic crust is formed at sea-floor spreading centers, and continental crust is formed through arc volcanism and accretion of terranes through tectonic processes; though some of these terranes may contain ophiolite sequences, which are pieces of oceanic crust, these are considered part of the continent when they exit the standard cycle of formation and spreading centers and subduction beneath continents. Oceanic crust is also denser than continental crust owing to their different compositions. Oceanic crust is denser because it has less silicon and more heavier elements ('mafic') than continental crust ('felsic'). As a result of this density stratification, oceanic crust generally lies below sea level (for example most of the Pacific Plate), while the continental crust buoyantly projects above sea level (see the page isostasy for explantion of this principle).

Q. 7. Write a note on the Earth.

Ans. Earth (or **the Earth**) is the third planet from the Sun, and the densest and fifth-largest of the eight planets in the Solar System. It is also the largest of the Solar System's four terrestrial planets. It is sometimes referred to as the World, the Blue Planet, or by its Latin name, *Terra*.

Earth formed 4·54 billion years ago, and life appeared on its surface within one billion years. The planet is home to millions of species, including humans. Earth's biosphere has significantly altered the atmosphere and other abiotic conditions on the planet, enabling the proliferation of aerobic organisms as well as the formation of the ozone layer which, together with Earth's magnetic field, blocks harmful solar radiation, permitting life on land. The physical properties of the Earth, as well as its geological history and orbit, have allowed life to persist during this period. The planet is expected to continue supporting life for at least another 500 million years.

Farth's outer surface is divided into several rigid segments, or tectonic plates, that migrate across the surface over periods of many millions of years. About 71% of the surface is covered by salt water oceans, with the remainder consisting of continents and islands which together have many lakes and other sources of water that contribute to the hydrosphere. Earth's poles are mostly covered with solid ice (Antarctic ice sheet) or sea ice (Arctic ice cap). The planet's interior remains active, with a thick layer of relatively solid mantle, a liquid outer core that generates a magnetic field, and a solid iron inner core.

Earth interacts with other objects in space, especially the Sun and the Moon. At present, Earth orbits the Sun once every 366·26 times it rotates about its own axis, which is equal to 365·26 solar days, or one sidereal year. The Earth's axis of rotation is tilted 23·4° away from the perpendicular of its orbital plane, producing seasonal variations on the planet's surface with a period of one tropical year (365·24 solar days). Earth's only known natural satellite, the Moon, which began orbiting it about 4·54 billion years ago, provides ocean tides, stabilizes the axial tilt, and gradually slows the planet's rotation. Between approximately 3·8 billion and 4·1 billion years ago, numerous asteroid impacts during the Late Heavy Bombardment caused significant changes to the greater surface environment.

Both the mineral resources of the planet, as well as the products of the biosphere, contribute resources that are used to support a global human population. These inhabitants are grouped into about 200 independent sovereign states, which interact through diplomacy, travel, trade, and military action. Human cultures have developed many views of the planet, including personification as a deity, a belief in a flat Earth or in the Earth as the center of the universe, and a modern perspective of the world as an integrated environment that requires stewardship.

Q. 8. Explain the Earthquake.

Ans. An **earthquake** (also known as a **quake, tremor** or **temblor**) is the result of a sudden release of energy in the Earth's crust that creates seismic waves. The **seismicity, seismism** or **seismic activity** of an area refers to the frequency, type and size of earthquakes experienced over a period of time. Earthquakes are measured using observations from seismometers. The moment magnitude is the most common scale on which earthquakes larger than approximately 5 are reported for the entire globe. The more numerous earthquakes smaller than magnitude 5 reported by national seismological observatories are measured mostly on the local magnitude scale, also referred to as the Richter scale. These two scales are numerically similar over their range of validity. Magnitude 3 or lower earthquakes are mostly almost imperceptible and magnitude 7 and over potentially cause serious damage over large areas, depending on their depth. The largest earthquakes in historic times have been of magnitude slightly over 7, although there is no limit to the possible magnitude. The most recent large earthquake of magnitude 9·0 or larger was a 9·0 magnitude earthquake in Japan in 2011 (as of March 2011), and it was the largest Japanese earthquake since records began. Intensity of shaking is measured on the modified Mercalli scale. The shallower an earthquake, the more damage to structures it causes, all else being equal.

At the Earth's surface, earthquakes manifest themselves by shaking and sometimes displacement of the ground. When the epicenter of a large earthquake is located offshore, the seabed may be displaced sufficiently to cause a tsunami. Earthquakes can also trigger landslides, and occasionally volcanic activity.

In its most general sense, and word *earthquake* is used to describe any seismic event—whether natural or caused by humans—that generates seismic waves. Earthquakes are caused mostly by rupture of geological faults, but also by other events such as volcanic activity, landslides, mine blasts, and nuclear tests. An earthquake's point of initial rupture is called its focus or hypocenter. The epicenter is the point at ground level directly above the hypocenter.

Q. 9. Write a note on the other layers of the Atmosphere.

Ans. Within the five principal layers determined by temperature are several layers determined by other properties.

- The ozone layer is contained within the stratosphere. In this layer ozone concentrations are about 2 to 8 parts per million, which is much higher than in the lower atmosphere but still very small compared to the main components of the atmosphere. It is mainly located in the lower portion of the stratosphere from about 15-35 km (9·3-22 mi; 49,000-110,000 ft), though the thickness varies seasonally and geographically. About 90% of the ozone in our atmosphere is contained in the stratosphere.
- The ionosphere, the part of the atmosphere that is ionized by solar radiation, stretches from 50 to 1,000 km (31 to 620 mi; 160,000 to 3,300,000 ft) and typically overlaps both the exosphere and the thermosphere. It forms the inner edge of the magnetosphere. It has practical importance because it influences, for example, radio propagation on the Earth. It is responsible for auroras.

- The homosphere and heterosphere are defined by whether the atmospheric gases are well mixed. In the homosphere the chemical composition of the atmosphere does not depend on molecular weight because the gases are mixed by turbulence. The homosphere includes the troposphere, stratosphere, and mesosphere. Above the ***turbopause*** at about 100 km (62 mi; 330,000 ft) (essentially corresponding to the mesopause), the composition varies with altitude. This is because the distance that particles can move without colliding with one another is large compared with the size of motions that cause mixing. This allows the gases to stratify by molecular weight, with the heavier ones such as oxygen and nitrogen present only near the bottom of the heterosphere. The upper part of the heterosphere is composed almost completely of hydrogen, the lightest element.
- The planetary boundary layer is the part of the troposphere that is nearest the Earth's surface and is directly affected by it, mainly through turbulent diffusion. During the day the planetary boundary layer usually is well-mixed, while at night it becomes stably stratified with weak or intermittent mixing. The depth of the planetary boundary layer ranges from as little as about 100 m on clear, calm nights to 3000 m or more during the afternoon in dry regions.

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

Q. 10. Explain the physical properties of Atmosphere.

Ans. Comparison of the 1962 US Standard Atmosphere graph of geometric altitude against air density, pressure, the speed of sound and temperature with approximate altitudes of various objects.

Pressure and thickness

The average atmospheric pressure at sea level is about 1 atmosphere (atm) = 101·3 kPa (kilopascals) = 14·7 psi (pounds per square inch) = 760 torr = 29·92 inches of mercury (symbol Hg). Total atmospheric mass is $5{\cdot}1480 \times 10^{18}$ kg ($1{\cdot}135 \times 10^{19}$ lb), about 2·5% less than would be inferred from the average sea level pressure and the Earth's area of 51007·2 megahectares, this portion being displaced by the Earth's mountainous terrain. Atmospheric pressure is the total weight of the air above unit area at the point where the pressure is measured. Thus air pressure varies with location and weather.

If atmospheric density were to remain constant with height the atmosphere would terminate abruptly at 8·50 km (27,900 ft). Instead, density decreases with height, dropping by 50% at an altitude of about 5·6 km (18,000 ft). As a result the pressure decrease is approximately exponential with height, so that pressure decreases by a factor of two approximately every 5·6 km (18,000 ft) and by a factor of e = 2·718... approximately every 7·64 km (25,100 ft), the latter being the average scale height of Earth's atmosphere below 70 km (43 mi; 230,000 ft). However, because of changes in temperature, average molecular weight, and gravity throughout the atmospheric column, the dependence of atmospheric pressure on altitude is modeled by separate equations for each of the layers listed above. Even in the exosphere, the atmosphere is still present. This can be seen by the effects of atmospheric drag on satellites.

In summary, the equations of pressure by altitude in the above references can be used directly to estimate atmospheric thickness. However, the following published data are given for reference :

- 50% of the atmosphere by mass is below an altitude of 5·6 km (18,000 ft).
- 90% of the atmosphere by mass is below an altitude of 16 km (52,000 ft). The common altitude of commercial airliners is about 10 km (33,000 ft) and Mt. Everest's summit is 8,848 m (29,029 ft) above sea level.
- 99·99997% of the atmosphere by mass is below 100 km (62 mi; 330,000 ft), although in the rarefield region above this there are auroras and other atmospheric effects. The highest X-15 plane flight in 1963 reached an altitude of 108·0 km (354,300 ft).

Density and mass

Temperature and mass density against altitude from the NRLMSISE-00 standard atmosphere model (the eight dotted lines in each 'decade' are at the eight cubes 8, 27, 64, ..., 729).

MAIN ARTICLE : DENSITY OF AIR

The density of air at sea level is about 1·2 kg/m^3 (1·2 g/L). Density is not measured directly but is calculated from measurements of temperature, pressure and humidity using the equation of state for air (a form of the ideal gas law). Atmospheric density decreases as the altitude increases. This variation can be approximately modeled using the barometric formula. More sophisticated models are used to predict orbital decay of satellites.

The average mass of the atmosphere is about 5 quadrillion (5 × 10^{15}) tonnes or 1/1,200,000 the mass of Earth. According to the **American National Center for Atmospheric Research,** "The total mean mass of the atmosphere is 5·1480 × 10^{18} kg with an annual range due to water vapor of 1·2 or 1·5 × 10^{15} kg depending on whether surface pressure or water vapor data are used; somewhat smaller than the previous estimate. The mean mass of water vapor is estimated as $1{\cdot}27 \times 10^{16}$ kg and the dry air mass as $5{\cdot}1352 \pm 0{\cdot}0003 \times 10^{18}$ kg."

Q. 11. Explain the evolution of Earth's atmosphere.

Ans. EVOLUTION OF EARTH'S ATMOSPHERE

Earliest atmosphere

The outgassings of the Earth were stripped away by solar winds early in the history of the planet until a steady state was established, the first atmosphere. Based on today's volcanic evidence, this atmosphere would have contained 60% hydrogen, 20% oxygen (mostly in the form of water vapor), 10% carbon di-oxide, 5 to 7% hydrogen sulfide, and smaller amounts of nitrogen, carbon monoxide, free hydrogen, methane and inert gases.

A major rainfall led to the buildup of a vast ocean, enriching the other agents, first carbon di-oxide and later nitrogen and inert gases. A major part of carbon di-oxide exhalations were soon dissolved in water and built up carbonate sediments.

Second atmosphere

Water-related sediments have been found dating from as early as 3·8 billion years ago. About 3·4 billion years ago, nitrogen was the major part of the then stable 'second atmosphere'. An influence of life has to be taken into account rather soon in the history of the atmosphere, since hints of early life forms are to be found as early as 3·5 billion years ago. The fact that this is not perfectly in line with the 30% lower solar radiance (compared to today) of the early Sun has been described as the 'faint young Sun paradox'.

The geological record however shows a continually relatively warm surface during the complete early temperature record of the Earth with the exception of one cold glacial phase about 2·4 billion years ago. In the late Archaean eon an oxygen-containing atmosphere began to develop, apparently from photosynthesizing algae which have been found as stromatolite fossils from 2·7 billion years ago. The early basic carbon isotopy (isotope ratio proportions) is very much in line with what is found today, suggesting that the fundamental features of the carbon cycle were established as early as 4 billion years ago.

Third atmosphere

Oxygen content of the atmosphere over the last billion years. The accretion of continents about 3·5 billion years ago added plate tectonics, constantly rearranging the continents and also shaping long-term climate evolution by allowing the transfer of carbon di-oxide to large land-based carbonat storages. Free oxygen did not exist until about 1·7 billion years ago and this can be seen with the development of the red beds and the end of the banded iron formations. This signifies a shift from a reducing atmosphere to an oxidising atmosphere. O_2 showed major ups and downs until reacing a steady state of more than 15%. The following time span was the Phanerozoic eon, during which oxygen-breathing metazoan life forms began to appear.

Currently, anthropogenic greenhouse gases are increasing in the atmosphere. According to the Intergovernmental Panel on Climate Change, this increase is the main cause of global warming.

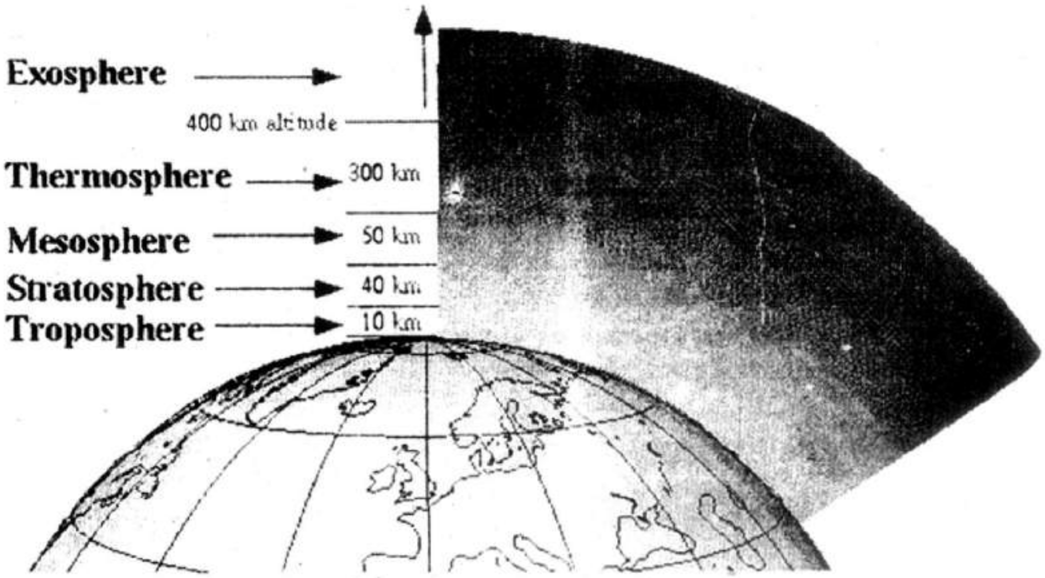
Air Pollution

Air pollution is the introduction of chemicals, particulate matter, or biological materials that cause harm or discomfort to organisms into the atmosphere. Stratospheric ozone depletion is believed to be caused by air pollution (chiefly from chlorofluorocarbons).

Q. 12. Explain the facts about the atmosphere.

Ans. A planet's climate is decided by its mass, its distance from the sun and the composition of its atmosphere. Earth's atmosphere is 78% nitrogen, 21% oxygen, and 1% other gases. Carbon di-oxide accounts for just 0·03-0·04%. Water vapour, varying in amount from 0 to 2%, carbon di-oxide and some other minor gases present in the atmosphere absorb some of the thermal radiation leaving the surface and emit radiation from much higher and colder levels out to space. These radiatively active gases are known as greenhouse gases because they act as a partial blanket for the thermal radiation from the surface and enable it to be substantially warmer than it would otherwise be, analogous to the effect of a greenhouse. This blanketing is known as the natural greenhouse effect. Without the greenhouse gases, Earth's average temperature would be roughly – 20°C.

- The earth's atmosphere is a very thin layer wrapped around a very large planet.
- Two gases make up the bulk of the earth's atmosphere : nitrogen (N_2), which comprises 78% of the atmosphere, and oxygen (O_2), which accounts for 21%. Various trace gases make up the remainder.
- Based on temperature, the atmosphere is divided into four layers : the troposphere, stratosphere, mesosphere, and thermosphere.
- Energy is transferred between the earth's surface and the atmosphere via conduction, convection, and radiation.
- Ocean currents play a significant role in transferring this heat poleward. Major currents, such as the northward flowing Gulf Stream, transport tremendous amounts of heat poleward and contribute to the development of many types of weather phenomena.



Cambridge university Graphic

The atmosphere is divided into five layers. It is thickest near the surface and thins out with height until it eventually merges with space.

(1) The **troposphere** is the first layer above the surface and contains half of the Earth's atmosphere. Weather occurs in this layer.

(2) Many jet aircrafts fly in the **stratosphere** because it is very stable. Also, the ozone layer absorbs harmful rays from the Sun.

(3) Meteors or rock fragments burn up in the **mesosphere.**

(4) The **thermosphere** is a layer with auroras. It is also where the space shuttle orbits.

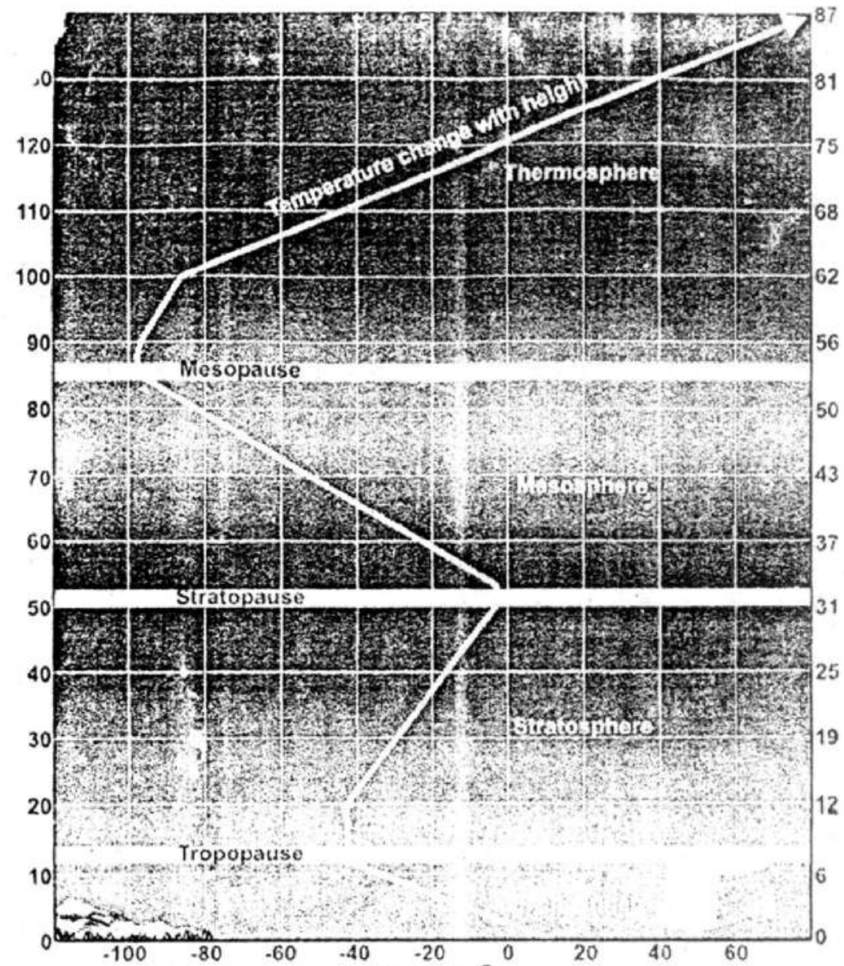
(5) The atmosphere merges into space in the extremely thin **exosphere**. This is the upper limit of our atmosphere .

The inhabitants of our planet live in the Troposphere. Earth's atmosphere varies in density and composition as the altitude increases above the surface. The lowest part of the atmosphere is called the troposphere (and it extends from the surface up to about 10 km (6 miles). The gases in this region are predominantly molecular Oxygen (O_2) and molecular Nitrogen (N_2). All weather is confined to this lower region and it contains 90% of the Earth's atmosphere and 99% of the water vapour. The highest mountains are still within the troposphere and all of our normal day-to-day activities occur here. The high altitude jet stream is found near the tropopause at the upper end of this region.

The layer above this is the Stratosphere, this is where the Ozone Layer is formed. The atmosphere above 10 km is called the stratosphere. The gas is still dense enough that hot air balloons can ascend to altitudes of 15-20 km and Helium balloons to nearly 35 km, but the air thins rapidly and the gas composition changes slightly as the altitude increases. Within the stratosphere, incoming solar radiation at wavelengths below 240 nm. is able to break up (or dissociate) molecular Oxygen (O_2) into individual Oxygen atoms, each of which, in turn, may combine with an Oxygen molecule (O_2), to form ozone, a molecule of Oxygen consisting of three Oxygen atoms (O_3). This gas reaches a peak density of a few parts per million at an altitude of about 25 km (16 miles).

The Ozone Layer absorbs ultra-violet radiation from the Sun. Without the Ozone Layer life as we know would cease to exist on our planet. Ozone is important because it is the only atmospheric gas which absorbs light in the B region of UVB rays.

The Ozone layer extends from a height of 20 kilometers to 60 kilometers above the Earth's surface. The air is very thin at these altitudes.



Standardized Temperature Profile

An average atmosphere profile through the lower layers of the atmosphere. Height (in miles and kilometers) is indicated along each side. Temperatures in the thermosphere continue to climb, reaching as high as 2000°C. **Credit : National Weather Service**

Troposphere

The troposphere begins at the Earth's surface and extends up to 4-12 miles (6-20 km) high. This is where we live. As the gases in this layer decrease with height, the air become thinner. Therefore, the atmosphere in the troposphere also decreases with height. As you climb higher, the atmosphere drops from about 62°F (17°C) to – 60°F (– 51°C). Almost all weather occurs in this region.

The height of the troposphere varies from the equator to the poles. At the equator it is around 11-12 miles (18-20 km) high, at 50°N and 50°S, $5\frac{1}{2}$ miles and at the poles just under four miles high. The transition boundary between the troposphere and the layer above is called the tropopause. Both the tropopause and the troposphere are known as the lower atmosphere.

Stratosphere

The Stratosphere extends from the tropopause up to 31 miles above the Earth's surface. This layer holds 19 percent of the atmosphere's gases and but very little water vapour.

Temperature increases with height as radiation is increasingly absorbed by oxygen molecules which leads to the formation of Ozone. The temperature rises from an average – 76°F (– 60°C) at tropopause to a maximum of about 5°F (– 15°C) at the stratopause due to this absorption of ultraviolet radiation. The increasing temperature also makes it a calm layer with movements of the gases slow.

The regions of the stratosphere and the mesosphere, along with the stratopause and mesopause, are called the middle atmosphere by scientists. The transition boundary which separates the stratosphere from the mesosphere is called the stratopause.

Mesosphere

The mesosphere extends from the stratopause to about 53 miles (85 km) above the earth. The gases, including the oxygen molecules, continue to become thinner and thinner with heignt. As such, the effect of the warming by ultraviolet radiation also becomes less and less leading to a decrease in temperature with height. On average, temperature decreases from about 5°F (– 15°C) to as low as – 184°F (– 120°C) at the mesopause. However, the gases in the mesosphere are thick enough to slow down meteorites hurtling into the atmosphere, where they burn up, leaving fiery trails in the night sky.

Thermosphere

The Thermosphere extends from the mesopause to 430 miles (690 km) above the earth. This layer is known as the upper atmosphere.

The gases of the thermosphere are increasingly thinner than in the mesosphere. As such, only the higher energy ultraviolet and X-ray radiation from the sun is absorbed. But because of this absorption, the temperature increases with height and can reach as high as 3,600°F (2000°C) near the top of this layer.

However, despite the high temperature, this layer of the atmosphere would still feel very cold to our skin because of the extremely thin air. The total amount of energy from the very few molecules in this layer is not sufficient enough to heat our skin.

Exosphere

The Exosphere is the outermost layer of the atmosphere and extends from the thermopause to 6200 miles (10,000 km) above the earth. In this layer, atoms and molecules escape into space and satellites orbit the earth. The transition boundary which separates the exosphere from the thermosphere below it is called the thermopause.

SHORT ANSWER TYPE QUESTIONS

Q. 1. Write a short note on the Exosphere.

Ans. In general, air pressure and density decrease in the atmosphere as height increases. However, temperature has a more complicated profile with altitude. Because the general pattern of this profile is constant and recognizable through means such as balloon soundings, temperature provides a useful metric to distinguish between atmospheric layers. In this way, Earth's atmosphere can be divided into five main layers. From highest to lowest, these layers are :

EXOSPHERE

The outermost layer of Earth's atmosphere extends from the exobase upward. It is mainly composed of hydrogen and helium. The particles are so far apart that they can travel hundreds of kilometers without colliding with one another. Since the particles rarely collide, the atmosphere no longer behaves like a fluid. These free-moving particles follow ballistic trajectories and may migrate into and out of the magnetosphere or the solar wind.

Q. 2. Write a note on the Thermosphere.

Ans. **THERMOSPHERE**

Temperature increases with height in the thermosphere from the mesopause up to the thermopause, then is constant with height. Unlike in the stratosphere, where the inversion is caused by absorption of radiation by ozone, in the thermosphere the inversion is a result of the extremely low density of molecules. The temperature of this layer can rise to 1,500°C (2,700°F), though the gas molecules are so far apart that temperature in the usual sense is not well defined. The air is so rarefied, that an individual molecule (of oxygen, for example) travels an average of 1 kilometer between collisions with other molecules. The International Space Station orbits in this layer, between 320 and 380 km (200 and 240 mi). Because of the relative infrequency of molecular collisions, air above the mesopause is poorly mixed compared to air below. While the composition from the troposphere to the mesosphere is fairly constant, above a certain point, air is poorly mixed and becomes compositionally stratified. The point dividing these two regions is known as the turbopause. The region below is the homosphere, and the region above is the heterosphere. The top of the thermosphere is the bottom of the exosphere, called the exobase. Its height varies with solar activity and ranges from about 350-800 km (220-500 mi; 1,100,000-2,600,000 ft).

Q. 3. Write a short note on the following :

(a) Mesosphere,

(b) Stratosphere,

(c) Troposphere.

Ans. **(a) MESOSPHERE**

The mesosphere extends from the stratopause to 80-85 km (50-53 mi; 260,000-280,000 ft). It is the layer where most meteors burn up upon entering the atmosphere. Temperature decreases with height in the mesosphere. The mesopause, the temperature minimum that marks the top of the mesosphere, is the coldest place on Earth and has an average temperature around – 85°C (– 120°F; 190 K). At the mesopause, temperatures may drop to – 100°C (– 150°F; 170 K). Due to the cold temperature of the mesosphere, water vapour is frozen, forming ice clouds (or Noctilucent clouds). A type of lightning referred to as either sprites or ELVES, form many miles above thunderclouds in the troposphere.

