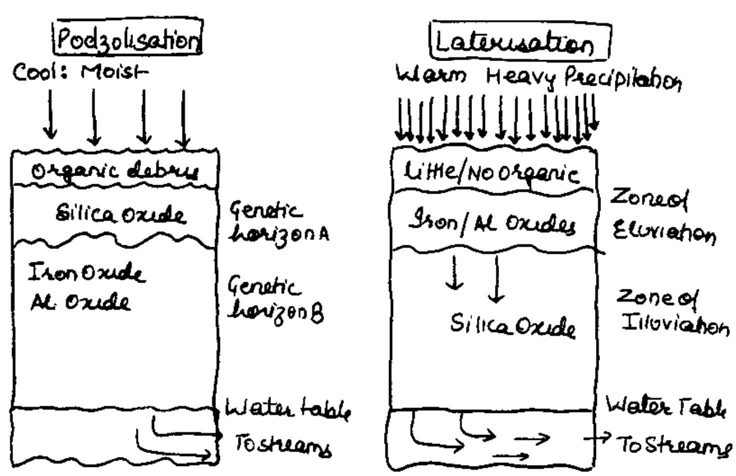
Que. 1 Explain soil regimes of global and local importance.

Ans. 1 Soils begin to develop when either rocks or deposits of loose material are colonized by simple plant and animal life. Once the organic processes of life and death begin to take place among mineral particles or disintegrated rock, differences begin to develop from the surface down through the soil parent material. This vertical differentiation comes about originally from such simple factors as the gradual accumulation of organic matter at the surface and the removal of fine particles and dissolved matter from the top layers by water percolating downward, followed by the deposition of these materials at a lower level.

As climate, vegetation, animal life, and steepness of slope affect soil formation over time, this vertical differentiation becomes more and more apparent. Often, especially in middle latitudes, fully developed soils exhibit a vertical zonation into distinct layers or **horizons** that are distinguished by their different physical and chemical properties.

Regimes of global Importance there are infinite possible combinations of the factors that function together to produce soils of all descriptions. Nevertheless, an examination of the world's soils reveals that they can be separated into a limited number of general types. The characteristics that differentiate these major types can be attributed to their soil-forming regimes, each resulting from a combination of different processes. The differences between these soil-forming regimes are primarily the result of climatic differences and indirectly the result of differences in plant cover.

At the broadest generalization, there are three primary soil-forming regimes that relate to climatic differences. These are **laterization, podzolization and calcification**. On a local scale, other processes become important but they are of lesser significance in world-wide distribution of soils. Soils may be formed by any one of these processes or by a combination of two or more, primarily depending on the climate but also on surface configuration, vegetation and parent material.



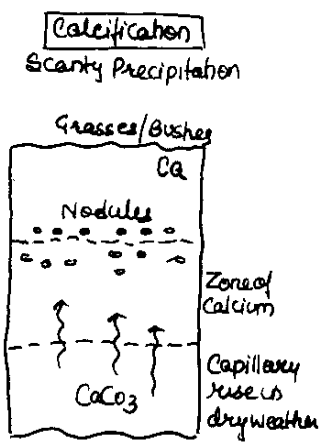
1. Laterization

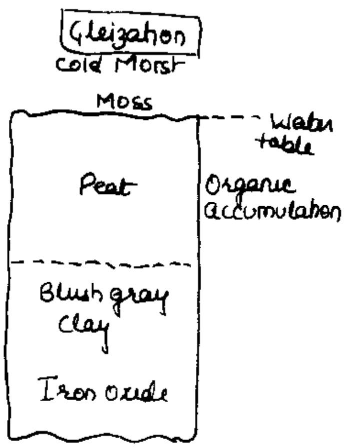
Laterization is a soil-forming process that occurs in humid tropical and subtropical climates as a result of the high temperatures and abundant precipitation. These effects produce rapid breakdown of rocks and decomposition of nearly all minerals. Despite the dense vegetation that is typical of these climates, little humus is incorporated into the soil because of the rapid decomposition of plant litter and enormous numbers of microorganisms in the soil. Because of the abundance of moisture, eluviation and leaching of all but iron and aluminum oxides play dominant roles in the formation of humid tropical soil.