(b) STRATOSPHERE

The stratosphere extends from the tropopause to about 51 km (32 mi; 170,000 ft). Temperature increases with height due to increased absorption of ultraviolet radiation by the ozone layer, which restricts turbulence and mixing. While the temperature may be – 60°C (– 76°F; 210 K) at the tropopause, the top of the stratosphere is much warmer, and may be near freezing. The stratopause, which is the boundary between the stratosphere and mesosphere, typically is at 50 to 55 km (31 to 34 mi; 160,000 to 180,000 ft). The pressure here is 1/1000 sea level.

(c) TROPOSPHERE

The troposphere begins at the surface and extends to between 9 km (30,000 ft) at the poles and 17 km (56,000 ft) at the equator, with some variation due to weather. The troposphere is mostly heated by transfer of energy from the surface, so on average the lowest part of the troposphere is warmest and temperature decreases with altitude. This promotes vertical mixing (hence the origin of its name in the Greek word 'τροπη', *trope*, meaning turn or overturn). The troposphere contains roughly 80% of the mass of the atmosphere. The tropopause is the boundary between the troposphere and stratosphere.

Q. 4. Write a short note on the atmosphere of Earth.

Ans. The **atmosphere of Earth** is a layer of gases surrounding the planet Earth that is retained by Earth's gravity. The atmosphere protects life on Earth by absorbing ultraviolet solar radiation, warming the surface through heat retention (greenhouse effect), and reducing temperature extremes between day and night (the diurnal temperature variation).

Atmospheric stratification describes the structure of the atmosphere, dividing it into distinct layers, each with specific characteristics such as temperature or composition. The atmosphere has a mass of about 5×10^{18} kg, three quarters of which is within about 11 km (6·8 mi; 36,000 ft) of the surface. The atmosphere becomes thinner and thinner with increasing altitude, with no definite boundary between the atmosphere and outer space. An altitude of 120 km (75 mi) is where atmospheric effects become noticeable during atmospheric reentry of spacecraft. The Kármán line, at 100 km (62 mi), also is often regarded as the boundary between atmosphere and outer space.

Air is the name given to atmosphere used in breathing and photosynthesis. Dry air contains roughly (by volume) 78·09% nitrogen, 20·95% oxygen, 0·93% argon, 0·039% carbon di-oxide, and small amounts of other gases. Air also contains a variable amount of water vapour, on average around 1%. While air content and atmospheric pressure varies at different layers, air suitable for the survival of terrestrial plants and terrestrial animals is currently only known to be found in Earth's troposphere and artificial atmospheres.

Q. 5. "Shaking and ground rupture are the main effects created by earthquakes." Explain.

Ans. **SHAKING AND GROUND RUPTURE**

Shaking and ground rupture are the main effects created by earthquakes, principally resulting in more or less severe damage to buildings and other rigid structures. The severity of the local effects depends on the complex combination of the earthquake magnitude, the distance from the epicenter, and the local geological and geomorphological conditions, which may amplify or reduce wave propagation. The ground-shaking is measured by ground acceleration.

Specific local geological, geomorphological, and geostructural features can induce high levels of shaking on the ground surface even from low-intensity earthquakes. This effect is called site or local amplification. It is principally due to the transfer of the seismic motion from hard deep soils to soft superficial soils and to effects of seismic energy focalization owing to typical geometrical setting of the deposits.

Ground rupture is a visible breaking and displacement of the Earth's surface along the trace of the fault, which may be of the order of several metres in the case of major earthquakes. Ground rupture is a major risk for large engineering structures such as dams, bridges and nuclear power stations and requires careful mapping of existing faults to identify any likely to break the ground surface within the life of the structure.

Q. 6. What do you mean by Tectonic earthquakes ?

Ans. Tectonic earthquakes occur anywhere in the earth where there is sufficient stored elastic strain energy to drive fracture propagation along a fault plane. The sides of a fault move past each other smoothly and aseismically only if there are no irregularities or asperities along the fault surface that increase the frictional resistance. Most fault surfaces do have such asperities and this leads to a form of stick-slip behaviour. Once the fault has locked, continued relative motion between the plates leads to incrasing stress and therefore, stored strain energy in the volume around the fault surface. This continues until the stress has risen sufficiently to break through the asperity, suddenly following sliding over the locked portion of the fault, releasing the stored energy. This energy is released as a combination of radiated elastic strain seismic waves, frictional heating of the fault surface, and cracking of the rock, thus causing an earthquake. This process of gradual build-up of strain and stress punctuated by occasional sudden earthquake failure is reffered to as the elastic-rebound theory. It is estimated that only 10 percent or less of an earthquake's total energy is radiated as seismic energy. Most of the earthquake's energy is used to power the earthquake fracture growth or is converted into heat generated by friction. Therefore, earthquakes lower the Earth's available elastic potential energy and raise its temperature, though these changes are negligible compared to the conductive and convective flow of heat out from the Earth's deep interior.

Q. 7. Describe the types of plate boundary.

Ans. Basically, three types of plate boundaries exist, with a fourth, fixed type, characterized by the way the plates relative to each other. They are associated with different types of surface phenomena. The different types of plate boundaries are :

1. *Transform boundaries (Conservative)* occur where plates slide or, perhaps more accurately, grind past each other along transform faults. The relative motion of the two plates is either sinistral (left side toward the observer) or dextral (right side toward the observer). The San Andreas Fault in California is an example of a transform boundary exhibiting dextral motion.

2. *Divergent boundaries (Constructive)* occur where two plates slide apart from each other. Mid-ocean ridges (e.g., Mid-Atlantic Ridge) and active zones of rifting (such as Africa's Great Rift Valley) are both examples of divergent boundaries.
3. *Convergent boundaries (Destructive)* (or *active margins*) occur where two plates slide towards each other commonly forming either a subduction zone (if one plate moves underneath the other) or a continental collision (if the two plates contain continental crust). Deep marine trenches are typically associated with subduction zones, and the basins that develop along the active boundary are often called 'foreland basins'. The subducting slab contains many hydrous minerals, which release their water on heating; this water then causes the mantle to melt, producing volcanism. Examples of this are the Andes mountain range in South America and the Japanese island arc.
4. *Plate boundary zones* occur where the effects of the interactions are unclear and the boundaries, usually occurring along a broad belt, are not well defined, and may show various types of movements in different episodes.

Q. 8. What do you mean by Driving Forces of Plate Motion ?

Ans. DRIVING FORCES OF PLATE MOTION

Plate tectonics is basically a kinematic phenomenon : Earth scientists agree upon the observation and deduction that the plates have moved one with respect to the other, and debate and find agreements on how and when. But still a major question remains on what the motor behind this movement is; the geodynamic mechanism, and here science diverges in different theories.

Generally it is accepted that tectonic plates are able to move because of the relative density of oceanic lithosphere and the relative weakness of the asthenosphere. Dissipation of heat from the mantle is acknowledged to be the original source of energy driving plate tectonics, through convection or large scale upwelling and doming. As a consequence, in the current view, although it is still a matter of some debate, because of the excess density of the oceanic lithosphere sinking in subduction zones a powerful source of plate motion is generated. When the new crust forms at mid-ocean ridges, this oceanic lithosphere is initially less dense than the underlying asthenosphere, but it becomes denser with age, as it conductively cools and thickens. The greater density of old lithosphere relative to the underlying asthenosphere allows it to sink into the deep mantle at subduction zones, providing most of the driving force for plate motions. The weakness of the asthenosphere allows the tectonic plates to move easily towards a subduction zone. Although subduction is believed to be the strongest force driving plate motions, it cannot be the only force since there are plates such as the North American Plate which are moving, yet are nowhere being subducted. The same is true for the enormous Eurasian Plate. The sources of plate motion are a matter of intensive research and discussion among earth scientists. One of the main points is that the kinematic pattern of the movements itself should be separated clearly from the possible geodynamic mechanism that is invoked as the driving forceof the observed movements, as some patterns may be explained by more than one mechanism. Basically, the driving forces that are advocated at the moment, can be divided in three categories : mantle dynamics related, gravity related (mostly secondary forces), and Earth rotation related.

Q. 9. What do you mean by Isostasy ?

Ans. Isostasy (Greek *isos* 'equal', *stasis* 'standstill') is a term used in geology to refer to the state of gravitational equilibrium between the earth's lithosphere and asthenosphere such that the tectonic plates 'float' at an elevation which depends on their thickness and density. This concept is invoked to explain how different topographic heights can exist at the Earth's surface. When a certain area of lithosphere reaches the state of isostasy, it is said to be in *isostatic equilibrium*. Isostasy is not a process that upsets equilibrium, but rather one which restores it (a negative feedback). It is generally accepted that the earth is a dynamic system that responds to loads in many different ways. However, isostasy provides an important 'view' of the processes that are happening in areas that are experiencing vertical movement. Certain areas (such as the Himalayas) are not in isostatic equilibrium, which has forced researchers to identify other reasons to explain their topographic heights (in the case of the Himalayas, which are still rising, by proposing that their elevation is being 'propped-up' by the force of the impacting Indian plate).

In the simplest example, isostasy is the principle of buoyancy where an object immersed in a liquid is buoyed with a force equal to the weight of the displaced liquid. On a geological scale, isostasy can be observed where the Earth's strong lithosphere exerts stress on the weaker asthenosphere which, over geological time flows laterally such that the load of the lithosphere is accommodated by height adjustments.

The general term 'isostasy' was coined in 1889 by the American geologist Clarence Dutton.

UNIT-II

LONG ANSWER TYPE QUESTIONS

Q. 1. What is the meaning of Rock ? Classify.

Ans. In geology, **rock** or **stone** is a naturally occurring solid aggregate of minerals and/or mineraloids. The Earth's outer solid layer, the lithosphere, is made of rock. In general rocks are of three types, namely, igneous, sedimentary, and metamorphic. The scientific study of rocks is called petrology, and petrology is an essential component of geology.

CLASSIFICATION OF ROCKS

1. Rock outcrop along a mountain creek near Orosi, Costa Rica : Rocks are generally classified by mineral and chemical composition, by the texture of the constituent particles and by the processes that formed them. These indicators separate rocks into igneous, sedimentary, and metamorphic. They are further classified according to particle size. The transformation of one rock type to another is described by the geological model called the rock cycle.

2. Sample of igneous gabbro : Igneous rocks are formed when molten magma cools and are divided into two main categories : plutonic rock and volcanic. Plutonic or intrusive rocks result when magma cools and crystallizes slowly within the Earth's crust (example granite), while volcanic or extrusive rocks result from magma reaching the surface either as lava or fragmental ejecta (examples pumice and basalt).

3. Sedimentary sandstone with iron oxide bands : Sedimentary rocks are formed by deposition of either clastic sediments, organic matter, or chemical precipitates (evaporites), followed by compaction of the particulate matter and cementation during diagenesis. Sedimentary rocks form at or near the Earth's surface. Mud rocks comprise 65% (mudstone, shale and siltstone); sandstones 20 to 25% and carbonate rocks 10 to 15% (limestone and dolostone).

4. Metamorphic banded gneiss : Metamorphic rocks are formed by subjecting any rock type (including previously formed metamorphic rock) to different temperature and pressure conditions than those in which the original rock was formed. These temperatures and pressures are always higher than those at the Earth's surface and must be sufficiently high so as to change the original minerals into other mineral types or else into other forms of the same minerals (e.g. by recrystallization).

The three classes of rocks—the igneous, the sedimentary and the metamorphic—are subdivided into many groups. There are, however, no hard and fast boundaries between allied rocks. By increase or decrease in the proportions of their constituent minerals they pass by every gradation into one another, the distinctive structures also of one kind of rock may often be traced gradually merging into those of another. Hence the definitions adopted in establishing rock nomenclature merely correspond to selected points (more or less arbitrary) in a continuously graduated series.

Q. 2. Explain the Earth's movement.

Ans. **ROTATION**

Earth's axial tilt (or obliquity) and its relation to the rotation axis and plane of orbit. Earth's rotation period relative to the Sun—its mean solar day—is 86,400 seconds of mean solar time (86,400·0025 SI seconds). As the Earth's solar day is now slightly longer than it was during the 19th century because of tidal acceleration, each day varies between 0 and 2 SI ms longer.

Earth's rotation period relative to the fixed stars, called its *stellar day* by the International Earth Rotation and Reference Systems Service (IERS), is 86164·098903691 seconds of mean solar time (UT1), or 23^h 56^m 4·098903691. Earth's rotation period relative to the precessing or moving mean vernal equinox, misnamed its *sidereal day*, is 86164·09053083288 seconds of mean solar time (UT1) (23^h 56^m 4·09053083288). Thus the sidereal day is shorter than the stellar day by about 8·4 ms. The length of the mean solar day in SI seconds is available from the IERS for the periods 1623-2005 and 1962-2005.

Apart from meteors within the atmosphere and low-orbiting satellites, the main apparent motion of celestial bodies in the Earth's sky is to the west at a rate of 15°/h = 15'/min. For bodies near the celestial equator, this is equivalent to an apparent diameter of the Sun or Moon every two minutes; from the planet's surface, the apparent sizes of the Sun and the Moon are approximately the same.

Orbit

Earth orbits the Sun at an average distance of about 150 million kilometers every 365·2564 mean solar days, or one sidereal year. From Earth, this gives an apparent movement of the Sun eastward with respect to the stars at a rate of about 1°/day, or a Sun or Moon diameter, every 12 hours. Because of this motion, on average it takes 24 hours—a solar day—for Earth to complete a full rotation about its axis so that the Sun returns to the meridian. The orbital speed of the Earth averages about 29·8 km/s (107,000 km/h), which is fast enough to cover the planet's diameter (about 12,600 km) in seven minutes, and the distance to the Moon (384,000 km) in four hours.

The Moon revolves with the Earth around a common barycenter every 27·32 days relative to the background stars. When combined with the Earth-Moon system's common revolution around the Sun, the period of the synodic month, from new moon to new moon, is 29·53 days. Viewed from the celestial north pole, the motion of Earth, the Moon and their axial rotations are all counterclockwise. Viewed from a vantage point above the north poles of both the Sun and the Earth, the Earth appears to revolve in a counterclockwise direction about the Sun. The orbital and axial planes are not precisely aligned : Earth's axis is tilted some 23·4 degrees from the perpendicular to the Earth-Sun plane, and the Earth-Moon plane is tilted about 5 degrees against the Earth-Sun plane. Without this tilt, there would be an eclipse every two weeks, alternating between lunar eclipses and solar eclipses.

The Hill sphere, or gravitational sphere of influence, of the Earth is about 1·5 Gm (or 1,550,000 kilometers) in radius. This is maximum distance at which the Earth's gravitational influence is stronger than the more distant Sun and planets. Objects must orbit the Earth within this radius, or they can become unbound by the gravitational perturbation of the Sun.

Earth, along with the Solar System, is situated in the Milky Way galaxy, orbiting about 28,000 light years from the center of the galaxy. It is currently about 20 light years above the galaxy's equatorial plane in the Orion spiral arm.

Q. 3. Rotation of Earth is related to driving force. Explain.

Ans. EARTH ROTATION RELATED TO DRIVING FORCES

Alfred Wegener, being a meteorologist, had proposed tidal forces and pole flight force as main driving mechanisms for continental drift. However, these forces were considered far too small to cause continental motion as the concept then was of continents plowing through oceanic crust. Therefore, Wegener converted to convection currents as the main driving force in the last edition of his book in 1929.

In the plate tectonics context (accepted since the seafloor spreading proposals of Heezen, Hess, Dietz, Morley, Vine and Matthews (see below) during the early 1960s) though, oceanic crust is in motion with the continents which caused the proposals related to Earth rotation to be reconsidered. In more recent literature, these driving forces are :

1. Tidal drag due to the gravitational force the Moon (and the Sun) exerts on the crust of the Earth;
2. Shear strain of the Earth's globe due to N-S compression related to the rotation and modulations of it;
3. Pole flight force : equatorial drift due to rotation and centrifugal effects : tendency of the plates to move from the poles to the equator (*'Polflucht'*);
4. Coriolis effect acting on plates when they move around the globe;
5. Global deformation of the geoid due to small displacements of rotational pole with respect to the Earth crust;
5. Other smaller deformation effects of the crust due to wobbles and spin movements of the Earth rotation on a smaller time scale.

In order for these mechanisms to be overall valid, systematic relationships should exist all over the globe between the orientation and kinematics of deformation, and the geographical latitudinal and longitudinal grid of the Earth itself. Ironically, these systematic relations studies in the second half of the nineteenth century and the first half of the twentieth century do underline exactly the opposite : that the plates had not moved in time, that the deformation grid was fixed with respect to the Earth equator and axis, and that gravitational driving forces were generally acting vertically and caused only locally horizontal movements (the so-called pre-plate tectonic, 'fixist theories'). Later studies (discussed below on this page) therefore invoked many of the relationships recognised during this pre-plate tectonics period, to support their theories (see the anticipations and reviews in the work of van Dijk and collaborators.

Of the many forces discussed in this paragraph, tidal force is still highly debated and defended as a possible principle driving force, whereas the other forces are used or in global geodynamic models not using the plate tectonics concepts (therefore beyond the discussions treated in this section), or proposed as minor modulations within the overall plate tectonics model.

In 1973 George W. Moore of the USGS and R. C. Bostrom presented evidence for a general westward drift of the Earth's lithosphere with respect to the mantle, and, therefore, tidal forces or tidal lag or 'friction' due to the Earth's rotation and the forces acting upon it by the Moon being a driving force for plate tectonics : as the Earth spins eastward beneath the moon, the moon's gravity ever so slightly pulls the Earth's surface layer back westward, just like proposed by Alfred Wegener (see above). In a more recent 2006 study, scientists reviewed and advocated these earlier proposed ideas. It has also been suggested recently in Lovett (2006) that this observation may also explain why Venus and Mars have no plate tectonics, since Venus has no moon and Mars' moons are too small to have significant tidal effects on Mars. In a recent paper it was suggested that, on the other hand, it can easily be observed that many plates are moving north and eastward, and that the dominantly westward motion of the Pacific ocean basins derives simply from the eastward bias of the Pacific spreading center (which is not a predicted manifestation of such lunar forces). In the same paper the authors admit, however, that relative to the lower mantle, there is a slight westward component in the motions of all the plates. They demonstrated though that the westward drift, seen only for the past 30 Ma, is attributed to the increased dominance of the steadily growing and accelerating Pacific plate. The debate is still open.

Q. 4. What do you mean by Drainage Patterns ?

Ans. DRAINAGE PATTERNS

Aerial photograph illustrating typical dendritic drainage pattern developed in an area underlain by Gila conglomerate. Gila County, arizona.

Over time, a stream system achieves a particular **drainage pattern** to its network of stream channels and tributaries as determined by local geologic factors. Drainage patterns or nets are classified on the basis of their form and texture. Their shape or pattern develops in response to the local topography and subsurface geology. Drainage channels develop where surface runoff is enhanced and earth materials provide the least resistance to erosion. The texture is governed by soil infiltration, and the volume of water available in a given period of time to enter the surface. If the soil has only a moderate infiltration capacity and a small amount of precipitation strikes the surface over a given period of time, the water will likely soak in rather than evaporate away. If a large amount of water strikes the surface then more water will evaporate, soaks into the surface, or ponds on level ground. On sloping surfaces this excess water will runoff. Fewer drainage channels will develop where the surface is flat and the soil infiltration is high because the water will soak into the surface. The fewer number of channels, the coarser will be the drainage pattern.

Dendritic Drainage Pattern

A dendritic drainage pattern is the most common form and looks like the branching pattern of tree roots. It develops in regions underlain by homogeneous material. That is, the subsurface geology has a similar resistance to weathering so there is no apparent control over the direction the tributaries take. Tributaries joining larger streams at acute angle (less than 90 degrees).

Parallel Drainage Pattern

Parallel drainage patterns form where there is a pronounced surface. A parallel pattern also develops in regions of parallel, like outcropping resistant rock bands. Tributary streams tend to parallel-like fashion following the slope of the surface. A parallel indicates the presence of a major fault that cuts across an area of bedrock. All forms of transitions can occur between parallel, patterns.

Trellis Drainage Pattern

Trellis drainage patterns look similar to their namesake, the common garden trellis. Trellis drainage develops in folded topography like that found in the Appalachian Mountains of North America. Down-turned folds called synclines form valleys in which resides the main channel of the stream. Short tributary streams enter the main channel at sharp angles as they run down sides of parallel ridges called anticlines. Tributaries join the main stream at nearly right angles.

Rectangular Drainage Pattern

The rectangular drainage pattern is found in regions that have undergone faulting. Streams follow the path of least resistance and thus are concentrated in places were exposed rock is the weakest. Movement of the surface due to faulting off-sets the direction of the stream. As a result, the tributary streams make shape bends and enter the main stream at high angles.

Radial Drainage Pattern

The radial drainage pattern develops around a central elevated point. This pattern is common to such conically shaped features as volcanoes. The tributary streams extend the headward reaches upslope toward the top of the volcano.

Centripetal Drainage Pattern

The centripetal drainage pattern is just the opposite of the radial as streams flow toward a central depression. This pattern is typical in the western and south western portions of the United States where basins exhibit interior drainage. During wetter portions of the year, these streams feed ephemeral lakes, which evaporate away during dry periods. Salt flats are created in these dry lake beds as salt dissolved in the lake water precipitates out of solution and is left behind when the water.

Deranged Drainage Pattern

Deranged or contorted patterns develop from the disruption of a pre-existing drainage pattern. Figure began as a dendritic pattern but was altered when overrun by glacier. After receiding, the glacier left behind fine grain material that form wetlands and deposits that dammed the stream to impound a small lake. The tributary streams appear significantly more contorted than they were prior to glaciation.

The patterns described above are **accordant**, or correlated with the structure and relief over which they flow. Those streams that are **discordant** with the rocks over which they flow are either antecedent or superimposed. For instance, **antecedent** streams flowed across bedrock structures prior to uplift. Slow mountain building permitted stream erosion to keep pace with uplift. Such appears to be the case for the Columbia River that cuts across the Cascade Mountains. Streams in portions of the Appalachian Mountains have formed in weaker rock that through time has eroded away. These streams appear to be **superimposed** over the rock layers that they presently flow over. The Cumberland Gap is a famous water gap formed in this way as it cuts through the folds of the Appalachians.

Q. 5. What do you mean by Erosion ?

Ans. Erosion is when materials are removed from the surface and changed into something else. It only works by hydraulic actions and transport of solids (sediment, soil, rock and other particles) in the natural environment, and leads to the deposition of these materials elsewhere. It usually occurs due to transport by wind, water, or ice; by down-slope creep of soil and other material under the force of gravity; or by living organisms, such as burrowing animals, in the case of bioerosion.

Although erosion is a natural process human land use policies also have had an effect on erosion, especially industrial agriculture, deforestation, and urban sprawl. Land that is used for industrial agriculture generally experiences a significantly greater rate of erosion than that of land under natural vegetation, or land used for sustainable agricultural practices. This is particularly true if tillage is used, which reduces vegetation cover on the surface of the soil and disturbs both soil structure and plant roots that would otherwise hold the soil in place. However, improved land use practices can limit erosion, using techniques such as terrace-building, no-till, and tree planting.

A certain amount of erosion is natural and, in fact, healthy for the ecosystem. For example, gravels continuously move downstream in watercourses. Excessive erosion, however, causes serious problems, such as receiving water sedimentation, ecosystem damage and outright loss of soil.

Erosion is distinguished from weathering, which is the process of chemical or physical breakdown of the minerals in the rocks. The two processes may occur concurrently, however.

Q. 6. What do you mean by Geomorphology ?

Ans. **GEOMORPHOLOGY**

Geomorphology is the scientific study of landforms and the processes that shape them. Geomorphologists seek to understand why landscapes look the way they do, to understand landform history and dynamics, and to predict future changes through a combination of field observation, physical experiments, and numerical modeling. Geomorphology is practiced within geography, geology, geodesy, engineering geology, archaeology, and geotechnical engineering, and this broad base of interest contributes to a wide variety of research styles and interests within the field.

The surface of Earth is modified by a combination of surface processes that sculpt landscapes, and geologic processes that cause tectonic uplift and subsidence. Surface processes comprise the action of water, wind, ice, fire, and living things on the surface of the Earth, along with chemical reactions that form soils and alter material properties, the stability and rate of change of topography under the force of gravity, and other factors, such as (in the very recent past) human alteration of the landscape. Many of these factors are strongly mediated by cliamte. Geologic processes include the uplift of mountain ranges, the growth of volcanoes, isostatic changes in land surface elevation (sometimes in response to surface processes), and the formation of deep sedimentary basins where the surface of Earth drops and is filled with material eroded from other parts of the landscape. The Earth surface and its topography therefore are an intersection of climatic, hydrologic, and biologic action with geologic processes.

The broad-scale topographies of Earth illustrate this intersection of surface and subsurface action. Mountain belts are uplifted due to geologic processes. Denudation of these high uplifted regions produces sediment that is transported and deposited elsewhere within the landscape or off the coast. On progressively smaller scales, similar ideas apply, where individual landsforms evolve in response to the balance of additive processes (uplift and deposition) and subtractive processes (subsidence and erosion). Often, these processes directly affect each other : ice sheets, water, and sediment are all loads that change topography through flexural isostasy. Topography can modify the local climate, for example through orographic precipitation, which in turn modifies the topography by changing the hydrologic regime in which it evolves. Many geomorphologists are particularly interested in the potential for feedbacks between climate and tectonics mediated by geomorphic processes.

In addition to these broad-scale questions, geomorphologists address issues that are more specific and/or more local. Glacial geomorphologists investigate glacial deposits such as moraines, eskers, and proglacial lakes, as well as glacial erosional features, to build chronologies of both small glaciers and large ice sheets and understand their motions and effects upon the landscape. Fluvial geomorphologists focus on rivers, how they transport sediment, migrate across the landscape, cut into bedrock, respond to enviornmental and tectonic changes, and interact with humans. Soils geomorphologists investigate spoil profiles and chemistry to learn about the history of a particular landscape and understand how climate, biota, and rock interact. Other geomorphologists study how hillslopes form and change. Still others investigate the relationships between ecology and geomorphology. Because geomorphology is defined to comprise everything related to the surface of Earth and its modification, it is a broad field with many facets.

Practical applications of geomorphology include hazard assessment (such as landslide prediction and mitigation), river control and stream restoration, and coastal protection.

Q. 7. Explain the cycle of Erosion by Davis.

Ans. William Morris Davis (February 12, 1850—February 5, 1934) was an American geographer, geologist, geomorphologist, and meteorologist, often called the 'father of American geography'. He was born into a Quaker family in Philadelphia, Pennsylvania, son of Edward M. Davis and Maria Mott Davis (a daughter of the women's advocate Lucretia Mott). He graduated from Harvard University in 1869 and received a Master of Engineering in the following year.

He then worked in Cordoba, Argentina for three years, then after working as an assistant to Nathaniel Shaler, he became an instructor in geology at Harvard, in 1879. (Davis never completed his Ph.D.) He married Ellen B. Warner of Springfield, Massachusetts in the same year.

His most influential scientific contribution was the cycle of erosion, first defined around 1884, which was a model of how rivers create landforms. His cycle of erosion suggests that (larger) rivers have three main sections : upper course, middle course, and lower course—each of which has distinct landforms and other properties associated with it.

Though it was a crucial early contribution to geomorphology, many of Davis' theories regarding landscape evolution, sometimes known as Davisian geomorphology, have been heavily criticised by modern geomorphologists. Also criticized were his tendency to go after and discredit geomorphologists who disagreed with his ideas and methods. In fact, until he retired, he had the study of landscape evolution almost monopolized.

In modern times, the accusation of someone using Davisian geomorphology is sometimes used when attempting to discredit the scientific papers of others.

He was a founder of the Association of American Geographers in 1904, and heavily involved with the National Geographic Society in its early years, writing a number of articles for the magazine.

Davis retired from Harvard in 1911. After his first wife died, Davis married Mary M. Wyman of Cambridge, Massachusetts in 1914, and, after her death, he married Lucy L. Tennant of Milton, Massachusetts in 1928, who survived him.

He died in Pasadena, California, shortly before his 84th birthday.

SHORT ANSWER TYPE QUESTIONS

Q. 1. Write a short note on the contemporary geomorphology.

Ans. CONTEMPORARY GEOMORPHOLOGY

Today, the field of geomorphology encompasses a very wide range of different approaches and interests. Modern researchers aim to draw out quantitative 'laws' that govern Earth surface processes, but equally, recognize the uniqueness of each landscape and environment in which these processes operate. Particularly important realizations in contemporary geomorphology include :

1. that not all landscapes can be considered as either 'stable' or 'perturbed', where this perturbed state is a temporary displacement away from some ideal target form. Instead, dynamic changes of the landscape are now seen as an essential part of their nature.
2. that many geomorphic systems are best understood in terms of the stochasticity of the processes occurring in them, that is, the probability distributions of event magnitudes and return times. This in turn has indicated the importance of chaotic determinism to landscapes, and that landscape properties are best considered statistically. The same processes in the same landscapes does not always lead to the same end results.

Q. 2. The rate of erosion depends on how many factors ?

Ans. The rate of erosion depends on many factors. Climatic factors include the amount and intensity of precipitation, the average temperature, as well as the typical temperature range, and seasonality, the wind speed, storm frequency. Erosion is caused by 'fluid flow'. Any substance, like wind, water, or ice, which flows consistently from one place to another, will facilitate erosion. The geologic factors include the sediment or rock type, its porosity and permeability, the slope (gradient) of the land, and whether the rocks are tilted, faulted, folded, or weathered. The biological factors include ground cover from vegetation or lack thereof, the type of organisms inhabiting the area, and the land use.

In general, given similar vegetation and ecosystems, area with high-intensity precipitation, more frequent rainfall, more wind, or more storms are expected to have more erosion. Sediment with high sand or silt contents and areas with steep slopes erode more easily, as do areas with highly fractured or weathered rock. Porosity and permeability of the sediment or rock affect the speed with which the water can percolate into the ground. If the water moves underground, less runoff is generated, reducing the amount of surface erosion. Sediments containing more clay tend to erode less than those with sand or silt. Here, however, the impact of atmospheric sodium on erodibility of clay should be considered.

The factor that is most subject to change is the amount and type of ground cover. In an undisturbed forest, the mineral soil is protected by a litter layer and an organic layer. These two layers protect the soil by absorbing the impact of rain drops. These layers and the underlying soil in a forest are porous and highly permeable to rainfall. Typically, only the most severe rainfall and large hailstorm events will lead to overland flow in a forest. If the trees are removed by fire or logging, infiltration rates become high and erosion low to the degree the forest floor remains intact. Severe fires can lead to significantly increased erosion if followed by heavy rainfall. In the case of construction or road building, when the litter layer is removed or compacted, the susceptibility of the soil to erosion is greatly increased.

Roads are especially likely to cause increased rates of erosion because, in addition to removing ground cover, they can significantly change drainage patterns, especially if an embankment has been made to support the road. A road that has a lot of rock and one that is 'hydrologically invisible' (that gets the water off the road as quickly as possible, mimicking natural drainage patterns) has the best chance of not causing increased erosion.

Many human activities remove vegetation from an area, making the soil susceptible to erosion. Logging can cause increased erosion rates due to soil compaction, exposure of mineral soil, for example roads and landings. However it is the removal of or compromise to the forest floor not the removal of the canopy that can lead to erosion. This is because rain drops striking tree leaves coalesce with other rain drops creating larger drops. When these larger drops fall (called throughfall) they again may reach terminal velocity and strike the ground with more energy than had they fallen in the open. Terminal velocity of rain drops is reached in about 8 meters. Because forest canopies are usually higher than this, leaf drop can regain terminal velocity. However, the intact forest floor, with its layers of leaf litter and organic matter, absorbs the impact of the rainfall.

Q. 3. What do you mean by Gravity ?

Ans. Mass wasting is the down-slope movement of rock and sediments, mainly due to the force of gravity. Mass movement is an important part of the erosional process, as it moves material from higher elevations to lower elevations where other eroding agents such as streams and glaciers can then pick up the material and move it to even lower elevations. Mass-movement processes are always occurring continuously on all slopes: some mass-movement processes act very slowly; others occur very suddenly, often with disastrous results. Any perceptible down-slope movement of rock or sediment is often referred to in general terms as a landslide. However, landslides can be classified in a much more detailed way that reflects the mechanisms responsible for the movement and the velocity at which the movement occurs. One of the visible topographical manifestations of a very slow form of such activity is a scree slope.

Slumping happens on steep hillsides, occuring along distinct fracture zones, often within materials like clay that, once released, may move quite rapidly downhill. They will often show a spoon-shaped isostatic depression, in which the material has begun to slide downhill. In some cases, the slump is caused by water beneath the slope weakening it. In many cases it is simply the result of poor engineering along highways where it is a regular occurrence.

Surface creep is the slow movement of soil and rock debris by gravity which is usually not perceptible except through extended observation. However, the term can also describe the rolling of dislodged soil particles 0·5 to 1·0 mm in diameter by wind along the soil surface.

Q. 4. Write a short note on the soil erosion and climate change.

Ans. The warmer atmospheric temperatures observed over the past decades are expected to lead to a more vigorous hydrological cycle, including more extreme rainfall events. In 1998 Karl and Knight reported that from 1910 to 1996 total precipitation over the contiguous U.S. increased, and that 53% of the increase came from the upper 10% of precipitation events (the most intense precipitation). The percent of precipitation coming from days of precipitation in excess of 50 mm has also increased significantly.

Studies on soil erosion suggest that increased rainfall amounts and intensities will lead to greater rates of erosion. Thus, if rainfall amounts and intensities increase in many parts of the world as expected, erosion will also increase, unless amelioration measures are taken. Soil erosion rates are expected to change in response to changes in climate for a variety of reasons. The most direct is the change in the erosive power of rainfall. Other reasons include : (a) changes in plant canopy caused by shifts in plant biomass production associated with moisture regime; (b) changes in litter cover on the ground caused by changes in both plant residue decomposition rates driven by temperature and moisture dependent soil microbial activity as well as plant biomass production rates; (c) changes in soil moisture due to shifting precipitation regimes and evapo-transpiration rates, which changes infiltration and runoff ratios; (d) soil erodibility changes due to decrease in soil organic matter concentrations in soils that lead to a soil structure that is more susceptible to erosion and increased runoff due to increased soil surface sealing and crusting; (e) a shift of winter precipitation from non-erosive snow to erosive rainfall due to increasing winter temperatures; (f) melting of permafrost, which induces an erodible soil state from a previously non-erodible one; and (g) shifts in land use made necessary to accommodate new climatic regimes.

Studies by Pruski and Nearing indicated that, other factors such as land use not considered, we can expect approximately a 1·7% change in soil erosion for each 1% change in total precipitation under climate change.

Q. 5. Give some facts about the rocks.

Ans. Some facts about the rocks are following :

1. All rocks are made of two or more minerals, but minerals are not made of rocks. A mineral is the same all the way through .
2. There are about 3,000 known minerals on the Earth.
3. Quartz is one of the most common minerals found on Earth, and basalt is the most common rock.
4. Diamond is the hardest natural substance on Earth, and a diamond is used to cut another diamond.
5. Marble forms from metamorphosed carbonate rock, most usually limestone.
6. Breccia is a rock composed of generally large, sharp fragments cemented together.
7. The biggest pure-gold nugget was found in Australia in 1869 and weighed 156 pounds. Gold is extremely soft and one of the most valuable minerals.
8. Geodes are plain balls of igneous or sedimentary rock on the outside, but contain beautiful crystals on the inside.
9. Feldspar is a term used for a very large group of minerals which are extremely abundant on Earth. Feldspars make up more than half of the Earth's crust.
10. The first recorded use of turquoise dates back to 5000 BC in Mesopotamia, where people used the gemstone to make beads, and lapis lazul is treasured for its rich blue color and is often used in jewelry. The ancient Egyptians used powdered lapis lazul as eye shadow. Jade is extremely strong which made it a perfect choice for making things like fish hooks, knives, hammers and axes throughout history.

Q. 6. Write a short note on the uses of Rocks.

Ans. The use of rocks has had a huge impact on the cultural and technological development of the human race. Rocks have been used by humans and other hominids for more than 2 million years. Lithic technology marks some of the oldest and continuously used technologies. The mining of rocks for their metal ore content has been one of the most important factors of human advancement, which has progressed at different rates in different places in part because of the kind of metals available from the rocks of a region.

The prehistory and history of civilization is classified into the Stone Age, Bronze Age, and Iron Age. Although the stone age has ended virtually everywhere, rocks continue to be used to construct buildings and infrastructure. When so used, rocks are called dimension stone.

Q. 7. Write a short note on the measuring and preventing Erosion.

Ans. **MEASURING AND PREVENTING EROSION**

Erosion is measured and further understood using tools such as the micro-erosion meter (MEM) and the traversing micro-erosion meter (TMEM). The MEM has proved helpful in measuring bedrock erosion in various ecosystems around the world. It can measure both terrestrial and oceanic erosion. On the other hand, the TMEM can be used to track the expanding and contracting of volatile rock formations and can give a reading of how quickly a rock formation is deteriorating.

Tactics for preventing erosion in the future have been under investigation by scientists and geologists all over the world. Today, the most effective method for erosion prevention is soil surface cover. In this method, some type of permeable material, left over crop residue for example, covers the soil surface, which includes rock and sediment debris. This decreases the deteriorating capabilities of the impact from rain, animals, machinery, or any other type of eroding agent. As a result, surface runoff is controlled which helps eliminate the transportation of eroded particles elsewhere, thus slowing the process of erosion as a whole.

Q. 8. Write a short note on the Tectonic effects of the Erosion.

Ans. River eroding volcanic ash flow Alaska Southwest, Valley of Ten Thousand Smokes. The removal by erosion of large amounts of rock from a particular region, and its deposition elsewhere, can result in a lightening of the load on the lower crust and mantle. This can cause tectonic or isostatic uplift in the region. Research undertaken since the early 1990s suggests that the spatial distribution of erosion at the surface of an orogen can exert a key influence on its growth and its final internal structure (see erosion and tectonics).

UNIT-III

LONG ANSWER TYPE QUESTIONS

Q. 1. What do you mean by Atmosphere ?

Ans. An **atmosphere** (New Latin *atmosphaera,* created in the 17th century from Greek 'ατμός' [*atmos*] 'vapor' and σφαιρα [*sphaira*] 'sphere') is a layer of gases that may surround a material body of sufficient mass, and that is held in place by the gravity of the body. An atmosphere may be retained for a longer duration, if the gravity is high and the atmosphere's temperature is low. Some planets consist mainly of various gases, but only their outer layer is their atmosphere.

The term stellar atmosphere describes the outer region of a star, and typically includes the portion starting from the opaque photosphere outwards. Relatively low-temperature stars may form compound molecules in their outer atmosphere. Earth's atmosphere, which contains oxygen used by mot organisms for respiration and carbon di-oxide used by plants, algae and cyanobacteria for photosynthesis, also protects living organisms from genetic damage by solar ultraviolet radiation. Its current composition is the product of billions of years of biochemical modification of the paleoatmosphere by living organisms.

Atmospheric Pressure

Atmospheric pressure is the force per unit area that is always applied perpendicularly to a surface by the surrounding gas. It is determined by a planet's gravitational force in combination with the total mass of a column of gas above a location. Units of air pressure are based on the internationally recognized standard atmosphere (atm), which is defined as 101,325 Pa (or 1,013,250 dynes per cm^2).

The pressure of an atmospheric gas decreases with altitude due to the diminishing mass of gas above each location. The height at which the pressure from an atmosphere declines by a factor of *e'* (an irrational number with a value of 2·71828..) is called the scale height and is denoted by H. For an atmosphere with a uniform temperature, the scale height is proportional to the temperature and inversely proportional to the mean molecular mass of dry air times the planet's gravitational acceleration. For such a model atmosphere, the pressure declines exponentially with increasing altitude. However, atmosphere are not uniform in temperature, so the exact determination of the atmospheric pressure at any particular altitude is more complex.

Atmospheric Escape

Surface gravity, the force that holds down an atmosphere, differs significantly among the planets. For example, the large gravitational force of the giant planet Jupiter is able to retain light gases such as hydrogen and helium that escape from lower gravity objects. Second, the distance from the sun determines the energy available to heat atmospheric gas to the point where its molecules' thermal motion exceed the planet's escape velocity, the speed at which gas molecules overcome a planet's gravitational grasp. Thus, the distant and cold Titan, Triton, and Pluto are able to retain their atmospheres despite relatively low gravities. Interstellar planets, theoretically, may also retain thick atmospheres.

Since a gas at any particular temperature will have molecules moving at a wide range of velocities, there will almost always be some slow leakage of gas into space. Lighter molecules move faster than heavier ones with the same thermal kinetic energy, and so gases of low molecular weight are lost more rapidly than those of high molecular weight. It is thought that Venus and Mars may have both lost much of their water when, after being photo dissociated into hydrogen and oxygen by solar ultraviolet, the hydrogen escaped. Earth's magnetic field helps to prevent this, as, normally, the solar wind would greatly enhance the escape of hydrogen.

However, over the past 3 billion years the Earth may have lost gases through the magnetic polar regions due to auroral activity, including a net 2% of its atmospheric oxygen.

Other mechanisms that can cause atmosphere depletion are solar wind-induced sputtering, impact erosion, weathering, and sequestration—sometimes referred to as 'freezing out'—into the regolith and polar caps.

Q. 2. Write a note on the composition of atmosphere.

Ans. **COMPOSITION**

Atmospheric gases scatter blue light more than other wavelengths, giving the Earth a blue halo when seen from space.

Initial atmospheric makeup is generally related to the chemistry and temperature of the local solar nebula during planetary formation and the subsequent escape of interior gases. These original atmospheres underwent much evolution over time, with the varying properties of each planet resulting in very different outcomes.

The atmospheres of the planets Venus and Mars are primarily composed of carbon di-oxide, with small quantities of nitrogen, argon, oxygen and traces of other gases.

The atmospheric composition on Earth is largely governed by the by-products of the very life that it sustains. Earth's atmosphere contains roughly (by molar content/volume) 78·08% nitrogen, 20·95% oxygen, a variable amount (average around 1·247%, National Center for Atmospheric Research) water vapor, 0·93% argon, 0·038% carbon di-oxide, and traces of hydrogen, helium, and other 'noble' gases.

The low temperatures and higher gravity of the gas giants—Jupiter, Saturn, Uranus and Neptune—allows them to more readily retain gases with low molecular masses. These planets have hydrogen-helium atmospheres, with trace amounts of more complex compounds.

Two satellites of the outer planets possess non-negligible atmospheres : Titan, a moon of Saturn, and Triton, a moon of Neptune, which are mainly nitrogen. Pluto, in the nearer part of its orbit, has an atmosphere of nitrogen and methane similar to Triton's, but these gases are frozen when farther from the Sun.

Other bodies within the Solar System have extremely thin atmospheres not in equilibrium. These include the Moon (sodium gas), Mercury (sodium gas), Europa (oxygen), lo (sulfur), and Enceladus (water vapor).

The atmospheric composition of an extra-solar planet was first determined using the Hubble Space Telescope. Planet HD 209458b is a gas giant with a close orbit around a star in the constellation Pegasus. The atmosphere is heated to temperatures over 1,000 K, and is steadily escaping into space. Hydrogen, oxygen, carbon and sulfur have been detected in the planet's inflated atmosphere.

Q. 3. What do you understand by Cyclones ?

Or

Explain the structure of Cyclones.

Ans. In meteorology, a **cyclone** is an area of closed, circular fluid motion rotating in the same direction as the Earth. This is usually characterized by inward spiraling winds that rotate anticlockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere of the Earth. A cyclone is a synonym for hurricane. Most large-scale cyclonic circulations are centered on areas of low atmospheric pressure. The largest low-pressure systems are cold-core polar cyclones and extratropical cyclones which lie on the synoptic scale. Warm-core cyclones such as tropical cyclones, mesocyclones, and polar lows lie within the smaller mesoscale. Subtropical cyclones are of intermediate size. Upper level cyclones can exist without the presence of a surface low, and can pinch off from the base of the Tropical Upper Tropospheric Trough during the summer months in the Northern Hemisphere. Cyclones have also been seen on extraterrestrial planets, such as Mars and Neptune.

Cyclogenesis describes the process of cyclone formation and intensification. Extratropical cyclones form as waves in large regions of enhanced mid-latitude temperature contrasts called baroclinic zones. These zones contract to form weather fronts as the cyclonic circulation closes and intensifies. Later in their life cycle, cyclones occlude as cold core systems. A cyclone's track is guided over the course of its 2 to 6 day life cycle by the steering flow of the cancer or subtropical jet stream.

Weather fronts separate two masses of air of different densities and are associated with the most prominent meteorological phenomena. Air masses separated by a front may differ in temperature or humidity. Strong cold fronts typically feature narrow bands of thunderstorms and severe weather, and may on occasion be preceded by squall lines or dry lines. They form west of the circulation center and generally move from west to east. Warm fronts form east of the cyclone center and are usually preceded by stratiform precipitation and fog. They move poleward ahead of the cyclone path. Occluded fronts form late in the cyclone life cycle near the center of the cyclone and often wrap around the storm center.

Tropical cyclogenesis describes the process of development of tropical cyclones. Tropical cyclones form due to latent heat driven by significant thunderstorm activity, and are warm core. Cyclones can transition between extratropical, subtropical, and tropical phases under the right conditions. Mesocyclones form as warm core cyclones over land, and can lead to tornado environments of high instability and low vertical wind shear.

Structure

There are a number of structural characteristics common to all cyclones. The cyclones have high pressure outside and low pressure inside. A cyclone is a low pressure area. A cyclone's center (often known in a mature tropical cyclone as the eye), is the area of lowest atmospheric pressure in the region. Near the center, the pressure gradient force (from the pressure in the center of the cyclone compared to the pressure outside the cyclone) and the force from the Coriolis effect must be in an approximate balance, or the cyclone would collapse on itself as a result of the difference in pressure.

Because of the Coriolis effect, the wind flow around a large cyclones is counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. In the Northern Hemisphere, the fastest winds relative to the surface of the Earth therefore occur on the eastern side of a northward-moving cyclone and on the northern side of a westward-moving one; the opposite occurs in the Southern Hemisphere. (The wind flow around an anticyclone, on the other hand, is clockwise in the northern hemisphere, and counterclockwise in the southern hemisphere).

Formation

The initial extratropical low pressure area forms at the location of the red dot on the image. It is usually perpendicular (at a right angle to) the leaf-like cloud formation seen on satellite during the early stage of cyclogenesis. The location of the axis of the upper level jet stream is in light blue.

CYCLOGENESIS AND TROPICAL CYCLOGENESIS

Cyclogenesis is the development or strengthening of cyclonic circulation in the atmosphere (a low pressure area). Cyclogenesis is an umbrella term for several different processes, all of which result in the development of some sort of cyclone. It can occur at various scales, from the microscale to the synoptic scale.

Extratropical cyclones form as waves along weather fronts before occluding later in their life cycle as cold core cyclones.

Tropical cyclones form due to latent heat driven by significant thunderstorm activity, and are warm one.

Mesocyclones form as warm core cyclones over land, and can lead to tornado formation. Waterspouts can also form from mesocyclones, but more often develop from environments of high instability and low vertical wind shear. Cyclogenesis is the opposite of cyclolysis, and has an anticyclonic (high pressure system) equivalent which deals with the formation of high pressure areas—Anticyclogenesis.

The surface low has a variety of ways of forming. Topography can force a surface low when dense low-level high pressure system ridges in east of a north-south mountain barrier. Mesoscale convective systems can spawn surface lows which are initially warm core. The disturbance can grow into a wave-like formation along the front and the low will be positioned at the crest. Around the low, flow will become cyclonic, by definition. This rotational flow will push polar air equatorward west of the low via its trailing cold front, and warmer air with push poleward low via the warm front. Usually the cold front will move at a quicker pace than the warm front and 'catch up' with it due to the slow erosion of higher density airmass located out ahead of the cyclone and the higher density airmass sweeping in behind the cyclone, usually resulting in a narrowing warm sector. At this point an occluded front forms where the warm air mass is pushed upwards into a trough of warm air aloft, which is also known as a trowal. Tropical cyclones form when the energy released by the condensation of moisture in rising air causes a positive feedback loop over warm ocean waters.

Tropical cyclogenesis is the technical term describing the development and strengthening of a tropical cyclone in the atmosphere. The mechanisms through which tropical cyclogenesis occurs are distinctly different from those through which mid-latitude cyclogenesis occurs. Tropical cyclogenesis involves the development of a warm-core cyclone, due to significant convection in a favourable atmospheric environment. There are six main requirements for tropical cyclogenesis : sufficiently warm sea surface temperatures, atmospheric instability, high humidity in the lower to middle levels of the troposphere, enough Coriolis force to develop a low pressure center, a preexisting low level focus or disturbance, and low vertical wind shear. An average of 86 tropical cyclones of tropical storm intensity form annually worldwide, with 47 reaching hurricane/typhoon strength, and 20 becoming intense tropical cyclones (at least Category 3 intensity on the Saffir-Simpson Hurricane Scale).

Q. 4. Explain the different layers of atmosphere.

Ans. Without our atmosphere, there would be no life on earth. Two gases make up the bulk of the earth's atmosphere : nitrogen (78%), oxygen (21%). Argon, carbon di-oxide and various trace gases make up the remainder. Scientists divided the atmosphere into four layers according to temperature : troposphere, stratosphere, mesosphere, and thermosphere. The temperature drops as we go up through the troposphere, but it rises as we move through the next layer, the stratosphere. The farther away from earth, the thinner the atmosphere gets.

1. Troposphere

This is the layer of the atmosphere closest to the Earth's surface, extending up to about 10-15 km above the Earth's surface. It contains 75% of the atmosphere's mass. The troposphere is wider at the equator than at the poles. Temperature and pressure drops as you go higher up the troposphere.

The Tropopause : At the very top of the troposphere is the tropopause where the temperature reaches a (stable) minimum. Some scientists call the tropopause a 'cold trap' because this is a point where rising water vapour cannot go higher because it changes into ice and is trapped. If there is no cold trap, Earth would loose all its water.

The uneven heating of the regions of the troposphere by the Sun causes convection currents and winds. Warm air from Earth's surface rises and cold air above it rushes in to replace it. When warm air reaches the tropopause, it cannot go higher as the air above it (in the stratosphere) is warmer and lighter...preventing much air convection beyond the tropopause. The tropopause acts like an invisible barrier and is the reason why most clouds form and weather phenomena occur within the troposphere.

The Greenhouse Effect : Heat from the Sun warms the Earth's surface but most of it is radiated and sent back into space. Water vapour and carbon di-oxide in the troposphere trap some of this heat, preventing it from escaping thus keep the Earth warm. This trapping of heat is called the 'greenhouse effect'.

However, if there is too much carbon di-oxide in the troposphere then it will trap too much heat. Scientists are afraid that the increasing amounts of carbon di-oxide would raise the Earth's surface temperature, bringing significant changes to worldwide weather patterns...shifting in climatic zones and the melting of the polar ice caps, which could raise the level of the world's oceans.

Do you know why the amount of carbon di-oxide is increasing ?

2. Stratosphere

This layer lies directly above the troposphere and is about 35 km deep. It extends from about 15 to 50 km above the Earth's surface. The lower portion of the stratosphere has a nearly constant temperature with height but in the upper portion the temperature increases with altitude because of absorption of sunlight by ozone. This temperature increase with altitude is the opposite of the situation in the troposphere.

The Ozone Layer : The stratosphere contains a thin layer of ozone which absorbs most of the harmful ultraviolet radiation from the Sun. The ozone layer is being depleted, and is getting thinner over Europe, Asia, North American and Antarctica...'holes' are appearing in the ozone layer.

3. Mesosphere

Directly above the stratosphere, extending from 50 to 80 km above the Earth's surface, the mesosphere is a cold layer where the temperature generally decreases with increasing altitude. Here in the mesosphere, the atmosphere is very rarefied nevertheless thick enough to slow down meteors hurtling into the atmosphere, where they burn up, leaving fiery trails in the night sky.

4. Thermosphere

The thermosphere extends from 80 km above the Earth's surface to outer space. The temperature is hot and may be as high as thousands of degrees as the few molecules that are present in the thermosphere receive extraordinary large amounts of energy from the Sun. However, the thermosphere would actually feel very cold to us because of the probability that these few molecules will hit our skin and transfer enough energy to cause appreciable heat is extremely low.

Q. 5. What do you mean by Humidity ?

Or

Explain the different types of Humidity.

Ans. Humidity is a term for the amount of water vapor in the air, and can refer to any one of several measurements of humidity. Formally, humid air is not 'moist air' but a mixture of water vapor and other constituents of air, and humidity is defined in terms of the water content of this mixture, called the *Absolute humidity*. In everyday usage, it commonly refers to relative humidity, expressed as a percent in weather forecasts and on household humidistats; it is so called because it measures the current absolute humidity relative to the maximum. *Specific humidity* is a ratio of the water vapor content of the mixture to the total air content (on a mass basis). The water vapor content of the mixture can be measured either as mass per volume or as a partial pressure, depending on the usage.

In meteorology, humidity indicates the likelihood of precipitation, dew, or fog. High relative humidity reduces the effectiveness of sweating in cooling the body by reducing the rate of evaporation of moisture from the skin. This effect is calculated in a heat index table, used during summer weather.

TYPES OF HUMIDITY

Absolute humidity

If all the water vapor in one cubic meter of air were condensed into a container, the mass of the water in the container could be measured with a scale to determine absolute humidity. The amount of water vapor in that cube of air is the absolute humidity of that cubic meter of air. More technically, absolute humidity on a volume basis is the mass of dissolved water vapor, m_w, per cubic water of total moist air, V_{net} :

$$AH = \frac{m_w}{V_{net}}$$

Absolute humidity ranges from 0 grams per cubic meter in dry air to 30 grams per cubic meter (0·22 ounce per cubic foot) when the vapor is saturated at 30°C. (See also Absolute Humidity table)

The absolute humidity changes as air pressure changes. This is very inconvenient for chemical engineering calculations, e.g. for clothes dryers, where temperature can vary considerably. As a result, absolute humidity is generally defined in chemical engineering as mass of water vapor per unit mass of dry air, also known as the **mass mixing ratio** (see below), which is much more rigorous for heat and mass balance calculations. Mass of water per unit volume as in the equation above would then be defined as **volumetric humidity.** Because of the potential confusion, British Standard BS 1339 (revised 2002) suggests avoiding the term 'absolute humidity'. Units should always be carefully checked. Most humidity charts are given in g/kg or kg/kg, but any mass units may be used.

The field concerned with the study of physical and thermodynamic properties of gas-vapor mixtures is named Psychrometrics.

Relative humidity

Relative humidity is defined as the ratio of the partial pressure of water vapor (in a gaseous mixture of air and water vapor) to the saturated vapor pressure of water at a given temperature. In other words, relative humidity is the amount of water vapor in the air at a specific temperature compared to the maximum water vapor that the air is able to hold without it condensing, at that given temperature. Relative humidity is expressed as a percentage and is calculated in the following manner :

$$P = \frac{P\,(H_2O)}{P'\,(H_2O)} \times 100$$

where,

$P(H_2O)$ is the partial pressure of water vapor in the gas mixture;

$P'(H_2O)$ is the saturation vapor pressure of water at the temperature of the gas mixture; and ϕ is the relative humidity of the gas mixture being considered.

Relative humidity is an important metric used in weather forecasts and reports, as it is an indicator of the likelihood of precipitation, dew, or fog. In hot summer weather, a rise in relative humidity also increases the apparent temperature to humans (and other animals) by hindering the evaporation of perspiration from the skin as the relative humidity rises. For example, according to the Heat Index, a relative humidity of 75% at 80°F (27°C) would feel like 83·574°F ± 1·3°F (28·652°C ± 1·7°C) at ~ 44% relative humidity.

Specific humidity

Specific humidity is the ratio of water vapor to dry air in a particular mass, and is sometimes referred to as humidity ratio. Specific humidity ratio is expressed as a ratio of grams of water vapor, m_v, per kilogram of dry air m_a.

Q. 6. Explain the climate of India.

Ans. A semi-arid wasteland near Tirunelveli, Tamil Nadu. Monsoon clouds dump torrents of rain on lush forests only kilometres away in windwar-facing Kerala. The Agasthyamalai Range mostly stops them from reaching Tirunelveli.

Uttarakhand's Valley of Flowers National Park. Its mountainous windward-facing location wedged between the Zanskars and the Greater Himalayas affords it ample orographic precipitation.

Analyzed according to the Koppen system, the **climate of India** resolves into six major climatic subtypes; their influences give rise to desert in the west, alpine tundra and glaciers in the north, humid tropical regions supporting rain forests in the southwest, and Indian Ocean island territories that flank the Indian subcontinent. Regions have starkly different—yet tightly clustered—microclimates. The nation is largely subject to four seasons : winter (January and February), summer (March to May), a monsoon (rainy) season (June to September), and a post-monsoon period (October to December).

India's geography and geology are climatically pivotal : the Thar Desert in the northwest and the Himalayas in the north work in tandem to effect a culturally and economically break-all monsoonal regime. As Earth's highest and most massive mountain range, the Himalayan system bars the influx of frigid katabatic winds from the icy Tibetan Plateau and northerly Central Asia. Most of North India is thus kept warm or is only mildly chilly or cold during winter; the same thermal dam keeps most regions in India hot in summer.

Though the Tropic of Cancer—the boundary between the tropics and subtropics—passes through the middle of India, the bulk of the country can be regarded as climatically tropical. As in much of the tropics, monsoonal and other weather patterns in India can be wildly unstable : epochal droughts, floods, cyclones, and other natural disasters are sporadic, but have displaced or ended millions of human lives. There is widespread scientific consensus that South Asia is likely to see such climatic events, along with their aleatory unpredictabilty, to change in frequency and are likely to increase in severity. Ongoing and future vegetative changes and current sea level rises and the attendant inundation of India's low-lying coastal areas are other impacts, current or predicted, that are attributable to global warming.

Q. 7. Explain the measurement of humidity.

Ans. MEASUREMENT

A hygrometer is a device used for measuring the humidity of the air. There are various devices used to measure and regulate humidity. A device used to measure humidity is called a psychrometer or hygrometer. A humidistat is used to regulate the humidity of a building with a dehumidifier. These can be analogous to a thermometer and thermostat for temperature control.

Humidity is also measured on a global scale using remotely placed satellites. These satellites are able to detect the concentration of water in the troposphere at altitudes between 4 and 12 kilometers. Satellites that can measure water vapor have sensors that are sensitive to infrared radiation. Water vapour specifically absorbs and re-radiates radiation in this spectral band. Satellite water vapour imagery plays an important role in monitoring climate conditions (like the formation of thunderstorms) and in the development of future weather forecasts.

Q. 8. Explain the role of greenhouse effect, percipitation, and humid subtropical climate.

Ans. While humidity itself is a climate variable, it also interacts strongly with other climate variables. The humidity is affected by winds and by rainfall. At the same time, humidity affects the energy budget and thereby influences temperatures in two major ways. First, water vapor in the atmosphere contains 'latent' energy. During transpiration or evaporation, this latent heat is removed from surface liquid, cooling the earth's surface. This is the biggest non-radiactive cooling effect at the surface. It compensates for roughly 70% of the average net radiative warming at the surface. Second, water vapor is the most important of all greenhouse gases. Water vapor, like a green lens that allows green light to pass through it but absorbs red light, is a 'selective absorber'. A long with other greenhouse gases, water vapor is transparent to most solar energy, as you can literally see. But it absorbs the infrared energy emitted (radiated) upward by the earth's surface, which is the reason that humid areas experience very little nocturnal cooling but dry desert regions cool considerably at night. This selective absorption causes the greenhouse effect. It raises the surface temperature substantially above its theoretical radiative equilibrium temperature with the sun, and water vapor is the cause of more of this warming than any other greenhouse gas.

The most humid cities on earth are generally located closer to the equator, near coastal regions. Cities in South and Southeast Asia are among the most humid, such as Kolkata, Chennai and Cochin in India, the cities of Manila in the Philippines and Bangkok in Thailand : these places experience extreme humidity during their rainy seasons combined with warmth giving the feel of a lukewarm sauna. Darwin, Australia experiences an extremely humid wet season from December to April. Shanghai and Hong Kong in China also have an extreme humid period in their summer months. Kuala Lumpur and Singapore have very high humidity all year round because of their proximity to water bodies and the equator and overcast weather. Perfectly clear days are dependent largely upon the season in which one decides to travel. During the South-west and North-east Monsoon seasons (respectively, late May to September and November to March), expect heavy rains and a relatively high humidity post-rainfall. Outside the monsoon seasons, humidity is high (in comparison to countries North of the Equator), but completely sunny days abound. In cooler places such as Northern Tasmania, Australia, high humidity is experienced all year due to the ocean between mainland Australia and Tasmania. In the summer the hot dry air is absorbed by this ocean and the temperature rarely climbs above 35 degrees Celsius.

In the United States the most humid cities, strictly in terms of relative humidity, are Forks and Olympia, Washington. This fact may come as a surprise to many, as the climate in this region rarely exhibits the discomfort usually associated with high humidity. Dew points are typically much lower on the West Coast than on the East. Because high dew points play a more significant role than relative humidity in the discomfort created during humid days, the air in these western cities usually does not feel 'humid'.

The highest dew points in the US are found in coastal Florida and Texas. When comparing Key West and Houston, two of the most humid cities from those states, coastal Florida seems to have the higher dew points on average. However, Houston lacks the coastal breeze present in Key West, and, as a much larger city, it suffers from the urban heat island effect. A dew point of 86 degrees Fahrenheit was recorded in southern Minnesota on July 23, 2005, though dew points over 80 degrees Fahrenheit are rare there. The US city with the lowest annual humidity is Las Vegas, Nevada, averaging 39% for a high and 21% as a low.

Q. 9. What is a meaning of Air density and Volume ?

Ans. VOLUME (THERMODYNAMICS) AND DENSITY OF AIR

Humidity depends on water vaporization and condensation, which, in turn, mainly depends on temperature. Therefore, when applying more pressure to a gas saturated with water, all components will initially decrease in volume approximately according to the ideal gas law. However, some of the water will condense until returning to almost the same humidity as before, giving the resulting total volume deviating from what the ideal gas law predicted. Conversely, decreasing temperature would also make some water condense, again making the final volume deviating from predicted by the ideal gas law. Therefore, gas volume may alternatively be expressed as the dry volume, excluding the humidity content. This fraction more accurately follows the ideal gas law. On the contrary the saturated volume is the volume a gas mixture would have if humidity was added to it until saturation (or 100% relative humidity).

Humid air is less dense than dry air because a molecule of water ($M \approx$ 18 u) is less massive than either a molecule of nitrogen ($M \approx 28$) or a molecule of oxygen ($M \approx 32$). About 78% of the molecules in dry air are nitrogen (N_2). Another 21% of the molecules in dry air are oxygen (O_2). The final 1% of dry air is a mixture of other gases.

For any gas, at a given temperature and pressure, the number of molecules present in a particular volume is constant—see ideal gas law. So when water molecules (vapor) are introduced into that volume of dry air, the number of air molecules in the volume must decrease by the same number, if the temperature and pressure remain constant. (The addition of water molecules, or any other molecules, to a gas, without removal of an equal number of other molecules, will necessarily require a change in temperature, pressure, or total volume; that is, a change in at least one of these three parameters. If temperature and pressure remain constant, the volume increases, and the dry air molecules that were displaced will initially move out into the additional volume, after which the mixture will eventually become uniform through diffusion.) Hence the mass per unit volume of the gas—its density—decreases. Isaac Newton discovered this phenomenon and wrote about it in his book *Opticks*.

Q. 10. Explain the effects of Humidity.

Ans. **EFFECTS**

Animals and plants

Humidity is one of the fundamental abiotic factors that defines any habitat, and is a determinant of which animals and plants can thrive in a given environment.

The human body sheds heat by a combination of evaporation of perspiration, heat convection in the surrounding air, and thermal radiation. Under conditions of high humidity, the evaporation of sweat from the skin decreases, and the body's efforts to maintain an acceptable body temperature may be significantly impaired. Also if the atmosphere is as warm as or warmer than the skin during times of high humidity, blood brought to the body surface cannot shed heat by conduction to the air, and a condition called hyperpyrexia results. With so much blood going to the external surface of the body, relatively less goes to the active muscles, the brain, and other internal organs. Physical strength declines, and fatigue occurs sooner than it would otherwise. Alertness and mental capacity also may be affected, resulting in heat stroke or hyperthermia.

Human comfort

Humans control their body temperature mainly by sweating and shivering. The United States Environmental Protection Agency cites the ASHRAE Standard 55-1992, *Thermal Environmental Conditions for Human Occupancy*, which recommends keeping relative humidity between 30% and 60%. At high humidity, sweating is less effective, and we feel hotter. At low humidity, the risk for nosebleeds increases, especially during cold winter seasons.

Some people experience difficulty breathing in high humidity environments. Some cases may possibly be related to respiratory conditions such as asthma, while others may be the product of anxiety. Sufferers will often hyperventilate in response, causing sensations of numbness, faintness, and loss of concentration, among others.

Air conditioning works by reducing humidity in summer. In winter, heating cold outdoor air can decrease relative humidity levels indoor to below 30%, leading to discomfort such as dry skin and excessive thirst.

Electronics

Many electronic devices have humidity specifications, for example, 5% to 95%. At the top end of the range, moisture may increase the conductivity of permeable insulators leading to malfunction. Too low humidity may make materials brittle. A particular danger to electronic items, regardless of the stated operating humidity range, is condensation. When an electronic item is moved from a cold place (e.g., garage, car, shed, an air conditioned space in the tropics) to a warm humid place (house, outside tropics), condensation may coat circuit boards and other insulators, leading to short circuit inside the equipment. Such short circuits may cause substantial permanent damage if the equipment is powered on before the condensation has evaporated. A similar condensation effect can often be observed when a person wearing glasses comes in from the cold. It is advisable to allow electronic equipment to acclimatise for several hours, after being brought in from the cold, before powering on. Some electronic devices can detect such a change and indicate, when plugged in and usually with a small droplet symbol, that they cannot be used until the risk from condensation has passed. In situations where time is critical, increasing air flow through the device's internals when, such as removing the side panel from a PC case and directing a fan to blow into the case will reduce significantly the time needed to acclimatise to the new environment.

On the opposite, very low humidity level favors the buildup of static electricity, which may result in spontaneous shutdown of computers when discharges occur. Apart from spurious erratic function, electrostatic discharges can cause dielectric breakdown in solid state devices, resulting in irreversible damage. Data centers often monitor relative humidity levels for these reasons.

Building construction

Traditional building designs typically had weak insulation, and it allowed air moisture to flow freely between the interior and exterior. The energy-efficient, heavily-sealed architecture introduced in the 20th century also sealed off the movement of moisture, ard this has resulted in a secondary problem of condensation forming in and around walls, which encourages the development of mold and mildew. Additionally, buildings with foundations not properly sealed will allow water to flow through the walls due to capillary action of pores found in masonry products. Solutions for energy-efficient buildings that avoid condensation are a current topic of architecture.

Q. 11. Write a history of Climate Regions of India.

Ans. The formation of the Himalayas during the Early Eocene some 53 million years ago was key in determining India's current climate; global climate and ocean chemistry may have been impacted.

During the Triassic period of some 250-199·6 Ma, the Indian subcontinent was part of a vast supercontinent known as Pangaea. Despite its position within a high-latitude belt ast 55-75° S—as opposed to its current position between 5 and 35° N, latitudes now occupied by Greenland and parts of the Antarctic Peninsula—India likely experienced a humid temperate climate with warm and frost-free weather, though with well-defined seasons. India later merged into the southern supercontinent Gondwana, a process beginning some 550-500 Ma. During the Late Paleozoic, Gondwana extended from a point at or near the South Pole to near the equator, where the Indian craton (stable continental crust) was positioned, resulting in a mild climate favourable to hosting high-biomass ecosystems. This is underscored by India's vast coal reserves—much of it from the late Paleozoic sedimentary sequence—the fourth-largest reserves in the world. During the Mesozoic, the world, including India, was considerably warmer than today. With the coming of the Carboniferous, global cooling stoked extensive glaciation, which spread northwards from South Africa towards India; this cool period lasted well into the Permian.

Tectonic movement by the Indian Plate caused it to pass over a geologic hotspot—the Reunion hotspot—now occupied by the volcanic island of Reunion. This resulted in a massive flood basalt event that laid down the Deccan Traps some 60-68 Ma, at the end of the Cretaceous period. This may have contributed to the global Cretaceous-Tertiary (K-T) extinction event, which caused India to experience significantly reduced insolation. Elevated atmospheric levels of sulphur gases formedaerosols such as sulfur di-oxide and sulfuric acid, similar to those found in the atmosphere of Venus; these precipitated as acid rain. Elevated carbon di-oxide emissions also contributed to the greenhouse effect, causing warmer weather that lasted long after the atmospheric shroud of dust and aerosols had cleared. Further climatic changes 20 million years ago, long after India had crashed into the Laurasian landmass, were severe enough to cause the extinction of many endemic Indian forms. The formation of the Himalayas resulted in blockage of frigid Central Asian air, preventing it from reaching India; this made its climate significantly warmer and more tropical in character than it would otherwise have been.

Regions

Average annual temperatures across India :

< 20·0°C	(< 68·0°F)
20·0-22·5°C	(68·0-72·5°F)
22·5-25·0°C	(72·5-77·0°F)
25·0-27·5°C	(77·0-81·5°F)
> 27·5°C	(> 81·5°F)

Climatic zones in India, based on the Koppen classification system :

Alpine	E (*ETh*)
Humid subtropical	C (*Cfa*)
Tropical wet-dry	A (*Aw*)
Tropical wet	A (*Am*)
Semi-arid	B (*BSh*)
Arid	B (*BWh*)

CLIMATIC REGIONS OF INDIA

India is home to an extraordinary variety of climatic regions, ranging from tropical in the south to temperate and alpine in the Himalayan north, where elevated regions receive sustained winter snowfall. The nation's climate is strongly influenced by the Himalayas and the Thar Desert. The Himalayas, along with the Hindu Kush mountains in Pakistan, prevent cold Central Asian katabatic winds from blowing in, keeping the bulk of the Indian subcontinent warmer than most locations at similar latitudes. Simultaneously, the Thar Desert plays a role in attracting moisture-laden southwest summer monsoon winds that, between June and October, provide the majority of India's rainfall. Four major climatic groupings predominate, into which fall seven climatic zones that, as designated by experts, are defined on the basis of such traits as temperature and precipitation. Groupings are assigned codes (see chart) according to the Koppen climate classification system.

Tropical wet

A tropical rainy climate governs regions experiencing persistent warm or high temperatures, which normally do not fall below 18°C (64°F). India hosts two climatic subtypes that fall under this group. The most humid is the tropical wet climate—also known as a tropical monsoon climate—that covers a strip of southwestern lowlands abutting the Malabar Coast, the

Western Ghats, and southern Assam. India's two island territories, Lakshadweep and the Andaman and Nicobar Islands, are also subject to this climate. Characterised by moderate to high year-round temperatures, even in the foothills, its rainfall is seasonal but heavy—typically above 2,000 mm (79 in) per year. Most rainfall occurs between May and November; this moisture is enough to sustain lush forests and other vegetation for the rest of the mainly dry year. December to March are the driest months, when days with precipitation are rare. The heavy monsoon rains are responsible for the exceptionally biodiverse tropical wet forests in parts of these regions. In India a tropical wet and dry climate is more common. Noticeably drier than areas with a tropical monsoon climate, it prevails over most of inland peninsular India except for a semi arid rain shadow east of the Western Ghats. Winter and early summer are long and dry periods with temperatures averaging above 18°C (64°F). Summer is exceedingly hot; temperatures in low-lying areas may exceed 50°C (122°F) during May, leading to heat waves that can each kill hundreds of Indians.

The rainy season lasts from June to September; annual rainfall averages between 750-1,500 mm (30-59 in) across the region. Once the dry northeast monsoon begins in September, most precipitation in India falls on Tamil Nadu, leaving other states comparatively dry. The state's normal annual rainfall is about 945 mm (37·2 in), of which 48% is delivered by the northeast monsoon and 32% by the southwest monsoon. Since the state is entirely dependent on rains for recharging its water resources, monsoon failures lead to acute water scarcity and severe drought. Tamil Nadu is classified into seven agro-climatic zones : northeast, northwest, west, southern, high rainfall, high altitude hilly, and the Kaveri River Delta, the last being the most fertile agricultural zone. The table below shows the maximum and minimum temperatures that the state experiences in the plains and hills. The Ganges Delta lies mostly in the tropical wet climate zone : it receives between 1,500 to 2,000 mm (50 to 79 in) of rainfall each year in the western part, and 2,000 to 3,000 mm (79 to 118 in) in the eastern part. The coolest month of the year, on average, is January; April and May are the warmest months. Average temperatures in January range from 14 to 25°C (57 to 77°F), and average temperatures in April range from 25 to 35°C (77 to 95°F). July is on average the wettest month : over 330 mm (13 in) of rain falls on the delta.

Tropical dry

A tropical arid semi-arid climate dominates regions where the rate of moisture loss through evapotranspiration exceeds that from precipitation; it is subdivided into three climatic subtypes. The first, a tropical semi-arid steppe climate, predominates over a long stretch of land south of Tropic of Cancer and east of the Western Ghats and the Cardamom Hills. The region, which includes Karnataka, inland Tamil Nadu, western Andhra Pradesh, and central Maharashtra, gets between 400-750 millimetres (15·7-29·5 in) annually. It is drought-prone, as it tends to have less reliable rainfall due to sporadic lateness or failure of the southwest monsoon. Karnataka is divided into three zones—coastal, north interior and south interior. Of these, the coastal zone receives the heaviest rainfall with an average rainfall of about 3,638·5 mm (143 in) per annum, far in excess of the state average of 1,139 mm (45 in). On contrast to norm, Agumbe in the Shivamogga district receives the second highest annual rainfall in India. North of the Krishna River, the summer monsoon is responsible for most rainfall; to the south, significant post-monsoon rainfall also occurs in October and November. In December, the coldest month, temperatures still average around 20-24°C (68-75°F). The months between March to May are hot and dry; mean monthly temperatures hover around 32°C, with 320 millimetres (13 in) precipitation. Hence, without artificial irrigation, this region is not suitable for permanent agriculture.

Most of western Rajasthan experiences an arid climatic regime. Cloudbursts are responsible for virtually all the region's annual precipitation, which totals less than 300 millimetres (11·8 in). Such bursts happen when monsoon winds sweep into the region during July, August, and September. Such rainfall is highly erratic; regions experiencing rainfall one year may not see precipitation for the next couple of years or so. Atmospheric moisture is largely prevented from precipitating due to continuous downdrafts and other factors. The summer months of May and June are exceptionally hot; mean monthly temperatures in the region hover around 35°C (95°F), with daily maxima occasionally topping 50°C (122°F). During winters, temperatures in some areas can drop below freezing due to waves of cold air from Central Asia. There is a large diurnal range of about 14°C (25·2°F) during summer; this widens by several degrees during winter.

To the west, in Gujarat, diverse climate conditions obtain. The winters are mild, pleasant, and dry with average daytime temperatures around 29°C (84°F) and nights around 12°C (54°F) with virtually full sun and clear nights. Summers are hot and dry with daytime temperatures around 41°C (106°F) and nights no lower than 29°C (84°F). In the weeks before the monsoon temperatures are similar to the above, but high humidity makes the air more uncomfortable. Relief comes with the monsoon. Temperatures are around 35°C (95°F) but humidity is very high; nights are around 27°C (81°F). Most of the rainfall occurs in this season, and the rain can cause severe floods. The sun is often occluded during the monsoon season.

East of the Thar Desrt, the Punjab-Haryana-Kathiawar region experiences a tropical and sub-tropical steppe climate. Haryana's climate resembles other states of the northern plains : extreme summer heat of up to 50°C and winter cold as low as 1°C. May and June are hottest; December and January are coldest. Rainfall is varied, with the Shivalik Hills region being the wettest and the Aravali Hills region being the driest. About 80% of the rainfall occurs in the monsoon season of July-September, which can cause flooding. The Punjabi climate is also governed by extremes of hot and cold. Areas near the Himalayan foothills receive heavy rainfall whereas those eloigned from them are hot and dry. Punjab's three-season climate sees summer months that spans from mid-April to the end of June. Temperatures typically range from 2°C to 40°C, but can reach 47°C (117°F) in summer and – 4°C in winter. The zone, a transitional climatic region separating tropical desert from humid sub-tropical savanna and forests, experiences temperatures that are less extreme than those of the desert. Average annual rainfall is 300-650 millimetres (11·8-25·6 in), but is very unreliable; as in much of the rest of India, the southwest monsoon accounts for most precipitation. Daily summer temperature maxima rise to around 40°C (104°F); this results in natural vegetation typically comprises short, coarse grasses.

Subtropical humid

Most of Northeast India and much of North India are subjec. to a humid subtropical climate. Though they experience hot summers, temperatures during the coldest months may fall as low as 0°C (32°F). Due to ample monsoon rains, India has only one subtype of this climate under the Koppen system : *Cwa*. In most of this region, there is very little precipitation during the winter, owing to powerful anticyclonic and katabatic (downward-flowing) winds from Central Asia.

Humid subtropical regions are subject to pronounced dry winters. Winter rainfall—and occasionally snowfall—is associated with large storm systems such as 'Nor'westers' and 'Western disturbances'; the latter are steered by westerlies towards the Himalayas. Most summer rainfall occurs during powerful thunderstorms associated with the southwest summer monsoon; occasional tropical cyclones also contribute. Annual rainfall ranges from less than 1,000 millimetres (39 in) in the west to over 2,500 millimetres (98 in) in parts of the northeast. As most of this region is far from the ocean, the wide temperature swings more characteristics of a continental climate predominate; the swings are wider than in those in tropical wet regions, ranging from 24°C (75°F) in north-central India to 27°C (81°F) in the east. Pangong Lake in Ladakh, an arid montane region lying deep witin the Himalayas.

India's northernmost areas are subject to a montane, or alpine, climate. In the Himalayas, the rate at which an air mass's temperature falls per kilometre (3,281 ft) of altitude gained (the dry adiabatic lapse rate) is 9·8°C/km. In terms of environmental lapse rate, ambient temperatures fall by 6·5°C (11·7°F) for every 1,000 metres (3,281 ft) rise in altitude. Thus, climates ranging from nearly tropical in the foothills to tundra above the snow line can coexist witin several hundred metres of each other. Sharp temperature contrasts between sunny and shady slopes, high diurnal temperature variability, temperature inversions, and altitude-dependent variability in rainfall are also common. The northern side of the western Himalayas, also known as the trans-Himalayan belt, is a region of barren, arid, frigid, and wind-blown wastelands. Most precipitation occurs as snowfall during the late winter and spring months.

Areas south of the Himalayas are largely protected from cold winter winds coming in from the Asian interior. The leeward side (northern face) of the mountains receives less rain while the southern slopes, well-exposed to the monsoon, get heavy rainfall. Areas situated at elevations of 1,070-2,290 metres (3,510-7,510 ft) receive the heaviest rainfall, which decreases rapidly at elevations above 2,290 metres (7,513 ft). The Himalayas experience their heaviest snowfall between December and February and at elevations above 1,500 metres (4,921 ft). Snowfall increases with elevation by up to several dozen millimetres per 100 metre (~ 2 in; 330 ft) increase. Elevations above 5,000 metres (16,404 ft) never experience rain; all precipitation falls as snow.

Q. 12. Explain the different seasons of India.

Ans. Following are the different seasons of India :

- **Winter**, occuring from December to early April. The year's coldest months are December and January, when temperatures average around 10-15°C (50-59°F) in the northwest; temperatures rise as one proceeds towards the equator, peaking around 20-25°C (68-77°F) in mainland India's southeast.
- **Summer** or **pre-monsoon** season, lasting from April to June (April to July in northwestern India). In western and southern regions, the hottest months in April; for northern regions, May is the hottest month. Temperatures average around 32-40°C (90-104°F) in most of the interior.
- **Monsoon** or **rainy** season, lasting from June to September. The season is dominated by the humid southwest summer monsoon, which slowly sweeps across the country beginning in late May or early June. Monsoon rains begin to recede from North India at the beginning of October. South India typically receives more rainfall.
- **Post-monsoon** season, lasting from October to December. In northwestern India, October and November are usually cloudless. Tamil Nadu receives most of its annual precipitation in the northeast monsoon season.

The Himalayan states, being more temperate, experience an additional two seasons : autumn, and spring. Traditionally, Indians note six seasons, each about two months long. These are the spring (*Sanskrit* : vasanta), summer (*grisma*), monsoon season (*varsa*), early autumn (*sarada*), late autumn (*hemanta*), and winter (*sisira*). These are based on the astronomical division of the twelve months into six parts. The ancient Hindu calendar also reflects these seasons in its arrangement of months.

Winter

Once the monsoons subside, average temperatures gradually fall across India. As the Sun's vertical rays move south of the equator, most of the country experiences moderately cool weather; temperatures change by about 0·6°C (1·08°F) per degree of latitude. December and January are the coldest months, with mean temperatures of 10-15°C (50-59°F) in Indian Himalayas. Mean temperatures are higher in the east and south, where they reach 20-25°C (68-77°F).

In northwestern India, virtually cloudless conditions prevail in October and November, resulting in wide diurnal temperature swings; as in much of the Deccan Plateau, they register at 16-20°C (61-68°F). However, from March to May, 'western disturbances' bring heavy bursts of rain and snow. These extra-tropical low-pressure systems originate in the eastern Mediterranean Sea. They are carried towards India by the subtropical westerlies, which are the prevailing winds blowing at North India's range of latitude. Once their passage is hindered by the Himalayas, they are unable to proceed further, and they release significant precipitation over the southern Himalayas.

There is a huge variation in the climatic conditions of Himachal Pradesh due to variation in altitude (450-6500 metres). The climate varies from hot and sub-humid tropical (450-900 metres) in the southern low tracts, warm and temperate (900-1800 metres), cool and temperate (1900-2400 metres) and cold glacial and alpine (2400-4800 metres) in the northern and eastern high elevated mountain ranges. By October, nights and mornings are very cold. Snowfall at elevations of nearly 3000 m is about 3 m and lasts from December start to March end. Elevations above 4500 m support perpetual snow. The spring season starts from mid February to mid April. The weather is pleasant and comfortable in the season. The rainy season starts at the end of the month of June. The landscape lushes green and fresh. During the season streams and natural springs are replenished. The heavy rains in July and August cause a lot of damage resulting into erosion, floods and landslides. Out of all the state districts, Dharamsala receives the highest rainfall, nearly about 3,400 mm (134 in). Spiti is the driest area of the state, where annual rainfall is below 50 mm. The three Himalayan states (Jammu and Kashmir in the extreme north, Himachal

Pradesh, and Uttarakhand) experience heavy snowfall; in Jammu and Kashmir, blizzards occur regularly, disrupting travel and other activities.

The rest of North India, including the Indo-Gangetic Plain, almost never receives snow. Temperatures in the plains occasionally fall below freezing, though never for more one or two days. Winter highs in Delhi range from 16 to 21°C (61 to 70°F). Nighttime temperatures average 2-8°C (36-46°F). In the plains of Punjab, lows can fall below freezing, dropping to around – 6°C (21°F) in Amritsar. Frost sometimes occurs, but the hallmark of the season is the notorious fog, which frequently disrupts daily life; fog grows thick enough to hinder visibility and disrupt air travel 15-20 days annually. In Bihar in middle of the Ganges plain, hot weather sets in and the summer lasts until the middle of June. The highest temperature is often registered in May which is the hottest time. Like the rest of the north, Bihar also experiences dust-storms, thunderstorms and dust raising winds during the hot season. Dust storms having a velocity of 48-64 km/h (30-40 mph) are most frequent in May and with second maximum in April and June. The hot winds (loo) of Bihar plains blow during April and May with an average velocity of 8-16 km/h (5-10 mph). These hot winds greatly affects human comfort during this season. Rain follows. The rainy season begins in June. The rainiest months are July and August. The rains are the gifts of the southwest monsoon. There are in Bihar three distinct areas where rainfall exceeds 1,800 mm (71 in). Two of them are in the northern and northwestern portions of the state; the third lies in the area around Netarhat. The southwest monsoon normally withdraws from Bihar in the first week of October. Eastern India's climate is much milder, experiencing moderately warm days and cool nights. Highs range from 23°C (73°F) in Patna to 26°C (79°F) in Kolkata (Calcutta); lows average from 8°C (46°F) in Patna to 14°C (57°F) in Kolkata.

Frigid winds from the Himalayas can depress temperatures near the Brahmaputra River. The Himalayas have a profound effect on the climate of the Indian subcontinent and the Tibetan plateau by preventing frigid and dry Arctic winds from blowing south into the subcontinent, which keeps South Asia much warmer than corresponding temperate regions in the other continents. It also forms a barrier for the monsoon winds, keeping them from traveling northwards, and causing heavy rainfall in the Terai region instead. The Himalayas are indeed believed to play an important role in the formation of Central Asian deserts such as the Taklamakan and Gobi. The mountain ranges prevent western winter disturbances in Iran from traveling further east, resulting in much snow in Kashmir and rainfall for parts of Punjab and northern India. Despite being a barrier to the cold northernly winter winds, the Brahmaputra valley receives part of the frigid winds, thus lowering the temperature in Northeast India and Bangladesh. The Himalayas, which are often called 'The Roof of the World', contain the greatest area of glaciers and permafrost outside of the poles. Ten of Asia's largest rivers flow from there. The two Himalayan states in the east, Sikkim and Arunachal Pradesh, receive substantial snowfall. The extreme north of West Bengal centred around Darjeeling experiences snowfall, but only rarely. Parts of Uttar Pradesh are also affected by snowfall of several meters in places. Rainfall in that state ranges from 1,000-2,000 mm (39-79 in) in the east to 600-1,000 mm (24-39 in) in the west.

In South India, particularly the hinterlands of Maharashtra, Madhya Pradesh, parts of Karnataka, and Andhra Pradesh, somewhat cooler weather prevails. Minimum temperatures in western Maharashtra, Madhya Pradesh and Chhattisgarh hover around 10°C (50°F); in the southern Deccan Plateau, they reach 16°C (61°F). Coastal areas—especially those near the Coromandel Coast and adjacent low-elevation interior tracts—are warm, with daily high temperatures of 30°C (86°F) and lows of around 21°C (70°F). The Western Ghats, including the Nilgiri Range, are exceptional; lows there can fall below freezing. This compares with a range of 12-14°C (54-57°F) on the Malabar Coast; there, as is the case for other coastal areas, the Indian Ocean exerts a strong moderating influence on weather. The region averages 800 millimetres (31 in) per year, most of which falls between October and December. The topography of the Bay of Bengal and the staggered weather pattern prevalent during the season favours the northeast monsoon, which has a tendency to cause cyclones and hurricanes rather than steady precipitation. As a result the coast is hit by what can mildly be termed as inclement wheather almost every year between October and January.

Summer

A summer view of Khajjiar, a hill station in Himachal Pradesh.

Summer in northwestern India lasts from April to July, and in the rest of the country from March to June. The temperatures in the north rise as the vertical rays of the Sun reach the Tropic of Cancer. The hottest month for the western and southern regions of the country is April; for most of North India, it is May. Temperatures of 50°C (122°F) and higher have been recorded in parts of India during this season. In cooler regions of North India, immense pre-monsoon squall-line thunderstorms, known locally as 'Nor'westers', commonly drop large hailstones. In Himachal Pradesh, Summer lasts from mid April till the end of June and most parts become very hot (except in alpine zone which experience mild summer) with the average temperature ranging from 28°C (82°F) to 32°C (90°F). Winter lasts from late November till mid March. Snowfall is generally common in alpine tracts that are above 2,200 metres (7,218 ft), especially those in the higher and trans-Himalayan regions. Near the coast the temperature hovers around 36°C (97°F), and the proximity of the sea increases the level of humidity. In southern India, the temperatures are higher on the east coast by a few degrees compared to the west coast.

By May, most of the Indian interior experiences mean temperatures over 32°C (90°F), while maximum temperatures often exceed 40°C (104°F). In the hot months of April and May, western disturbances, with their cooling influence, may still arrive, but rapidly diminish in frequency as summer progresses. Notably, a higher frequency of such disturbances in April correlates with a delayed monsoon onset (thus extending summer) in northwest India. In eastern India, monsoon onset dates have been steadily advancing over the past several decades, resulting in shorter summers there.

Altitude affects the temperature to a large extent, with higher parts of the Deccan Plateau and other areas being relatively cooler. Hill stations, such as Ootacamund ('Ooty') in the Western Ghats and Kalimpong in the eastern Himalayas, with average maximum temperatures of around 25°C (77°F), offer some respite from the heat. At lower elevations, in parts of northern and western India, a strong, hot, and dry wind known as the Looblows in from the west during the daytime; with very high temperatures, in some cases up to around 45°C (113°F); it can cause fatal cases of sunstroke. Tornadoes may also occur, concentrated in a corridor stretching from northeastern India towards Pakistan. They are rare, however; only several dozen have been reported since 1835.

Monsoon

The southwest summer monsoon, a four-month period when massive convective thunderstorms dominate India's weather, is Earth's most productive wet season. A product of southeast trade winds originating from a high-pressure mass centered over the southern Indian Ocean, the monsoonal torrents supply over 80% of India's annual rainfall. Attracted by a low-pressure region centered over South Asia, the mass spawns surface winds that ferry humid air into India from the southwest. These inflows ultimately result from a northward shift of the local jet stream, which itself results from rising summer temperatures over Tibet and the Indian subcontinent. The void left by the jet stream, which switches from a route just south of the Himalayas to one tracking north of Tibet, then attracts warm, humid air.

The main factor behind this shift is the high summer temperature difference between Central Asia and the Indian Ocean. This is accompanied by a seasonal excursion of the normally equatorial intertropical convergence zone (ITCZ), a low-pressure belt of highly unstable weather, northward towards India. This system intensified to its present strength as a result of the Tibetan Plateau's uplift, which accompanied the Eocene-Oligocene transition event, a major episode of global cooling and aridification which occurred 34-49 Ma.

The southwest monsoon arrives in two branches : the Bay of Bengal branch and the Arabian Sea branch. The latter extends towards a low-pressure area over the Thar Desert and is roughly three times stronger than the Bay of Bengal branch. The monsoon typically breaks over Indian territory by around 25 May, when it lashes the Andaman and Nicobar Islands in the Bay of Bengal. It strikes the Indian mainland around 1 June near the Malabar Coast of Kerala. By 9 June, it reaches Mumbai; it appears over Delhi by 29 June. The Bay of Bengal branch, which initially tracks the Coromandal Coast northeast from Cape Comorin to Orissa, swerves to the northwest towards the Indo-Gangetic Plain. The Arabian Sea branch moves northeast towards the Himalayas. By the first week of July, the entire country experiences monsoon rain; on average, South India receives more rainfall than North India. However, Northwest India receives the most precipitation. Monsoon clouds begin retreating from North India by the end of August; it withdraws from Mumbai by 5 October. As India further cools during September, the southwest monsoon weakens. By the end of November, it has left the country.

Pre-monsoon clouds, as they appear in Mumbai, western Maharashtra.

Monsoon rains impact the health of the Indian economy; as Indian agriculture employes 600 million people and composes 20% of the national GDP, good monsoons correlate with a booming economy. Weak or failed monsoons (droughts) result in widespread agricultural losses and substantially hinder overall economic growth. Yet such rains reduce temperatures and can replenish groundwater tables, rivers, and lakes.

Post-monsoon

During the post-monsoon months of October to December, a different monsoon cycle, the northeast (or 'retreating') monsoon, brings dry, cool, and dense Central Asian air masses to large parts of India. Winds spill across the Himalayas and flow to the southwest across the country, resulting in clear, sunny skies. Though the India Meteorological Department (IMD) and other sources refers to this period as a fourth ('post-monsoon') season, other sources designate only three seasons. Depending on location, this period lasts from October to November, after the southwest monsoon has peaked. Less and less precipitation falls, and vegetation begins to dry out. In most parts of India, this period marks the transition from wet to dry seasonal conditions. Average daily maximum temperatures range between 28 and 34°C (82 and 93°F).

The northeast monsoon, which begins in September, lasts through the post-monsoon seasons, and only ends in March. It carries winds that have already lost their moisture while crossing central Asia and the vast rain shadow region lying north of the Himalayas. They cross India diagonally from northeast to southwest. However, the large indentation made by the

Bay of Bengal into India's eastern coast means that the flows are humidified before reaching Cape Comorin and rest of Tamil Nadu, meaning that the state, and also some parts of Kerala, experience significant precipitation in the psot-monsoon and winter periods. However, parts of West Bengal, Orissa, Andra Pradesh, Karnataka and Northeast India also receive minor precipitation from the northeast monsoon.

SHORT ANSWER TYPE QUESTIONS

Q. 1. What do you mean by Polar Cyclone ?

Ans. **POLAR CYCLONE**

A **polar, sub-polar**, or **Arctic cyclone** (also known as a **polar vortex**) is a vast area of low pressure which strengthens in the winter and weakens in the summer. A polar cyclone is a low pressure weather system, usually spanning 1,000 kilometres (620 mi) to 2,000 kilometres (1,200 mi), in which the air circulates in a counterclockwise direction in the northern hemisphere, and a clockwise direction in the southern hemisphere. In the Northern Hemisphere, the polar cyclone has two centers on average. One center lies near Baffin Island and the other over northeast Siberia. In the southern hemisphere, it tends to be located near the edge of the Ross ice shelf near 160 west longitude. When the polar vortex is strong, westerly flow descends to the Earth's surface. When the polar cyclone is weak, significant cold outbreaks occur.

Q. 2. What is the meaning of Polar Law ?

Ans. **POLAR LAW**

A **polar law** is a small-scale, short-lived atmospheric low pressure system (depression) that is found over the ocean areas poleward of the main polar front in both the Northern and Southern Hemispheres. During winter, when cold-core lows with temperatures in the mid-levels of the troposphere reach – 45°C (– 49°F) move over open waters, deep convection forms which allows polar low development to become possible. The systems usually have a horizontal length scale of less than 1,000 kilometres (620 mi) and exist for no more than a couple of days. They are part of the larger class of mesoscale weather systems. Polar lows can be difficult to detect using conventional weather reports and are a hazard to high-latitude operations, such as shipping and gas and oil platforms. Polar lows have been referred to by many other terms, such as polar mesoscale vortex, Arctic hurricane, Arctic low, and cold air depression. Today the term is usually reserved for the more vigorous systems that have near-surface winds of at least 17 m/s.

Q. 3. What is Extratropical Cyclone ?

Ans. A fictitious synoptic chart of an extratropical cyclone affecting the UK and Ireland. The blue arrows between isobars indicate the direction of the wind, while the 'L' symbol denotes the centre of the 'low'. Note the occluded, cold and warm frontal boundaries.

Main article : *Extratropical cyclone*

An **extratropical cyclone** is a synoptic scale low pressure weather system that has neither tropical nor polar characteristics, being connected with fronts and horizontal gradients in temperature and dew point otherwise known as 'baroclinic zones'.

The descriptor 'extratropical' refers to the fact that this type of cyclone generally occurs outside of the tropics, in the middle latitudes of the planet. These systems may also be described as 'mid-latitude cyclones' due to their area of formation, or 'post-tropical cyclones' where extratropical transition has occurred, and are often described as 'depressions' or 'lows' by weather forecasters and the general public. These are the everyday phenomena which along with anti-cyclones, drive the weasther over much of the Earth.

Although extratropical cyclones are almost always classified as baroclinic since they form along zones of temperature and dewpoint gradient within the westerlies, they can sometimes become barotropic late in their life cycle when the temperature distribution around the cyclone becomes fairly uniform with radius. An extratropical cyclone can transform into a subtropical storm, and from there into a tropical cyclone, if it dwells over warm waters and develops central convection, which warms its core.

Q. 4. Write a note on Subtropical Cyclone.

Ans. A **subtropical cyclone** is a weather system that has some characteristics of a tropical cyclone and some characteristics of an extra-tropical cyclone. They can form between the equator and the 50th parallel. As early as the 1950s, meteorologists were unclear whether they should be characterized as tropical cyclone. or extratropical cyclones, and used terms such as quasi-tropical and semi-tro ical to describe the cyclone hybrids. By 1972, the National Hurricane Ce nter officially recognized this cyclone category. Subtropical cyclones began to receive names off the official tropical cyclone list in the Atlantic Basin in 2002. They have broad wind patterns with maximum sustained winds located farther from the center than typical tropical cyclones and exist in areas of weak to moderate temperature gradient.

Since they form fro n initially extratropical cyclones which have colder temperatures aloft than normally found in the tropics, the sea surface temperatures required for their formation are lower than the tropical cyclone threshold by three degrees Celsius, or five degrees Fahrenheit, lying around 23 degrees Celsius. This means that subtropical cyclones are more likely to form outside the traditional bounds of the hurricane season. Although subtropical storms rarely have hurricane-force winds, they may become tropical in nature as their cores warm.

Q. 5. Explain the Earth's atmosphere.

Ans. EARTH'S ATMOSPHERE

• The Earth's atmosphere consists, from the ground up, of the troposphere (which includes the planetary boundary layer or peplosphere as lowest layer), stratosphere (which includes the ozone layer), mesosphere, thermosphere (which contains the ionosphere), exosphere and also the magnetosphere. Each of the layers has a different lapse rate, defining the rate of change in temperature with height.

Three quarters of the atmosphere lies within the troposphere, and the depth of this layer varies between 17 km at the equator and 7 km at the poles. The ozone layer, which absorbs ultraviolet energy from the Sun, is located primarily in the stratosphere, at altitudes of 15 to 35 km. The Karman line, located within the thermosphere at an altitude of 100 km, is commonly used to define the boundary between the Earth's atmosphere and outer space. However, the exosphere can extend from 500 up to 10,00 km above the surface, where it interacts with the planet's magnetosphere.

Q. 6. Explain the atmospheric circulation of atmosphere.

Ans. ATMOSPHERIC CIRCULATION

The circulation of the atmosphere occurs due to thermal differences when convection becomes a more efficient transporter of heat than thermal radiation. On planets where the primary heat source is solar radiation, excess heat in the tropics is transported to higher latitudes. When a planet generates a significant amount of heat internally, such as is the case for Jupiter, convection in the atmosphere can transport thermal energy from the higher temperature inteiror up to the surface.

Importance

From the perspective of the planetary geologist, the atmosphere is an evolutionary agent essential to the morphology of a planet. The wind transports dust and other particles which erodes the relief and leaves deposits (eolian processes). Frost and precipitations, which depend on the composition, also influence the relief. Climate changes can influence a planet's geological history. Conversely, studying surface of earth leads to an understanding of the atmosphere and climate of a planet—both its present state and its past.

For a meteorologist, the composition of the atmosphere determines the climate and its variations. For a biologist, the composition is closely dependent on the appearance of the life and its evolution.

UNIT-IV

LONG ANSWER TYPE QUESTIONS

Q. 1. What is the meaning of Exosphere ?

Ans. Earth atmosphere diagram showing the exosphere and other layers. The layers are to scale. From Earth's surface to the top of the stratosphere (50 km) is just under 1% of Earth's radius.

The **exosphere** is the uppermost layer of Earth's atmosphere. In the exosphere, an upward travelling molecule moving fast enough to attain escape velocity can escape to space with a low chance of collisions; if it is moving below escape velocity it will be prevented from escaping from the celestial body by gravity. In either case, such a molecule is unlikely to collide with another molecule due to the exosphere's low density.

EARTH'S EXOSPHERE

The main gases within the Earth's exosphere are the lightest gases, mainly hydrogen, with some helium, carbon di-oxide, and atomic oxygen near the exobase. The exosphere is the last layer before outer space. Since there is no clear boundary between outer space and the exosphere, the exosphere is sometimes considered a part of outer space.

Lower boundary

The altitude of its lower boundary, known as the *thermopause* and *exobase*, ranges from about 250 to 500 kilometres (160 to 310 mi) depending on solar activity. Its lower boundary at the edge of the thermosphere has sometimes been estimated to be 500 to 1,000 km (310 to 620 mi) above the Earth's surface. The **exobase** is also called the **critical level**, the lowest altitude of the exosphere, and is typically defined in one or two ways :

1. The height above which there are negligible atomic collisions between the particles (free molecular flow), and
2. The height above which constituent atoms are on purely ballistic trajectories.

If we define the exobase as the height at which upward traveling molecules experience one collision on average, then at this position the mean free path of a molecule is equal to one pressure scale height. This is shown in the following. Consider a volume of air, with horizontal area A and height equal to the mean free path l, at pressure p and temperature T. For an ideal gas, the number of molecules contained in it is :

$$n = \frac{pAl}{RT}$$

where R is the universal gas constant. From the requirement that each molecule traveling upward undergoes on average one collision, the pressure is :

$$p = \frac{m_A n g}{A}$$

where m_A is the mean molecular mass of the gas. Solving these two equations gives :

$$l = \frac{RT}{m_A g}$$

which is the equation for the pressure scale height. As the pressure scale height is almost equal to the density scale height of the primary constituent, and since the Knudsen number is the ratio of mean free path and typical density fluctuation scale, this means that the exobase lies in the region where $Kn \mid h_{EB} \mid \cong 1$.

The fluctuation in the height of the exobase is important because this provides atmospheric drag on satellites, eventually causing them to fall from orbit if no action is taken to maintain the orbit.

Upper boundary

The upper boundary of the exosphere can be defined theoretically by the altitude about 190,000 kilometres (120,000 mi), half the distance to the Moon, at which the influence of solar radiation pressure on atomic hydrogen velocities exceeds that of the Earth's gravitational pull. The exosphere observable from space as the geocorona is seen to extend to at least 100,000 kilometres (62,000 mi) from the surface of the Earth. The exosphere is a transitional zone between Earth's atmosphere and interplanetary space.

Q. 2. Write the history of Ocean.

Ans. The Ocean is an experimental metal band from Berlin, Germany. Their work combines elements of progressive metal and electronic soundscapes, occasionally incorporating strings to create their aggressive post-metal sound. The band often describes its sound as 'ambient soundtrack doomrock'.

History

The Ocean was founded in 2000 by guitarist and songwriter Robin Staps. During the following two years, about 40 musicians joined and left the band until a stable line-up established. July 2002 saw The Ocean play their first concert at Berlin's now defunct semi-legal Eimer Club. Shortly after, the band released their eponymous debut album featuring *Islands/ Tides*, a 30-minute-long song that also constituted the substance of their early live shows.

After a brief tour with Swedish crust punk outfit Coma in early 2003, the band signed to Make My Day Records, which then released *Fogdiver*, an

EP consisting of five instrumental songs—despite the fact that on stage, at least two singers could be found. Unlike its predecessor, this recording received considerable acclaim from critics throughout a variety of genres.

During winter and spring 2004, the Ocean recorded what was to become the material for their two following albums. The calmer and more atmospheric half of this recording session was released as *Fluxion* in August 2004; a joint effort of Make My Day and Throne Records. While the fact that the band now used vocals on their recordings seemed to make the music more accessible to some, it also caused many other critics to consider the album a step backwards in terms of innovation and originality. In interviews, the band would comment on this by pointing out the perceived closed-mindedness of some of the reviewers and their supposed inability to deal with the harshness and brutality the anti-Christian, anti-theistic vocals now added to The Ocean's sound.

After singing to Metal Blade Records in summer 2005, all the remaining songs from the session were released as *Aeolian*. Since *Fluxion* and *Aeolian* had originally been planned as a double CD with a mellow and a brutal part—a plan that did not work out—*Aeolian* came across as very different from its predecessor. Unlike on previous albums, classical instruments and electronic sounds were hardly used here, making the record sound rather minimalistic. But whereas *Fluxion* had featured only one singer, seven of them could be found on *Aeolian*, among them Nate Newton, Sean Ingram, and Tomas Hallbom, whose names were also used extensively for the album's promotion campaign. According to the band, Meta's voice on *Fluxion* had created a monotony that was to be avoided on *Aeolian*. March 2006 saw the North American release of the album. Later that year, a joint vinyl version of *Fluxion* and *Aeolian* was released by Throne Records, featuring three records in different colors. Recently in late 2007, they released a new 2 disc album entitled *Precambrian*. In April 2008, The Ocean embarked on a year long tour through Europe and North America with banks like Intronaut, Opeth, and At The Gates. In April 2009 it was announced that primary *Precambrian* vocalist, and full time touring member Mike Pilat was leaving the band for personal reasons and other commitments.

On November 17, 2009, Robin Staps announced that a replacement vocalist had been found, Loic Rossetti. The Ocean released two albums in 2010, *Heliocentric* on April 9 and *Anthropocentric* on November 9. Taken together, the two albums "represent a fundamental and philosophical critique of Christianity," with *Heliocentric* describing the internal battles within the Catholic Church over the heliocentrism of Copernicus and galileo, and *Anthropocentric* critiquing the fundamentalist Protestant view of Creationism.

They announced that their first live DVD would be filmed on the 29th of January 2011 in Berlin at the Museum fur Musikinstrumente and will only contain tracks from their album Precambrian.

On the 3rd of August 2011, The Ocean announced via its Facebook page that Robin Staps is working on new material for an upcoming album. They have stated that recording will get under way in early 2012 and hinted at the possibility of releasing another double album.

Q. 3. What do you mean by Tides ?

Ans. Tides are the rise and fall of sea levels caused by the combined effects of the gravitational forces exerted by the moon and the sun and the rotation of the Earth.

Most places in the ocean usually experience two high tides and two low tides each day (semi-diurnal tide), but some locations experience only one high and one low tide each day (diurnal tide). The times and amplitude of the tides at the coast are influenced by the alignment of the sun and moon, by the pattern of tides in the deep ocean and by the shape of the coastline and near-shore bathymetry (see *Timing*).

Tides vary on timescales ranging from hours to years due to numerous influences. To make accurate records, tide gauges at fixed stations meausre the water level over time. Gauges ignore variations caused by waves with periods shorter than minutes. These data are compared to the reference (or datum) level usually called mean sea level.

While tides are usually the largest source of short-term sea-level fluctuations, sea levels are also subject to forces such as wind and barometric pressure changes, resulting in storm surges, especially in shallow seas and near coasts.

Tidal phenomena are not limited to the oceans, but can occur in other systems whenever a gravitational field that varies in time and space is present. For example, the solid part of the Earth is affected by tides, though this is not as easily seen as the water tidal movements.

Q. 4. Write a note on the types of Tides.

Ans. TYPES OF TIDES

Tide changes proceed via the following stages :

- Sea level rises over several hours, covering the intertidal zone; flood tide.
- The water rises to its highest level, reaching high tide.
- Sea level falls over several hours, revealing the intertidal zone; ebb tide.
- The water stops falling, reaching low tide.

Tides produce oscillating currents known as tidal streams. The moment that the tidal current ceases is called slack water or slack tide. The tide then reverses direction and is said to be turning. Slack water usually occurs near high water and low water. But there are locations where the moments of slack tide differ significantly from those of high and low water.

Tides are most commonly *semi-diurnal* (two high waters and two low waters each day), or *diurnal* (one tidal cycle per day). The two high waters on a givne day are typically not the same height (the daily inequality); these are the **higher high** water and the **lower high water** in tide tables. Similarly, the two low waters each day are the **higher low water** and the **lower low water.** The daily inequality is not consistent and is generally small when the moon is over the equator.

Q. 5. Explain the Tidal constituents.

Ans. TIDAL CONSTITUENTS

Tidal changes are the net result of multiple influences that act over varying periods. These influences are called tidal constituents. The primary constituents are the Earth's rotation, the positions of moon and the sun relative to Earth, the moon's altitude (elevation) above the Earth's equator, and bathymetry.

Variations with periods of less than half a day are called *harmonic constituents*. Conversely, cycles of days, months, or years are referred to as *long period* constituents.

The tidal forces affect the entire earth, but the movement of the solid Earth is only centimeters. The atmosphere is much more fluid and compressible so its surface moves kilometers, in the sense of the contour level of a particular low pressure in the outer atmosphere.

Principal lunar semi-diurnal constituent

In most locations, the largest constituent is the 'principal lunar semi-diurnal', also known as the M2 (or M_2) tidal constituent. Its period is about 12 hours and 25·2 minutes, exactly half *a tidal lunar day,* which is the average time separating one lunar zenith from the next, and thus is the time required for the Earth to rotate once relative to the moon. Simple tide clocks track this constituent. The lunar day is longer than the Earth day because the moon orbits in the same direction the Earth spins. This is analogous to the minute hand on a watch crossing the hour hand at 12:00 and then again at about 1:05 (not at 1:00).

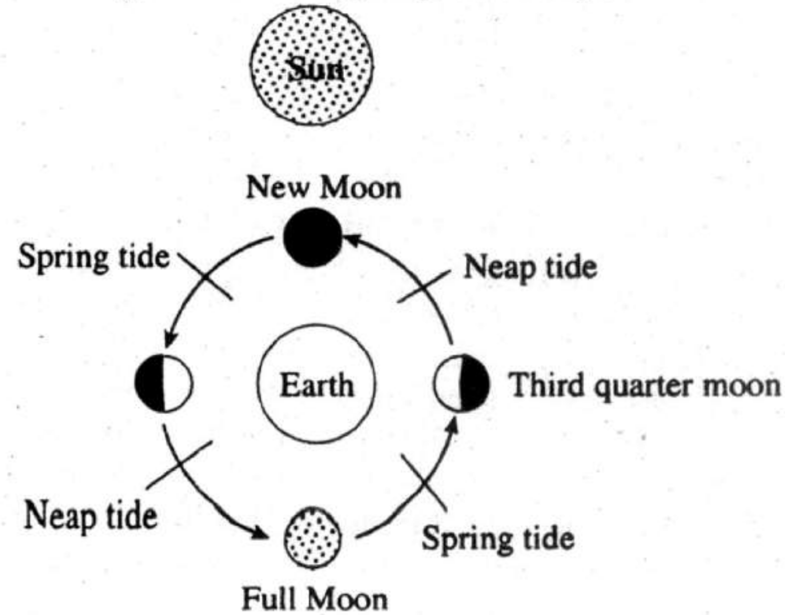
The moon orbits the Earth in the same direction as the Earth rotates on its axis, so it takes slightly more than a day—about 24 hours and 50 minutes—for the moon to return to the same location in the sky. During this time, it has passed overhead (culmination) once and underfoot once (at an hour angle of 00:00 and 12:00 respectively), so in many places the period of strongest tidal forcing is the above mentioned, about 12 hours and 25 minutes. The moment of highest tide is not necessarily when the moon is nearest to zenith or nadir, but the period of the forcing still determines the time between high tides.

Because of gravitational field created by the moon weakens with distance from the moon, it exerts a sl·ghtly stronger force on the side of the Earth facing the moon than average, and a slightly weaker force on the opposite side. The moon thus tends to 'stretch' the Earth slightly along the line connecting the two bodies. The solid Earth deforms a bit, but ocean water, being fluid, is free to move much more in response to the tidal force, particularly horizontally. As the Earth rotates, the magnitude and direction of the tidal force at any particular point on the Earth's surface change constantly; although the ocean never reaches equilibrium—there is never time for the fluid to 'catch up' to the state it would eventually reach if the tidal force were constant—the changing tidal force nonetheless causes rhythmic changes in sea surface height.

Semi-diurnal range differences

When there are two high tides each day with different heights (and two low tides also of different heights), the pattern is called a *mixed semi-diurnal tide.*

Range Variation : Springs and Neaps



THE TYPES OF TIDES

The semi-diurnal range (the difference in height between high and low waters over about half a day) varies in a two-week cycle. Approximately twice a month, around new moon and full moon when the sun, moon and Earth form a line (a condition known as syzygy) the tidal force due to the sun reinforces that due to the moon. The tide's range is then at its maximum : this is called the **spring tide**, or just *springs*. It is not named after the season but, like that word, derives from the meaning 'jump, burst forth, rise', as in a natural spring.

When the moon is at first quarter or third quarter, the sun and moon are separated by 90° when viewed from the Earth, and the solar tidal force partially cancels the moon's. At these points in the lunar cycle, the tide's range is at its minimum : this is called the **neap** tide, or *neaps* (a word of uncertain origin).

Spring tides result in high waters that are higher than average, low waters that are lower than average, 'slack water' time that is shorter than average and stronger tidal currents than average. Neaps result in less extreme tidal conditions. There is about a seven-day interval between springs and neaps.

Q. 6. What do you mean by Waves ?

Ans. In physics, a **wave** is a disturbance (an oscillation) that travels through space and time, accompanied by the transfer of energy.

Waves travel and the **wave motion** transfers energy from one point to another, often with no permanent displacement of the particles of the medium—that is, with little or no associated mass transport. They consist, instead, of oscillations or vibrations around almost fixed locations. For example, a cork on rippling water will be bob up and down, staying in about the same place while the wave itself moves onwards.

One type of wave is a mechanical wave, which propagates through a medium in which the substance of this medium is deformed. The deformation reverses itself owing to restoring forces resulting from its deformation. For example, sound waves propagate via air molecules bumping into their neighbours. This transfers some energy to these neighbours, which will cause a cascade of collisions between neighbouring molecules. When air molecules collide with their neighbours, they also bounce away from them (restoring force). This keeps the molecules from continuing to travel in the direction of the wave.

Another type of wave can travel through a vacuum, e.g. electromagnetic radiation (including visible light, ultraviolet radiation, infrared radiation, gamma rays, X-rays and radio waves). This type of wave consists of periodic oscillations in electrical and magnetic fields.

A main distinction can be made between transverse and longitudinal waves. Transverse waves occur when a disturbance creates oscillations perpendicular (at right angles) to the propagation (the direction of energy transfer). Longitudinal waves occur when the oscillations are parallel to the direction of propagation.

Waves are described by a wave equation which sets out how the disturbance proceeds over time. The mathematical form of this equation varies depending on the type of wave.

Q. 7. Write the general features of Waves.

Ans. A single, all-encompassing definition for the term *wave* is not straightforward. A vibration can be defined as a *back-and-forth* motion around a reference value. However, a vibration is not necessarily a wave. An attempt to define the necessary and sufficient characteristics that qualify a phenomenon to be called a *wave* results in a fuzzy border line.

The term *wave* is often intuitively understood as referring to a transport of spatial disturbances that are generally not accompanied by a motion of the medium occupying this space as a whole. In a wave, the energy of a vibration is moving away from the source in the form of a disturbance within the surrounding medium (Hall 1980, p. 8). However, this notion is problematic for a standing wave (for example, a wave on a string), where energy is moving in both directions equally, or for electromagnetic/light waves in a vacuum, where the concept of medium does not apply and the inherent interaction of its component is the main reason of its motion and broadcasting. There are water waves on the ocean surface; light waves emitted by the Sun; microwaves used in microwave ovens; radio waves broadcast by radio stations; and sound waves generated by radio receivers, telephone handsets and living creatures (as voices).

It may appear that the description of waves is closely related to their physical origin for each specific instance of a wave process. For example, acoustics is distinguished from optics in that sound waves are related to a mechanical rather than an electromagnetic wave transfer caused by vibration. Concepts such as mass, momentum, inertia, or elasticity, become therefore crucial in describing acoustic (as distinct from optic) wave processes. This difference in origin introduces certain wave characteristics particular to the properties of the medium involved. For example, in the case of air : vortices, radiation pressure, shock waves etc.; in the case of solids : Rayleigh waves, dispersion etc.; and so on.

Other properties, however, although they are usually described in an origin-specific manner, may be generalized to all waves. For such reasons, wave theory represents a particular branch of physics that is concerned with the properties of wave processes independently from their physical origin. For example, based on the mechanical origin of acoustic waves, a moving disturbance in space-time can exist if and only if the medium involved is neither infinitely stiff nor infinitely pliable. If all the parts making up a medium were rigidly *bound,* then they would all vibrate as one, with no delay in the transmission of the vibration and therefore no wave motion. This is impossible because it would violate general relativity. On the other hand, if all the parts were independent, then there would not be any transmission of the vibration and again, no wave motion. Although the above statements are meaningless in the case of waves that do not require a medium, they reveal a characteristic that is relevant to all waves regardless of origin : within a wave, the phase of a vibration (that is, its position within the vibration cycle) is different for adjacent points in space because the vibration reaches these points at different times.

Similarly, wave processes revealed from the study of waves other than sound waves can be significant to the understanding of sound phenomena. A relevant example is Thomas Young's principle of interference (Young, 1802, in Hunt 1992, p. 132). This principle was first introduced in Young's study of light and, within some specific contexts (for example, scattering of sound by sound), is still a researched area in the study of sound.

Q. 8. What do you mean by Global Warming ?

Ans. The tiny low-lying islands of Lakshadweep may be inundated by sea level rises associated with global warming.

Current sea level rise, increased cyclonic activity, increased ambient temperatures, and increasingly fickle precipitation patterns are effects of global warming that have affected or are projected to impact India. Thousands of people have been displaced by ongoing sea level rises that have submerged low-lying islands in the Sundarbans. Temperature rises on the Tibetan Plateau are causing Himalayan glaciers to retreat, threatening the flow rate of the Ganges, Brahmaputra, Yamuna, and other major rivers; the livelihoods of hundreds of thousands of farmers depend on these rivers. A 2007 World Wide Fund for Nature (WWF) report states that the Indus River may run dry for the same reason.

Severe landslides and floods are projected to become increasingly common in such states as Assam. Ecological disasters, such as a 1998 coral bleaching event that killed off more than 70% of corals in the reef ecosystems off Lakshadweep and the Andamans and was brought on by elevated ocean temperatures tied to global warming, are also projected to become increasingly common. Meghalaya and other northeastern states are also concerned that rising sea levels will submerge much of Bangladesh and spawn a refugee crisis. If severe climate changes occurs, Bangladesh and parts of India that border it may lose vast tracts of coastal land.

The Indira Gandhi Institute of Development Research has reported that, if the predictions relating to global warming made by the Intergovernmental Panel on Climate Change come to fruition, climate-related factors could cause India's GDP to decline by up to 9%. Contributing to this would be shifting growing seasons for major crops such as rice, production of which could fall by 40%. Around seven million people are projected to be displaced due to, among other factors, submersion of parts of Mumbai and Chennai if global temperatures were to rise by a mere 2°C (3·6°F). Such shifts are not new. Earlier in the Holocene epoch (4,800-6,300 years ago). parts of what is now the Thar Desert were wet enough to support perennial lakes; researchers have proposed that this was due to much higher winter precipitation, which coincided with stronger monsoons. Kashmir's erstwhile subtropical climate dramatically cooled 2,6-3·7 Ma and experienced prolonged cold spells starting 600,000 years ago.

Q. 9. What do you mean by Altitude ?

Ans. The changing distance separating the moon and Earth also affects tide heights. When the moon is at perigee, the range increases, and when it is at apogee, the range shrinks. Every $7\frac{1}{2}$ lunations (the full cycles from full moon to new to full), perigee coincides with either a new or full moon causing perigean spring tides with the largest *tidal range.* If a stórm happens to be moving onshore at this time, the consequences (property damage, etc.) can be severe.

Bathymetry

The shape of the shoreline and the ocean floor changes the way that tides propagate, so there is no simple, general rule that predicts the time of high water from the moon's position in the sky. Coastal characteristics such as underwater bathymetry and coastline shape mean that individual location characteristics affect tide forecasting; actual high water time and height may differ from model predictions due to the coastal morphology's effects on tidal flow. However, for a given location the relationship between lunar altitude and the time of high or low tide (the lunitidal interval) is relatively constant and predictable, as is the time of high or low tide relative to other points on the same coast. For example, the high tide at Norfolk, Virginia, predictably occurs approximately two and a half hours before the moon passes directly overhead.

Land masses and ocean basins acts as barriers against water moving freely around the globe, and their varied shapes and sizes affect the tidal frequencies. As a result, tidal patterns vary. For example, in the U.S., the East coast has predominantly semi-diurnal tides, as do Europe's Atlantic coasts, while the West coast predominantly has mixed tides.

Other constituents

These include solar gravitational effects, the obliquity (tilt) of the Earth's equator and rotational axis, the inclination of the plane of the lunar orbit and the elliptical shape of the Earth's orbit of the sun.

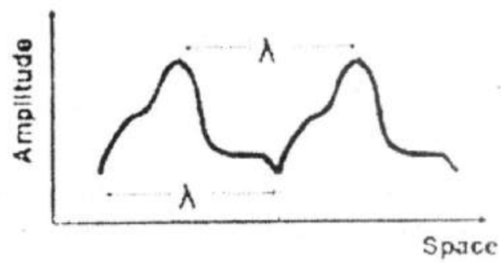
A compound tide (or overtide) results from the swallow-water interaction of its two parent waves.

Q. 10. Explain the Mathematical description of one-dimensional waves.

Ans. MATHEMATICAL DESCRIPTION OF ONE-DIMENSIONAL WAVES

Wave equation

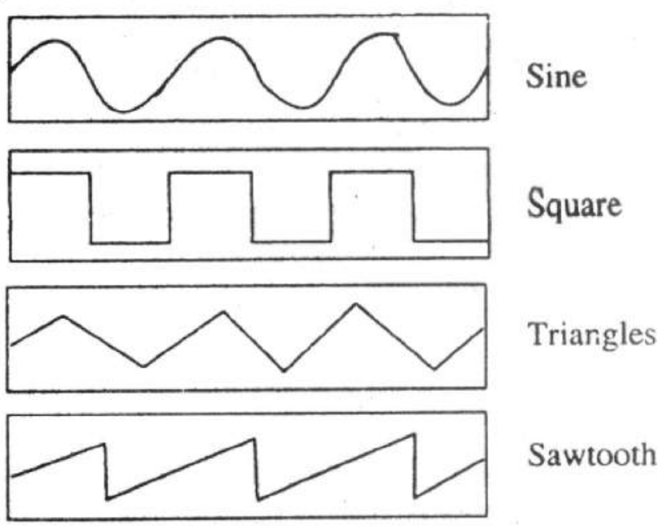
Wave equation and D' Alembert's formula : Consider a traveling transverse wave (which may be a pulse) on a string (the medium). Consdier the string to have a single spatial dimension. Consider this wave as traveling.



Wavelength λ, can be measured between any two corresponding points on a waveform

- in the x direction in space. E.g., let the positive x direction be to the right, and the negative x direction be to the left.
- with constant amplitude u
- with constant velocity v, where v is
  - independent of wavelength (no dispersion)
  - independent of amplitude (linear media, not nonlinear).
- with constant waveform, or shape.

Wave forms



Sine, square, triangle and sawtooth waveforms.

The form or shape of F in d'Alembert's formula involves the argument $x - vt$. Constant values of this argument correspond to constant values of F, and these constant values occur if x increases at the same rate that vt increases. That is, the wave shaped like the function F will move in the positive x-direction at velocity v (and G will propagate at the same speed in the negative x-direction).

In the case of a periodic function F with period λ, that is, $F(x + \lambda - vt) = F(x - vt)$, the periodicity of F in space means that a snapshot of the wave at a given time t finds the wave varying periodically in space with period λ (the wavelength of the wave). In a similar fashion, this periodicity of F implies a periodicity in time as well : $F[x - v(t + T)] = F(x - vt)$ provided $vT = \lambda$, so an observation of the wave at a fixed location x finds the wave undulating periodically in time with period $T = \lambda/v$.

Q. 11 Write a note on the Amplitude and Modulation.

Ans. **AMPLITUDE AND MODULATION**

Illustration of the *envelope* (the slowly varying red curve) of an amplitude-modulated wave. The fast varying blue curve is the *carrier* wave, which is being modulated.

Main article : *Amplitude modulation*

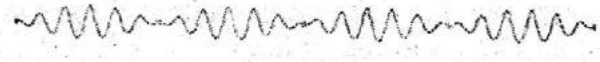
See also : *Frequency modulation and Phase modulation*

The amplitude of a wave may be constant (in which case the wave is a *c.w.* or continuous wave), or may be *modulated* so as to vary with time and/or position. The outline of the variation in amplitude is called the *envelope* of the wave. Mathematically, the modulated wave can be written in the form :

where A (x, t) is the amplitude envelope of the wave, k is the *wavenumber* and ϕ is the *phase*. If the group velocity v_g (see below) is wavelength-independent, this equation can be simplified as :

showing that the envelope moves with the group velocity and retains its shape. Otherwise, in cases where the group velocity varies with wavelength, the pulse shape changes in a manner often described using an *envelope equation.*

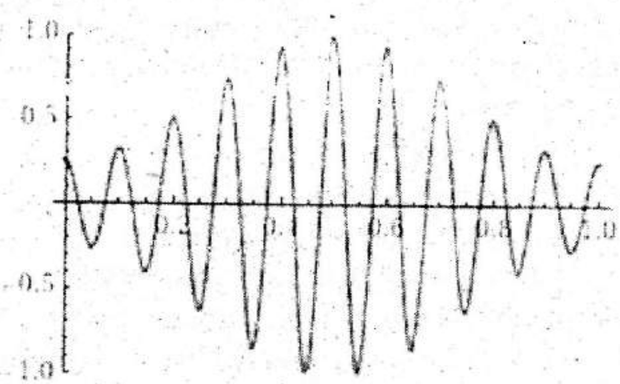
Phase velocity and group velocity



Frequency dispersion in groups of gravity waves on the surface of deep water. The red dot moves with the phase velocity, and the green dots propagate with the group velocity.

Phase Velocity and Group Velocity

There are two velocities that are associated with waves, the phase velocity and the group velocity. To understand them, one must consider several types of waveform. For simplification, examination is restricted to one dimension.



This shows a wave with the Group velocity and Phase velocity going on different directions.

SHORT ANSWER TYPE QUESTIONS

Q. 1. What do you mean floods and landslides ?

Ans. FLOODS AND LANDSLIDES

In the Lower Himalaya, landslides are common. The young age of the region's hills result in labile rock formations, which are susceptible to slippages. Rising population and development pressures, particularly from logging and tourism, cause defeorestation. The result, denuded hillsides, exacerbates the severity of landslides, since tree cover impedes the downhill flow of water. Parts of the Western Ghats also suffer from low-intensity landslides. Avalanches occur in Kashmir, Himachal Pradesh, and Sikkim.

Floods are the msot common natural disaster in India. The heavy southwest monsoon rains cause the Brahmaputra and other rivers to distend their banks, often flooding surrounding areas. Though they provide rice paddy farmers with a largely dependable source of natural irrigation and fertilisation, the floods can kill thousands and displace millions. Excess, erratic, or untimely monsoon rainfall may also wash away or otherwise ruin crops. Almost all of India is flood-prone, and extreme precipitation events, such as flash floods and torrential rains, have become increasingly common in central India over the past several decades, coinciding with rising.

Q. 2. What do you mean by Droughts ?

Ans. Indian agriculture is heavily dependent on the monsoon as a source of water. In some parts of India, the failure of the monsoons result in water shortages, resulting in below-average crop yields. This is particularly true of major drought-prone regions such as southern and eastern Maharashtra, northern Karnataka, Andhra Pradesh, Orissa, Gujarat, and Rajasthan. In the past, droughts have periodically led to major Indian famines. These include the Bengal famine of 1770, in which up to one third of the population in affected areas died; the 1876-1877 famine, in which over five million people died; the 1899 famine, in which over 4·5 million died; and the Bengal famine of 1943, in which over five million died from starvation and famine-related illnesses.

All such episodes of severe drought correlate with El Nino-Southern Oscillation (ENSO) events. El Nino-related droughts have also been implicated in periodic declines in Indian agricultural output. Nevertheless, ENSO events that have coincided with abnormally high sea surfaces temperatures in the Indian Ocean—in one instance during 1997 and 1998 by up to 3°C (37°F)—have resulted in increased oceanic evaporation, resulting in unusually wet weather across India. Such anomalies have occurred during a sustained warm spell that begin in the 1990s. A contrasting phenomenon is that, instead of the usual high pressure air mass over the sourthern Indian Ocean, an ENSO-related oceanic low pressure convergence center forms; it then continually pulls dry air from Central Asia, desiccating India during what should have been the humid summer monsoon season. This reversed air flow causes India's droughts. The extent that an ENSO event raises sea surface temperatures in the central Pacific Ocean influences the extent of drought.

Q. 3. Explain the atmospheric pollution.

Ans. **ATMOSPHERIC POLLUTION**

Clouds of thick haze and smoke may form over the Ganges river basin.

Thick haze and smoke originating from burning biomass in north-western India and air pollution from large industrial cities in northern India often concentrate over the Ganges Basin. Prevailing westerlies carry aerosols along the southern margins of the sheer-faced Tibetan Plateau towards eastern India and the Bay of Bengal. Dust and black carbon, which are blown towards higher altitudes by winds at the southern margins of the Himalayas, can absorb shortwave radiation and heat the air over the Tibetan Plateau. The net atmospheric heating due to aerosol absorption causes the air to warm and convect upwards, increasing the concentration of moisture in the mid-troposphere and providing positive feedback that stimulates further heating of aerosols.

Q. 4. Write the History of Tidal Physics.

Ans. HISTORY OF TIDAL PHYSICS

Tidal physics was important in the early development of heliocentrism and celestial mechanics, with the existence of two daily tides being explained by the moon's gravity. Later the daily tides were explained more precisely by the interaction of the moon's gravity and the sun's gravity to cause the variation of tides.

An early explanation of tides was given by Galileo Galilei in his 1632 *Dialogue Concerning the Two Chief World Systems*, whose working title was *Dialogue on the Tides*. However, the resulting theory was incorrect—he attributed the tides to water sloshing due to the Earth's movement around the sun, hoping to provide mechanical proof of the Earth's movement—and the value of the theory is disputed, as discussed there. At the same time Johannes Kepler correctly suggested that the moon caused the tides, based upon ancient observation and correlations, an explanation which was rejected by Galileo. It was originally mentioned in Ptolemy's Tetrabiblos as being derived from ancient observation.

Isaac Newton (1642-1727) was the first person to explain tides by the gravitational attraction of masses. His explanation of the tides (and many other phenomena) was published in the *Principia* (1687). and used his theory of universal gravitation to account for the tide-generating forces as due to the lunar and solar attractions. Newton and others before Pierre-Simon Laplace worked with an equilibrium theory, largely concerned with an approximation that describes the tides that would occur in a non-inertial ocean evenly covering the whole Earth. The tide-generating force (or its corresponding potential) is still relevant to tidal theory, but as an intermediate quantity rather than as a final result; theory has to consider also the Earth's accumulated dynamic tidal response to the force, a response that is influenced by bathymetry, Earth's rotation, and other factors.

In 1740, the Academic Royale des Sciences in Paris offered a prize for the best theoretical essay on tides. Daniel Bernoulli, Leonhard Euler, Colin Maclaurin and Antoine Cavalleri shared the prize.

Maclaurin used Newton's theory to show that a smooth sphere covered by a sufficiently deep ocean under the tidal force of a single deforming body is a prolate spheroid (essentially a three dimensional oval) with major axis directed toward the deforming body. Maclaurin was the first to write about the Earth's rotational effects on motion. Euler realized that the tidal force's *horizontal* component (more than the vertical) drives the tide. In 1744 Jean le Rond d'Alembert studied tidal equations for the atmosphere which did not include rotation.

Pierre-Simon Laplace formulated a system of partial differential equations relating the ocean's horizontal flow to its surface height, the first major dynamic theory for water tides. The Laplace tidal equations are still in use today. William Thomson, 1st Baron Kelvin, rewrote Laplace's equations in terms of vorticity which allowed for solutions describing tidally driven coastally trapped waves, known as Kelvin waves.

Others including Kelvin and Henri Poincare further developed Laplace's theory. Based on these developments and the lunar theory of E. W. Brown describing the motions of the moon, Arthur Thomas Doodson developed and published in 1921 the first modern development of the tide-generating potential in harmonic form : Doodson distinguished 388 tidal frequencies. Some of his methods remain in use.

Q. 5. Explain the Tidal Force.

Ans. **TIDAL FORCES**

The tidal force produced by a massive object (moon, hereafter) on a small particle located on or in an extensive body (Earth, hereafter) is the vector difference between the gravitational force exerted by the moon on the particle, and the gravitational force that would be exerted on the particle if it were located at the Earth's center of mass. Thus, the tidal force depends not on the strength of the lunar gravitational field, but on its gradient (which falls off approximately as the inverse cube of the distance to the originating gravitational body). The solar *gravitational force* on the Earth is on average 179 times stronger than the lunar, but because the sun is on average 389 times farther from the Earth, its field gradient is weaker. The solar tidal force is 46% as large as the lunar. More precisely, the lunar tidal acceleration (along the moon-Earth axis, at the Earth's surface) is about $1{\cdot}1 \times 10^{-7}\, g$, while the solar tidal acceleration (along the sun-Earth axis, at the Earth's surface) is about $0{\cdot}52 \times 10^{-7}\, g$, where g is the gravitational acceleration at the Earth's surface. Venus has the largest effect of the other planets, at 0·000113 times the solar effect.

The lunar gravity differential field at the Earth's surface is known as the tide-generating force. This is the primary mechanism that drives tidal action and explains two equipotential tidal bulges, accounting for two daily high waters.

Tidal forces can also be analysed this way : each point of the Earth experiences the moon's radially decreasing gravity differently. Only the tidal forces' *horizontal* components actually tidally accelerate the water particles since there is small resistance. The tidal force on a particle equals about one ten millionth that of Earth's gravitational force.

The ocean's surface is closely approximated by an equipotential surface, (ignoring ocean currents) commonly referred to as the geoid. Since the gravitational force is equal to the potential's gradient, there are no tangential forces on such a surface, and the ocean surface is thus in gravitational equilibrium. Now consider the effect of massive external bodies such as the moon and sun. These bodies have strong gravitational fields that diminish with distance in space and which act to alter the shape of an equipotential surface on the Earth. This deformation has a fixed spatial orientation relative to the influencing body. The Earth's rotation relative to this shape causes the daily tidal cycle. Gravitational forces follow an inverse-square law (force is inversely proportional to the square of the distance), but tidal forces are inversely proportional to the cube of the distance. The ocean surface moves to adjust to changing tidal equipotential, tending to rise when the tidal potential is high, which occurs on the part of the Earth nearest to and furthest from the moon. When the tidal equipotential changes, the ocean surface is no longer aligned with it, so that the apparent direction of the vertical shifts. The surface then experiences a down slope, in the direction that the equipotential has risen.

Q. 6. Write a note on the following :

(a) Laplace's tidal equations,

(b) Amplitude and cycle time.

Ans. **LAPLACE'S TIDAL EQUATIONS**

Ocean depths are much smaller than their horizontal extent. Thus, the response to tidal forcing can be modelled using the Laplace tidal equations which incorporate the following features :

1. The vertical (or radial) velocity is negligible, and there is no vertical shear—this is a sheet flow.
2. The forcing is only horizontal (tangential).
3. The Coriolis effect appears as a fictitious lateral forcing proportional to velocity.
4. The surface height's rate of change is proportional to the negative divergence of velocity multiplied by the depth. As the horizontal velocity stretches or compresses the ocean as a sheet, the volume thins or thickens, respectively.

The boundary conditions dictate no flow across the coastline and free slip at the bottom.

The Coriolis effect steers waves to the right in the northern hemisphere and to the left in the southern allowing coastally trapped waves. Finally, a dissipation term can be added which is an analog to viscosity.

AMPLITUDE AND CYCLE TIME

The theoretical amplitude of oceanic tides caused by the moon is about 54 centimetres (21 in) at the highest point, which corresponds to the amplitude that would reached if the ocean possessed a uniform depth, there were no landmasses, and the Earth were rotating in step with the moon's orbit. The sun similarly causes tides, of which the theoretical amplitude is about 25 centimetres (9·8 in) (46% of that of the moon) with a cycle time of 12 hours. At spring tide the two effects add to each other to a theoretical level of 79 centimetres (31 in), while at neap tide the theoretical level is reduced to 29 centimetres (11 in). Since the orbits of the Earth about the sun, and the moon about the Earth, are elliptical, tidal amplitudes change somewhat as a result of the varying Earth-sun and Earth-moon distasnces. This causes a variation in the tidal force and theoretical amplitude of about ± 18% for the moon and ± 5% for the sun. If both the sun and moon were at their closest positions and aligned at new moon, the theoretical amplitude would reach 93 centimetres (37 in).

Real amplitudes differ considerably, not only because of depth variations and continental obstacles, but also because wave propagation across the ocean has a natural period of the same order of magnitude as the rotation period : if there were no land masses, it would take about 30 hours for a long wavelength surface wave to propagate along the equator halfway around the Earth (by comparison, the Earth's lithosphere has a natural period of about 57 minutes). Earth tides, which raise and lower the bottom of the ocean, and the tide's own gravitational self attraction are both significant and further complicate the ocean's response to tidal forces.

Q. 7. Write a short note on the Tidal acceleration.

Ans. **TIDAL ACCELERATION**

Earth's tidal oscillations introduce dissipation at an average rate of about 3·75 terrawatt. About 98% of this dissipation is by marine tidal movement. Dissipation arises as basin-scale tidal flows drive smaller-scale flows which experience turbulent dissipation. This tidal drag creates torque on the moon that gradually transfers angular momentum to its orbit, and a gradual increase in Earth-moon separation. The equal and opposite torque on the Earth correspondingly decreases its rotational velocity. Thus, over geologic time, the moon recedes from the Earth, at about 3·8 centimetres (1·5 in)/year, lengthening the terrestrial day. Day length has increased by about 2 hours in the last 600 million years. Assuming (as a crude approximation) that the deceleration rate has been constant, this would imply that 70 million years ago, day length was on the order of 1% shorter with about 4 more days per year.

UNIT-V

LONG ANSWER TYPE QUESTIONS

Q. 1. "The Biosphere is the global sum of all ecosystems." Explain.

Ans. The **biosphere** is the global sum of all ecosystems. It can also be called the zone of life on Earth, a closed (apart from solar and cosmic radiation) and self-regulating system. From the broadest biophysiological point of view, the biosphere is the global ecological system integrating all living beings and their relationships, including their interaction with the elements of the lithosphere, hydrosphere and atmosphere. The biosphere is postulated to have evolved, beginning through a process of biogenesis or biopoesis, at least some 3·5 billion years ago.

In a broader sense; biospheres are any closed, self-regulating system containing ecosystems; including artificial ones such as Biosphere 2 and BIOS-3; and, potentially, ones on other planets or moons.

ORIGIN AND USE OF THE TERM

The term "biosphere" was coined by geologist **Eduard Suess** in 1875, which is defined as :

"The place on Earth's surface where life dwells."

While this concept has a geological origin, it is an indication of the impact of both **Darwin** and **Maury** on the earth sciences. The biosphere's ecological context comes from the 1920s, preceding the 1935 introduction of the term 'ecosystem' by **Sir Arthur Tansley.** Vernadsky defined ecology as the science of the biosphere. It is an interdisciplinary concept for intergrating astronomy, geophysics, meteorology, biogeography, evolution, geology, geochemistry, hydrology and, generally speaking, all life and earth sciences.

Narrow Definitions

A familiar scene on Earth which simultaneously shows the lithosphere, hydrosphere and atmosphere.

Some life scientists and earth scientists use *biosphere* in a more limited sense. For example, geochemists define the biosphere as being the total sum of living organisms (the 'biomass' or 'biota' as referred to by biologists and ecologists). In this sense, the biosphere is but one of four separate components of the geochemical model, the other three being *lithosphere*, *hydrosphere*, and *atmosphere*. The narrow meaning used by geochemists is one of the consequences of specialization in modern science. Some might prefer the word *ecosphere*, coined in the 1960s, as all encompassing of both biological and physical components of the planet.

The Second International Conference on Closed Life Systems defined *biospherics* as the science and technology of analogs and models of Earth's biosphere; *i.e.*, artificial Earth-like biospheres. Others may include the creation of artificial non-Earth biospheres—for example, human-centered biospheres or a native Martian biosphere—in the field of biospherics.

Gaia Hypothesis

In the early 1970s, **Lynn Margulis,** a microbiolcgist from the United States, added to the hypothesis, specifically noting the ties between the biosphere and other Earth systems. For example, when carbon di-oxide levels increase in the atmosphere, plants grow more quickly. As their growth continues, they remove more and more carbon di-oxide from the atmosphere.

Many scientists are now involved in new fields of study that examine interactions between biotic and abiotic factors in the biosphere, such as geobiology and geomicrobiology.

Ecosystems occur when communities and their physical environment work together as a system. The difference between this and a biosphere is simple, the biosphere is everything in general terms.

Q. 2. Explain the extent of Earth's biosphere.

Ans. Water covers 71% of the Earth's surface. Image is the Earth photographed from Apollo 17. Every part of the planet, from the polar ice caps to the Equator, supports life of some kind. Recent advances in microbiology have demonstrated that microbes live deep beneath the Earth's terrestrial surface, and that the total mass of microbial life in so-called 'uninhabitable zones' may, in biomass, exceed all animal and plant life on the surface. The actual thickness of the biosphere on earth is difficult to measure. Birds typically fly at altitudes of 650 to 1,800 metres, and fish that live deep underwater can be found down to – 8,372 metres in the Puerto Rico Trench.

There are more extreme examples for life on the planet : Ruppell's vulture has been found at altitudes of 11,300 metres; bar-headed geese migrate at altitudes of at least 8,300 metres; yaks live at elevations between 3,200 to 5,400 metres above sea level; mountain goats live up 3,050 metres. herbivorous animals at these elevations depend on lichens, grasses, and herbs.

Microscopic organisms live at such extremes that, taking them into consideration puts the thickness of the biosphere much greater. Culturable microbes have been found in the Earth's upper atmosphere as high as 41 km

(25 mi) (Wainwright et al., 2003, in FEMS Microbiology Letters). It is unlikely, however, that microbes are active at such altitudes, where temperatures and air pressure are extremely low and ultraviolet radiation very high. More likely these microbes were brought into the upper atmosphere by winds or possibly volcanic eruptions. Barophilic marine microbes have been found at more than 10 km (6 mi) depth in the Marianas Trench (Takamia et al., 1997, in FEMS Microbiology Letters). Microbes are not limited to the air, water or the Earth's surface. Culturable thermophilic microbes have been extracted from cores drilled more than 5 km (3 mi) into the Earth's crust in Sweden (Gold, 1992, and Szewzyk, 1994, both in PNAS), from rocks between 65-75°C. Temperature increases with increasing depth into the Earth's crust. The speed at which the temperature increases depends on many factors, including type of crust (continental vs. oceanic), rock type, geographic location, etc. The upper known limit of temperature at which microbial life can exist is 122°C (*Methanopyrus kandleri* Strain 116), and it is likely that the limit of life in the 'deep biosphere' is defined by temperature rather than absolute depth.

Our biosphere is divided into a number of biomes, inhabited by broadly similar flora and fauna. On land, biomes are separated primarily by latitude. Terrestrial biomes lying within the Arctic and Antarctic Circles are relatively barren of plant and animal life, while most of the more populous biomes lie near the equator. Terrestrial organisms in temperate and Arctic biomes have relatively small amounts of total biomass, smaller energy budgets, and display prominent adeptations to cold, including world-spanning migrations, social adaptations, homeothermy, estivation and multiple layers of insulation.

Q. 3. What do you mean by Biome ?

Ans. Biomes are climatically and geographically defined as similar climatic conditions on the Earth, such as communities of plants, animals, and soil organisms, and are often referred to as ecosystems. Some parts of the earth have more or less the same kind of abiotic and biotic factors spread over a large area, creating a typical ecosystem over that area. Such major ecosystems are termed as biomes. Bic .nes are defined by factors such as plant structures (such as trees, shrubs, and grasses), leaf types (such as broadleaf and needleleaf), plant spacing (forest, woodland, savanna), and climate. Unlike ecozones, biomes are not defined by genetic, taxonomic, or historical similarities. Biomes are often identified with particular patterns of ecological succession and climax vegetation (quasiequilibrium state of the local ecosystem). An ecosystem has many biotopes and a biome is a major habitat type. A major habitat type, however, is a comp.oise, as it has a intrinsic inhomogeneity.

The biodiversity characteristic of each extinction, especially the diversity of fauna and subdominant plant forms, is a function of abiotic factors and the biomass productivity of the dominant vegetation. In terrestrial biomes, species diversity tends to correlate positively with net primary productivity, moisture availability, and temperature.

Ecoregions are grouped into both biomes and ecozones.

A fundamental classification of biomes is :

1. Terrestrial (land) biomes,
2. Aquatic biomes (including freshwater biomes and marine biomes).

Biomes are often known in English by local names. For example, a temperate grassland or shrubland biome is known commonly as *steppe* in cental Asia, prairie in North America, and *pampas* in South America. Tropical grasslands are known as savanna in Australis, whereas in southern Africa it is known as certain kinds of *veld* (from Afrikaans).

Sometimes an entire biome may be targeted for protection, especially under an individual nation's biodiversity action plan.

Climate is a major factor determining the distribution of terrestrial biomes. Among the important climatic factors are :

- **Latitude :** Arctic, boreal, temperate, subtropical, tropical.
- **Humidity :** Humid, semihumid, semiarid and arid.
  * **Seasonal Variation :** Rainfall may be distributed evenly throughout the year or be marked by seasonal variations.
  * **Dry summer, wet winter :** Most regions of the earth receive most of their rainfall during the summer months; Mediterranean climate regions receive their rainfall during the winter months.
- **Elevation :** Increasing elevation causes a distribution of habitat types similar to that of increasing latitude.

The most widely used systems of classifying biomes correspond to latitude (or temperature zoning) and humidity. Biodiversity generally increases away from the poles towards the equator and increases with humidity.

Q. 4. Write a note on the Biome Classification Schemes.

Ans. BIOME CLASSIFICATION SCHEMES

Biomes are classification schemes which define biomes using climatic parameters. Particularly in the 1970s and 1980s, there was a significant push to understand the relationship between these climatic parameters and properties of ecosystem energetics because such discoveries would enable the prediction of rates of energy capture and transfer among components within ecosystems. Such a study was conducted by Sims et al. (1978) on North American grasslands. The study found a positive logistic correlation between evapotranspiration in mm/yr and above-ground net primary production in g/m^2/yr. More general results from the study were that precipitation and water use lead to above-ground primary production, solar radiation and temperature lead to belowground primary production (roots), and temperature and water lead to cool and warm season growth habit. These findings help explain the categories used in Holdridge's bioclassification scheme, which were then later simplified in Whittaker's. The number of classification schemes and the variety of determinants used in those schemes, however, should be taken as strong indicators that biomes do not all fit perfectly into the classification schemes created.

Holdridge Scheme

The Holdridge classification scheme, developed by botanist L. R. Holdridge, maps climates based on four categories.

- Average total precipitation is the potential evapotranspiration divided by the precipitation; the ratio increases from humid to arid regions.
- Potential evapotranspiration (PET).
- Mean annual biotemperature (°C) : at or below freezing, all have the same effect on plants, and delineating between – 10°C and – 30°C would yield unrealistic results.

In this scheme, climates are classified based on the biological effect of temperature and rainfall on vegetation under the assumption that these two abiotic factors are the largest determinants of the type of vegetation found in an area. Holdridge uses the four axes to define 30 so-called 'humidity provinces', which are clearly visible in the Holdridge diagram. While his scheme largely ignores soil and sun exposure, Holdridge did acknowledge that these, too, were important factors in biomes determination.

Whittaker's biome-type classification scheme

Whittaker appreciated biome-types as a representation of the great diversity of the living world, and saw the need to establish a simple way to classify them. He based his classification scheme on two abiotic factors; precipitation and temperature. His scheme can be seen as a simplification of Holdridge's, one more readily accessible, but perhaps missing the greater specificity that Holdridge's provides.

Whittaker based his representation of global biomes on both previous theoretical assertions and an ever-increasing empirical sampling of global ecosystems. He was in a unique position to make such a holistic assertion because he had previously compiled a review of biome classification.

Key definitions for understanding Whittaker's scheme

- **Physiognomy :** The apparent characteristics, outward features, or appearance of ecological communities or species.

- **Biome :** a grouping of terrestrial ecosystems on a given continent that are similar in vegetation structure, physiognomy, features of the environment and characteristics of their animal communities.
- **Formation :** a major kind of community of plants on a given continent.
- **Biome-type :** grouping of convergent biomes or formations of different continents, defined by physiognomy.
- **Formation-type :** a grouping of convergent formations.

Whittaker's distinction between biome and formation can be simplified; formation is used when applied to plant communities only, while biome is used when concerned with both plants and animals. Whittaker's convention of biome-type or formation-type is simply a broader method to categorize similar communities.

Whittaker's parameters for classifying biome-types

Whittaker, seeing the need for a simpler way to express the relationship of community structure to the environment, used what he called 'gradient analysis' of ecocline patterns to relate communities to climate on a worldwide scale. Whittaker considered four main ecoclines in the terrestrial realm.

1. Intertidal levels : The wetness gradient of areas that are exposed to alternating water and dryness with intensities that vary by location from high to low tide.
2. Climatic moisture gradient.
3. Temperature gradient by altitude.
4. Temperature gradient by latitude.

Along these gradients, Whittaker noted several trends that allowed him to qualitatively establish biome-types.

- The gradient runs from favorable to extreme, with corresponding changes in productivity.
- Changes in physiognomic complexity vary with the favorability of the environment (decreasing community structure and reduction of stratal differentiation as the environment becomes less favorable).
- Trends in diversity of structure follow trends in species diversity; alpha and beta species diversities decrease from favorable to extreme environments.
- Each growth-form (*i.e.*, grasses, shrubs, etc.) has its characteristic place of maximum importance along the ecoclines.
- The Same growth forms may be dominant in similar environments in widely different parts of the world.

Whittaker summed the effects of gradients (3) and (4) to get an overall temperature gradient, and combined this with gradient (2), the moisture gradient, to express the above conclusions in what is known as the Whittakar classification scheme. The scheme graphs average annual precipitation (*x*-axis) versus average annual temperature (*y*-axis) to classify biome-types.

Walter System

The Heinrich Walter classification scheme, developed by Heinrich Walter, a German ecologist, differs from both the Whittaker and Holdridge schemes because it takes into account the seasonality of temperature and precipitation. The system, also based on precipitation and temperature, finds 9 major biomes, with the important climate traits and vegetation types summarized in the accompanying table. The boundaries of each biome correlate to the conditions of moisture and cold stress that the strong determinants of plant form, and therefore the vegetation that defines the region. Extreme conditions, such as flooding in a swamp, can create different kinds of communities within the same biome.

- I : Equatorial
    * Always moist and lacking temperature seasonality
    * Evergreen tropical rain forest
- II : Tropical
    * Summer rainy season and cooler 'winter' dry season
    * Seasonal forest, scrub, or savanna
- III : Subtropical
    * Highly seasonal, arid climate
    * Desert vegetation with considerable exposed surface
- IV : Mediterranean
    * Winter rainy season and summer drought
    * Sclerophyllous (drought-adapted), frost-sensitive shrublands and woodlands
- V : Warm temperate
    * Occasional frost, often with summer rainfall maximum
    * Temperate evergreen forest, somewhat frost-sensitive
- VI : Nemoral
    * Moderate climate with winter freezing
    * Frost-resistant, deciduous, temperate forest
- VII : Continental
    * Arid, with warm or hot summers and cold winters
    * Gransslands and temperate deserts

- VIII : Boreal
  - Cold temperate with cool summers and long winters
  - Evergreen, frost-hardy, needle-leaved forest (taiga)
- IX : Polar
  - Very short, cool summers and long, very cold winters
  - Low, evergreen vegetation, without trees, growing over permanently frozen soils.

Bailey System

Robert G. Bailey almost developed a biogeographical classification system for the United States in a map published in 1976. He subsequently expanded the system to include the rest of South America in 1981, and the world in 1989. The Bailey system, based on climate, is divided into seven domains (polar, humid temperate, dry, humid, and humid tropical), with further divisions based on other climate characteristics (subarctic, warm temperate, hot temperate, and subtropical; marine and continental; lowland and mountain).

- **100 Polar Domain**
  - 120 Tundra Division
  - M120 Tundra Division - Mountain Provinces
  - 130 Subarctic Division
  - M130 Subarctic Division - Mountain Provinces
- **200 Humid Temperate Domain**
  - 210 Warm Continental Division
  - M210 Warm Continental Division - Mountain Provinces
  - 220 Hot Continental Division
  - M220 Hot Subtropical Division - Mountain Provinces
  - 230 Subtropical Division
  - M230 Subtropical Division - Mountain Provinces
  - 240 Marine Division
  - M240 Marine Division - Mountain Provinces
  - 250 Prairie Divison
  - 260 Mediterranean Divison
  - M260 Mediterranean Divison - Mountain Provinces
- **300 Dry Domain**
  - 310 Tropical/Subtropical Steppe Division
  - M310 Tropical/Subtropical Steppe Division - Mountain Provinces

WWF System

A team of biologists convened by the World Wide Fund for Nature (WWF) developed an ecological land classification system that identified fourteen biomes, called **major habitat types,** and further divided the world's land area into 867 terrestrial ecoregions. Each terrestrial ecoregion has a specific EcoID, format XXnnNN (XX is the ecozone, nn is the biome number, NN is the individual number). This classification is used to define the Global 200 list of ecoregions identified by the WWF as priorities for conservation. The WWF major habitat types are :

- 01 Tropical and subtropical moist broadleaf forests (tropical and subtropical, humid)
- 02 Tropical and subtropical dry broadleaf forests (tropical and subtropical, semihumid)
- 03 Tropical and subtropical coniferous forests (tropical and subtropical, semihumid)
- 04 Temperate broadleaf and mixed forests (temperate, humid)
- 05 Temperate coniferous forests (temperate, humid to semihumid)
- 06 Boreal forests/taiga (subarctic, humid)
- 07 Tropical and subtropical grasslands, savannas, and shrublands (tropical and subtropical, semiarid)
- 08 Temperate grasslands, savannas, and shrublands (temperate, semiarid)
- 09 Flooded grassland and savannas (temperate to tropical, fresh or brackish water inundated)
- 10 Montane grasslands and shrublands (alpine or montane climate)
- 11 Tundra (Arctic)
- 12 Mediterranean forests, woodlands, and scrub or sclerophyll forests (temperate warm, semihumid to semiarid with winter rainfall)
- 13 Deserts and xeric shrublands (temperate to tropical, arid)
- 14 Mangrove (subtropical and tropical, salt water inundated)

Q. 5. Explain the different types of biotic succession.

Ans. There are different types of biotic succession which can be of primary or secondary type. The primary succession is also known as the prisere. It occurs on the bare areas which include the sand dunes, lava sediments, exposed sea floor and the newly submerged areas. These conditions are very difficult for the pioneer community to survive. it takes around 1000 years to establish itself. The secondary succession is also known as the subsere. It does not occur on the bare areas but the areas which are destroyed previously. The destruction may occur due to the presence of forest fires, recently cleared and harvested areas, landslide, overgrazed area, submergence and the drought.

The subsere has an organic matter which is fertile and provides a succession very quickly. As soon as the conditions become favourable, the seeds, species and the underground parts give rise to a new community. This ultimately forms a climax community. The subsere takes around 100 to 200 years to develop depending upon the area whether it is a grass or a forest. The moss sphagnum may also invade the secondary succession. It affects the succession of stages and never allows the climax community to develop. The different stages of succession which are present on the rocks are known as the lithosere. The lithosere is also known as the xerosome as the rocks have the water deficiency. The rock is not a favorable place for the living beings as they do not have water and neither have the ability to absorb the rain water. They are devoid of nutrients. When the temperature is high they can increase their surface temperature and it is very difficult forthe plants to survive at these temperatures. The lichens are the first organisms that are able to survive under these extreme conditions. They occur in the temperate areas. The blue green algae can also survive at these conditions and they exist in the tropical areas.

Q. 6. What do you mean by Ecosystem ?

Ans. An **ecosystem** is a biological environment consisting of all the organisms living in a particular area, as well as all the nonliving (abiotic), physical components of the environment with which the organisms interact, such as air, soil, water and sunlight.

Rainforests often have a great deal of biodiversity with many plant and animal species. This is the Gambia River in Senegal's Niokolo-Koba National Park.

The entire array of organisms inhabiting a particular ecosystem is called a community. The number of species making up such a community may vary from a myriad to a single species such as *Desulforudis*. In a typical ecosystem, plants and other photosynthetic organisms are the producers that provide the food. Ecosystems can be permanent or temporary. Ecosystems usually from a number of food webs.

Ecosystems are functional units consisting of living things in a given area, non-living chemical and physical factors of their environment, linked together through nutrient cycle and energy flow.

  * **Lentic,** the ecosystem of a lake, pond or swamp.
  * **Lotic,** the ecosystem of a river, stream or spring.

- **Artificial,** ecosystems created by humans.

Central to the ecosystem concept is the idea that living organisms interact with every other element in their local environment. **Eugene Odum**, a founder of ecology, stated : "Any unit that includes all of the organisms (*i.e.*, the 'community') in a given area interacting with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity, and material cycles (*i.e.*, exchange of materials between living and nonliving parts) within the system is an ecosystem.

Etymology

The term ecosystem was coined in 1930 by **Roy Claham** to mean the combined physical and biological components of an environment. British ecologist **Arthur Tansley** later refined the term, describing it as "The whole system, ... including not the organism-complex, but also the whole complex of physical factors forming what we call the environment." Tansley regarded ecosystems not simply as natural units, but as mental isolates. Tansley later defined the spatial extent of ecosystems using the term ecotope.

Examples of Ecosystems

- Agroecosystem
- Aquatic ecosystem
- Chaparral
- Coral reef
- Desert
- Forest
- Farm
- Greater Yellowstone Ecosystem
- Human ecosystem
- Large marine ecosystem
- Littoral zone
- Lotic
- Marine ecosystem
- Pond ecosystem

Biomes are a classification of globally similar areas, including ecosystems, such as ecological communities of plants and animals, soil organisms and climaic conditions. Biomes are in part defined based on factors such as plant structures (such as trees, shrubs and grasses), leaf types (such as broadleaf and needleleaf), plant spacing (forest, woodland, savanna) and climate. Unlike ecozones, biomes are not defined by genetic, taxonomic or historical similarities. Biomes are often identified with particular patterns of ecological succession and climax vegetation.

A fundamental classification of biomes is :

1. Terrestrial (land) biomes.
2. Freshwater biomes.
3. Marine biomes.

Q. 7. The Biosphere is the Biological Component of Earth System. Explain.

Ans. The **biosphere** is the biological component of earth systems, which also include the lithosphere, hydrosphere, atmosphere and other 'spheres' (e.g. cryosphere, anthrosphere, etc.). The biosphere includes all living organisms on earth, together with the dead organic matter produced by them. The biosphere concept is common to many scientific disciplines including astronomy, geophysics, geology, hydrology, biogeography and evolution, and is a core concept in ecology, earth science and physical geography. A key component of earth systems, the biosphere interacts with and exchanges matter and energy with the other spheres, helping to drive the global biogeochemical cycling of carbon, nitrogen, phosphorus, sulfur and other elements. From an ecological point of view, the biosphere is the 'global ecosystem', comprising the totality of biodiversity on earth and performing all manner of biological functions, including photosynthesis, respiration, decomposition, nitrogen fixation and denitrification.

The biosphere is dynamic, undergoing strong seasonal cycles in primary productivity and the many biological processes driven by the energy captured by photosynthesis. Seasonal cycles in solar irradiation of the hemispheres is the main driver of this dynamic, especially by its strong effect on terrestrial primary productivity in the temperate and boreal biomes, which essentially cease productivity in the winter time.

The biosphere has evolved since the first single-called organisms originated 3·5 billion years ago under atmospheric conditions resembling those of our neighboring planets Mars and Venus, which have atmospheres composed primarily of carbon di-oxide. Billions of years of primary production by plants released oxygen from this carbon di-oxide and deposited the carbon in sedimentas, eventually producing the oxygen-rich atmosphere we know today. Free oxygen, both for breathing (O_2, respiration) and in the stratospheric ozone (O_3) that protects us from harmful UV radiation, has made possible life as we know it while transforming the chemistry of earth systems forever.

As a result of long-term interactions between the biosphere and the other earth systems, there is almost no part of the earth's surface that has not been profoundly altered by living organisms. The earth is a living planet, even in terms of its physics and chemistry. A concept related to, but different from, that of the biosphere, is the Gaia hypotheses, which posits that living organisms have and continue to transform earth systems for their own benefit.

HISTORY OF THE BIOSPHERE CONCEPT

The term 'biosphere' originated with the geologist Eduard Suess in 1875, who defined it as "the place on earth's surface where life dwells". Vladimir I. Vernadsky first defined the biosphere in a form resembling its current ecological usage in his long-overlooked book of the same title, originally published in 1926 . It is Vernadsky's work that redefined ecology as the science of the biosphere and placed the biosphere concept in its current central position in earth systems science.

levels of organization of Ecology, highlighting the Biosphere. (Credit : **Erle Ellis)**

The biosphere is a core concept within Biology and Ecology, where it serves as the highest level of biological organization, which begins with parts of cells and proceed to populations, species, ecoregions, biomes and finally, the biospher. Global patterns of biodiversity within the biosphere are described using biomes.

In earth science, the biosphere represents the role of living organisms and their remains in controlling and interacting with the other spheres in the global biogeochemical cycles and energy budgets. The biosphere plays a central role in the biogeochemical processing of carbon, nitrogen, phosphorus, sulfur and other elements. As a result, biogeochemical processes such as photosynthesis and nitrogen fixation are critical to understanding the chemistry and physics of earth systems as a whole. The physical properties of the biosphere in terms of its surface reflectance (albedo) and exchange of heat and moisture with the atmosphere are also critical for understanding global circulation of heat and moisture and therefore climate. Alterations in both the physics (albedo, heat exchange) and chemistry (carbon di-oxide, methane, etc.) of earth systems by the biosphere are fundamental in underst inding anthropogenic global warming.

Q. 8. Explain the Ecosystem.

Ans. Ecosystems have become particularly important politically, since the Convention on Biological Diversity (CBD) - ratified by 192 countries - defines "the protection of ecosystems, natural habitats and the maintenance of viable populations of s ecies in r atural surroundings" as a commitment of ratifying countries. Th s has cre ted the political necessity to spatially identify ecosystems and somehov distinguish among them. The CBD defines an 'ecosystem' as a "dynar ic complex of plant, animal and micro-organism communities a d their r n-living environment interacting as a functional unit."

With the need of protecting ecosystems, the political need arose to describe and identify them efficiently. Vreugdenhil et al. argued that this could be achieved most effectively by using a physiognomic-ecological classification system, as ecosystems are easily recognizable in the field as well as on satellite images. They argued that the structure and seasonality of the associated vegetation, or flora, complemented with ecological data(such as elevation, humidity, and drainage), are each determining modifiers that separate partially distinct sets of species. This is true not only for plant species, but also for species of animals, fungi and bacteria. The degree of ecosystem distinction is subject to the physiognomic modifiers that can be identified on an image and/or in the field. Where necessary, specific fauna elements can be added, such as seasonal concentrations of animals and the distribution of coral reefs.

Several physiognomic-ecological classification systems are available :

- Physiognomic-Ecological Classification of Plant Formations of the Earth : a system based on the 1974 work of Mueller-Dombois and Heinz Ellenberg, and developed by UNESCO. This classification "describes the above-ground or underwater vegetation structures and cover as observed in the field, described as plant life forms. This classification is fundamentally a species-independent physiognomic, hierarchical vegetation classification system which also takes into account ecological factors such as climate, elevation, human influences such as grazing, hydric regimes and survival strategies such as seasonality. The system was expanded with a basic classification for open water formations."
- Land Cover Classification System (LCCS), developed by the Food and Agriculture Organization (FAO).
- Forest-Range Environmental Study Ecosystemns (FRES) developed by the United States Forest Service for use in the United States.

Several aquatic classification systems are available, and an effort is being made by the United States Geological Survey (USGS) and the Inter-American Biodiversity Information Network (IABIN) to design a complete ecosystem classification system that will cover both terrestrial and aquatic ecosystems.

From a philosophy of science perspective, ecosystems are not discrete units of nature that simply can be identified using the most 'correct' type of classification approach. In agreement with the definition by Tansley ('mental isolates'), any attempt to delineate or classify ecosystems should be explicit about the observer/analyst input in the classification including its normative rationale.

Two Giant Sequoias, Sequoia National Park. Note the large fire scar at the base of the right-hand tree; fires do not kill the trees but do remove competing thin-barked species, and aid Giant Sequoia regeneration.

Q. 9. Explain the functions and biodiversity of the Ecosystem.

Or

Write a note on the study of Ecosystem.

Ans. From an anthropocentric point of view, some people preceive ecosystems as production units that produce goods and services, such as wood by forest ecosystems and grass for cattle by natural grasslands. Meat from wild animals, often referred to as bush meat in Africa, has proven to be extremely successful under well-controlled management schemes in South Africa and Kenyta. Much less successful has been the discovery and commercialization of substances of wild organism for pharmaceutical purposes. Services derived from ecosystems are referred to as ecosystem services. They may include :

1. Facilitating the enjoyment of nature, which may generate many forms of income and employment in the tourism sector, often referred to as eco-tourisms,
2. Water retention, thus facilitating a more evenly distributed release of waster,
3. Soil protection, open-air laboratory for scientific research, etc.

The side of a tide pool showing sea stars (*Dermasterias*), sea anemones (*Anthopleura*) and sea sponges in Santa Cruz, California.

A greater degree of species or biological diversity—commonly referred to as Biodiversity—of an ecosystem may contribute to greater resilience of an ecosystem, because there are more species present at a location to respond to change and thus 'absorb' or reduce its effects. "Some theories predict that biodiversity will promote ecosystem integrity in changing climates, because high diversity ensures that functional groups will retain at least one species able to tolerate altered condition. This reduces the effect before the ecosystem's structure is fundamentally changed to a different state. One hypothesis about this is the River Poper Hypothesis. According to Paul and Anne Ehrlich "the diversity of life is something like the rivets on an airplane. Each species plays a small but significant role in the working of the whole, and the loss of any rivet weakens the plane by a small but measurable amount. Pop too many rivets and the plane will crash that is, some vital function will collapse." They are saying if too many species die out them some sort of vital function of the ecosystem such as food web would collapse causing the ecosystem to fail. However rivets come in different sizes and have different critical functions in construction, when thinking about species as rivets the variety and distribution in the overall structure is important.

This is not universally the case and there is no proven relationship between the species diversity of an ecosystem and its ability to provide goods and services on a sustainable level : Humid tropical forests produce very few goods and direct services and are extremely vulnerable to change, while many temperate forests readily grow back to their previous state of development within a lifetime after felling or a forest fire. Some grasslands have been sustainably exploited for thousands of years (Mongolia, Africa, European peat and mooreland communities).

THE STUDY OF ECOSYSTEMS

Loch Lomond in Scotland forms a relatively isolated ecosystem. The fish community of this lake has remained unchanged over a very long period of time.

Ecosystem dynamics

Introduction of new elements, whethei biotic or abiotic, into an ecosystem tend to have a disruptive effect. In some cases, this can lead to ecological collapse or 'trophic cascading' and the death of many species within the ecosystem. Under this deterministic vision, the abstract notion of ecological health attempts to measure the robustness and recovery capacity for an ecosystem; *i.e.*, how far the ecosystem is away from its steady state.

Often, however, ecosystems have the ability to rebound from a disruptive agent. The difference between collapse or a gentle rebound is determined by two factors—the toxicity of the introduced element and the resiliency of the original ecosystem.

Ecosystems are primarily governed by stochastic (chance) events, the reactions these events provoke on non-living materials and the responses by organisms to the conditions surrounding them. Thus, an ecosystem results from the sum of individual responses of organisms to stimuli from elements in the environment. The presence or absence of populations merely depends on reproductive and dispersal success, and population levels fluctuate in response to stochastic events. As the number of species in an ecosystem is higher, the number of stimuli is also higher. Since the beginning of life organisms have survived continuous change through natural selection of successful feeding, reproductive and dispersal behaviour. Through natural selection the planet's species have continuously adapted to change through variation in their biological composition and distribution. Mathematically it can be demonstrated that greater numbers of different interacting factors tend to dampen fluctuations in each of the individual factors.

Spiny forest at Ifaty, Madagascar, featuring various Anansonia (baobab) species, Alluaudia procera (Madagascar ocotillo) and other vegetation.

Given the great diversity among organisms on earth, most ecosystems only changed very gradually, as some species would disappear while others would move in. Locally, sub-populations continuously go extinct, to be replaced later through dispersal of other sub-populations. Stochastists do recognize that certain intrinsic regulating mechanisms occur in nature. Feedback and response mechanisms at the species level regulate population levels, most notably through territorial behaviour. Andrewatha and Birch suggest that territorial behaviour tends to keep populations at levels where food supply is not a limiting factor. Hence, stochastists see territorial behaivour as a regulatory mechanism at the species level but not at the ecosystem levle. Thus, in their vision, ecosystems are not regulated by feedback and response mechanisms from the ecosystem itself and there is no such thing as a balance of nature.

If ecosystems are governed primarily by stochastic processes, through which its subsequent state would be determined by both predictable and random actions, they may be more resilient to sudden change than each species individually. In the absence of a balance of nature, the species composition of ecosystems would undergo shifts that would depend on the nature of the change, but entire ecological collapse would probably be infrequent events.

The theoretical ecologist Robert Ulanowicz has used information theory tools to describe the structure of ecosystems, emphasizing mutual information (correlations) in sutdied systems. Drawing on this methodology and prior observations of complex ecosystems, Ulanowicz depicts approaches to determining the stress levels on ecosystems and predicting system reactions to defined types of alteration in their settings (such as increased or reduced energy, flow, and eutrophication).

In addition, Eric Sanderson has developed the Muir web, based on experience on the Mannahatta project. This graphical schematic shows how different species are connected to each other, not only regarding their position in the food chain, but also regarding other services, *i.e.*, provisioning of shelter.

SHORT ANSWER TYPE QUESTIONS

Q. 1. Write a short note on the Specific biospheres.

Ans. SPECIFIC BIOSPHERES

When the word is followed by a number, it is usually referring to a specific system or number. Thus :

- Biosphere 1, the planet Earth
- Biosphere 2, a laboratory in Arizona which contains 3·15 acres (13,000 m^2) of closed ecosystem.
- BIOS-3, a closed ecosystem at the Institute of Biophysics in Krasnoyarsk, Siberia, in what was then the Soviet Union.
- Biosphere J (CEEF, Closed Ecology Experiment Facilities), an experiment in Japan.

Ecosystem ecology

Ecosystem ecology is the integrated study of biotic and abiotic components of ecosystems and their interactions within an ecosystem framework. This science examines how ecosystems work and relates this to their components such as chemicals, bedrock, soil, plants, and animals. Ecosystem ecology examines physical and biological structure and examines how these ecosystem characteristics interact.

Q. 2. Write a note on the Ecosystem services.

Ans. ECOSYSTEM SERVICES

Ecosystem services are "fundamental life-support services upon which human civilization depends," and can be direct or indirect. Examples of direct ecosystem services are : pollination, wood and erosion prevention. Indirect services could be considered climate moderation, nutrient cycles and detoxifying natural substances. The services and goods an ecosystem provides are often undervalued as many of them are without market value. Broad examples include :

- Regulating (climate, floods, nutrient balance, water filtration)
- Provisioning (food, medicine, fur, minerals)
- Cultural (science, spiritual, ceremonial, recreation, aesthetic)
- Supporting (nutrient cycling, photosynthesis, soil formation).

Q. 3. Explain the Biosphere researchers.

Ans. Researchers make direct observations on the biosphere using global remote sensing platforms. Beginning in the 1980s (AVHRR), this effort has evolved into advanced remote sensing systems that can scan the entire surface of the earth at least once each day (MODIS). These observations are now used to quantify the activities of the biosphere, primarily in terms of vegetation cover and function, using spectral indices such as NDVI. Future remote sensing efforts will directly observe global patterns of carbon di-oxide exchange with the biosphere caused by photo-synthesis, respiration and the combustion of biomass and fossil fuels (OCO).

To better understand the biogeochemical cycles of carbon and other elements, and the role of biospheric processes like photosynthesis, respiration and the storage of carbon in soils and vegetation, researchers have developed a variety of global biogeochemical models (e.g. CASA). There are also global models of vegetation patterns across the biosphere that are driven by climate (e.g. LPJ). Modeling plays an especially important role in understanding biospheric patterns and processes because there is only one earth : it is impossible to conduct global experiments on the entire biosphere or complete global processes (though some consider our current use of fossil fuels to be such an experiment). Understanding how humans are altering the biosphere and other earth systems has become a very active area of study, with concerted global efforts originating in the 1970s with the Man and the Biosphere Programme of UNESCO (MAB), which also established a global system of biosphere reserves. Since the late 1980s, international scientific research on the biosphere has been coordinated by the International Geosphere-Biosphere Programme (IGBP).

Q. 4. What is the future of Biosphere ?

Ans. The Biosphere II 'experiments', which were conducted in the early 1990s in Arizona using private funding, enclosed a complex array of plants and animals together with humans in a sealed greenhouse complex which included a large 'ocean'. Within a short time, this 'experimental biosphere' demonstrated how little we understand biosphere I (the biosphere of our planet) : the project failed to replicate the basic biogeochemical functions that support life on Earth. Without resorting to drastic chemical interventions to inject oxygen and reduce toxic levels of carbon di-oxide, it was impossible to support human life in the complex. Moreover, many keystone species, such as pollinators died off within a short time.

Many now see this as a good analogy for the current changes in atmospheric composition we are causing by rapidly burning off the fossil carbon captured by plants over millions of years, and by our conversion of forests to croplands. By releasing carbon stored by the biosphere over geologic time back to the atmosphere at unprecedented rates, humans are causing rapid global warming, and this warming is further altering global biogeochemical cycles and patterns of biodiversity across the biosphere. Anthropogenic climate change together with land use change and other anthropogenic alterations of the biosphere and other spheres have now reached such a high level that some earth scientist are now calling for the recognition that we have now entered a new, human-dominated, geologic era : the anthropocene.

Clearly, we are in need of greater understanding of how to better manage our one and only biosphere for the long-term benefit of ourselves and all other organisms.

Q. 5. Write a short note on the Anthropogenic biomes.

Ans. ANTHROPOGENIC BIOMES

Humans have fundamentally altered global patterns of biodiversity and ecosystem processes. As a result, vegetation forms predicted by conventional biome systems are rarely observed across most of Earth's land surface. Anthropogenic biomes provide an alternative view of the terrestrial biosphere based on global patterns of sustained direct human interaction with ecosystems, including agriculture, human settlements, urbanization, forestry and other uses of land. Anthropogenic biomes offer a new way forward in ecology and conservation by recognizing the irreversible coupling of human and ecological systems at global scales and moving us toward an understanding how best to live in and manage our biosphere and the anthropogenic biosphere we live in. The main biomes in the world are freshwater, marine, coniferous, deciduous, ice, mountains, boreal, grasslands, tundra, and rainforests.

Major anthropogenic biomes

- Dense settlements
- Villages
- Croplands
- Rangelands
- Forested.

Q. 6. Write a note on the Earth's biosphere.

Ans. The biosphere is all life on our planet. This includes all the things that are living as well as the remains of those that have died but have not yet decomposed. The biosphere includes life on land and in the oceans—multitudes of plants, animals, fungi, protists, and bacteria.

Have you heard the expression carbon-based life forms ? The living things on our planet are called carbon-based because most of the molecules in them are chains of carbon atoms linked together. These carbon chains really add up when you consider the total amount of life on the planet. Add it all up and the life on our planet contains approximately 1900 gigatons of carbon. That's heaver than 116 billion school buses.

The biosphere has a great impact on the climate because the biosphere is closely connected to the atmosphere. When plants harness the Sun's energy through photosynthesis, oxygen is released into the atmosphere and carbon di-oxide is taken out. When plants and animals respire, carbon di-oxide gas is added to the atmosphere and oxygen is taken out. Microbes living in soils can add nitrous oxide gas to the atmosphere. As humans burn components of the biosphere such as fossil fuels, forests and fields, greenhouse gases such as carbon di-oxide and nitrous oxide are released in the atmosphere.

OBJECTIVE TYPE QUESTIONS

1. Pedology is concerned with the study of :

(a) Nature (b) Goal
(c) Soils (d) Atmosphere. **Ans.** (c)

2. Geosynclines are divided into how many parts ?

(a) Miogeosynclines (b) Eugeosynclines
(c) 'a' and 'b' both (d) None of the above. **Ans.** (c)

3. The eugeosynclines often contain exotic :

(a) Flysch (b) Melange
(c) Both sediments (d) None of the above. **Ans.** (c)

4. The geosyncline concept was first developed by the American geologists :

(a) James Wali (b) James Dwight Dana
(c) 'a' and 'b' both (d) None of the above. **Ans.** (c)

5. Oceanic lithosphere consists mainly of :

(a) Mafic crust (b) Ultramafic mantle
(c) 'a' and 'b' both (d) None of the above. **Ans.** (c)

6. The......are defined by whether the atmospheric gases are well mixed.

(a) homosphere (b) heterosphere
(c) 'a' and 'b' both (d) None of the above. **Ans.** (c)

7. Water related sediments have been found dating from as early as......billion years ago.

(a) 3·8 (b) 3·10
(c) 3·9 (d) 3·7. **Ans.** (a)

8. Energy is transferred between the Earth's surface and the atmosphere via :

(a) Conduction (b) Convection
(c) Radiation (d) All the above. **Ans.** (d)

9. Stratospheric ozone depetion is believed to be caused by :

(a) Air pollution (b) Water pollution
(c) Noise pollution (d) Land pollution. **Ans.** (a)

10. Earth's atmosphere is :

(a) 78% Nitrogen (b) 21% Oxygen
(c) 1% other gases (d) All the above. **Ans.** (d)

11. The atmosphere is divided into......layers.

(a) four (b) five
(c) six (d) eight. **Ans.** (b)

12. The stratosphere extends from the tropopause up to......above the Earth's surface.

(a) 31 miles (b) 32 miles
(c) 38 miles (d) 36 miles. **Ans.** (a)

13. The thermosphere extends from the mesopause to......above the Earth.

(a) 230 miles (b) 430 miles
(c) 330 miles (d) 420 miles. **Ans.** (b)

14. ......decrease in the atmosphere as height increases.

(a) Air pressure (b) Density
(c) 'a' and 'b' both (d) None of the above. **Ans.** (c)

15. Air is the name given to atmosphere used in :

(a) Breathing (b) Photosynthesis
(c) 'a' and 'b' both (d) None of the above. **Ans.** (c)

16. The general term 'isostacy' was coined in......by the American geologist Clarence Dutton.

(a) 1889 (b) 1884
(c) 1996 (d) 1887. **Ans.** (a)

17. In geology......is a naturally occurring solid aggregate of minerals and/or mineraloids.

(a) Rock (b) Stone
(c) 'a' and 'b' both (d) None of the above. **Ans.** (c)

18. ......rocks are formed by subjecting any rock type to different temperature and pressure conditions than those in which the original rock was formed.

(a) Sedimentary rocks (b) Metamorphic rocks
(c) Igneous rocks (d) None of the above. **Ans.** (b)

19. Igneous rocks are formed when molten magma cools and are divided into......main categories.

(a) two (b) three
(c) four (d) five. **Ans.** (a)

20. Today, the field of geomorphology encompasses a very wide range of different :

(a) Approaches (b) Interests
(c) 'a' and 'b' both (d) None of the above. **Ans.** (c)

21. There are about......known minerals on the Earth.

(a) 3000 (b) 4000
(c) 5000 (d) 6000. **Ans.** (a)

22. The prehistory and history of civilization is classified into the :

(a) Stone Age (b) Bronze Age
(c) Iron Age (d) All the above. **Ans.** (d)

23. Erosion is measured and further understood using tools such as the :

(a) Micro-erosion meter (MEM)

(b) Traversing micro-erosion meter (TMEM)

(c) 'a' and 'b' both

(d) None of the above. Ans. (c)

24. ......gases make up the bulk of the Earth's atmosphere.

(a) Two (b) Three

(c) Four (d) Six. Ans. (a)

25. The thermosphere extends from......above the Earth's surface to outer space.

(a) 60 km (b) 70 km

(c) 80 km (d) 50 km. Ans. (c)

26. A device used to measure humidity is called a psychrometer or :

(a) Hygrometer (b) Thermostat

(c) Thermometer (d) None of the above. Ans. (a)

27. Humidity depends on :

(a) Water vaporization (b) Condensation

(c) 'a' and 'b' both (d) None of the above. Ans. (c)

28. Humans control their body temperature mainly by :

(a) Sweating (b) Shivering

(c) 'a' and 'b' both (d) None of the above. Ans. (c)

29. December to March are the......months.

(a) coolest month (b) driest month

(c) easiest month (d) rainy month. Ans. (b)

30. Humid subtropical regions are subject to pronounced :

(a) Dry winter (b) Summer

(c) Rainy seasons (d) None of the above. Ans. (a)

31. India's northernmost areas are subject to a :

(a) Nonteme (b) Alpine

(c) Climate (d) All the above. Ans. (d)

32. ......season lasting from June to September.

(a) Monsoon (b) Rainy season

(c) 'a' and 'b' both (d) None of the above. Ans. (c)

33. A fictitious synoptic chart of an extratropical-cyclone affecting the :

(a) U.K. (b) Ireland

(c) 'a' and 'b' both (d) None of the above. Ans. (c)

34. The atmosphere is an evolutionary agent essential to the :
(a) Morphology of a planet (b) Morphology of a star
(c) Morphology of a moon (d) None of the above. **Ans.** (a)

35. The......is the uppermost layer of Earth's atmosphere.
(a) lethosphere (b) biosphere
(c) hydrosphere (d) exosphere. **Ans.** (d)

36. The Ocean is an experimental metal band from :
(a) Berlin (b) Germany
(c) 'a' and 'b' both (d) None of the above. **Ans.** (c)

37. The changing distance separating the......and......also affects tide heights :
(a) Moon (b) Earth
(c) 'a' and 'b' both (d) None of the above. **Ans.** (c)

38. There are how many velocities that are associated with waves, the ?
(a) Phase velocity (b) Group velocity
(c) 'a' and 'b' both (d) None of the above. **Ans.** (c)

39. ......are the most common natural disaster in India.
(a) Floods (b) Monsoon
(c) Tides (d) All the above. **Ans.** (a)

40. Day length has increased by about......in the last 600 million years.
(a) 3 hours (b) 4 hours
(c) 5 hours (d) 2 hours. **Ans.** (d)

41. A familiar scene on Earth which simultaneously shows the ?
(a) Lithosphere (b) Hydrosphere
(c) Atmosphere (d) All the above. **Ans.** (d)

42. The term 'biosphere' was coined by geologist Edward Suess in :
(a) 1875 (b) 1874
(c) 1876 (d) 1877. **Ans.** (a)

43. The term ecosystem was coined in......by Roy Clapham.
(a) 1920 (b) 1925
(c) 1930 (d) 1924. **Ans.** (c)

44. A fundamental classification of biomes is :
(a) Terrestrial biomes (b) Freshwater biomes
(c) Marine biomes (d) All the above. **Ans.** (d)

45. Humans have fundamentally altered global patterns of :
(a) Biodiversity (b) Ecosystem processes
(c) 'a' and 'b' both (d) None of the above. **Ans.** (c)

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