2. Podzolization This occurs in its purest form in the high middle latitudes, where the climate is moist with short, cool summers and long, severe winters. The typical coniferous forest of this climate is an integral part of the process of podzolizaion. Podzolization can take place beyond the typical cold, moist climate when the parent material is highly acidic, as on the sands common along the east coast of the United States. The pine forests that can grow in such acidic conditions return acids to the soil, promoting the process of podzolization.

3. Calcification

The third distinctive soil-forming process is called **calcification.** In contrast to both laterization and podzolization, which require humid climates, calcification demands climates where evapotranspiration exceeds precipitation. In areas of low precipitation, the air is often loaded with alkali dusts such as calcium carbonate (CaCO3). When calm conditions prevail or when it rains, the dust settles across the landscape and accumulates in the soil. The rainfall is just sufficient to translocate these materials to the B horizon of soils. Over hundreds to thousands of years, the CaCO3-enriched dust concentrates in the B horizons of soils, forming hard layers of caliches or the much thicker calcretes. These accumulations can be enhanced by the upward (capillary) movement of dissolved alkaline salts in groundwater when the water table is near the surface.





Regimes of Local Importance

Two additional soil-forming processes are important enough to merit consideration. Both are characteristic of areas with locally poor drainage, although they occur under strikingly different climatic conditions.

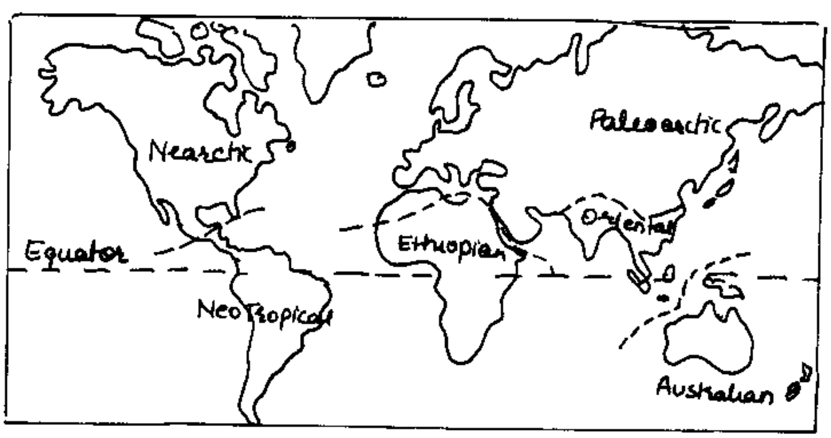
The first, **salinization,** occurs in stream valleys, interior basins, or other low lying areas in desert regions that have high groundwater tables. The high groundwater can be the result of adjacent mountain ranges or stream flow originating outside a desert region, but increasingly it is the result of extensive irrigation. Rapid evaporation of this water leaves behind the high concentration of soluble salts in the soil that characterizes the soil-forming regime and gradually destroys the agricultural productivity of the area. An extreme example of salinization is the fertile crescent of Mesopotamia (Iraq), where thousands of years of irrigated agriculture in the desert has led to soils too salty to cultivate today.

The second, **gleization,** occurs in poorly drained areas under cold and wet environmental conditions. This process is usually associated with peat bogs, where the soil is an accumulation of humus layers overlying a blue-gray layer of thick, gummy, water-saturated clay. (Unreduced iron in the early stages of decomposition imparts the blue-gray color to the soil). In formerly glaciated, poorly drained regions such as northern Russia, Ireland, Scotland, and Scandinavia, the peat has long been harvested and used as an important source of energy.

Que. 2 Give an account of world distribution of land animals.

Ans. 2 Zoo geography deals with the geographic distribution of animals. The world is divided into a number of zoo-geographic or faunal regions. According to **Wallace** (1876), the following zoo-geographic regions of the world may be observed:

(i)**Palaerctic region:** This largest region includes whole of Europe, northern China, Japan, Soviet Russia, northern part of Africa and Persia, etc. It is subdivided into Europeans, Mediterranean, Siberian and Manchurian sub regions. Fauna is represented by 135 families of terrestrial vertebrates (33 mammals, 68 of birds, 24 of reptiles, 10 of amphibians and fishes).



ii)**Ethiopian region:** This includes whole of Africa and Arabia, Madagascar and Mauritius. The fauna is much varied, resented by about 161 families of terres trial vertebrates; of which 30 are endemic to this region which include such mammals as aye-aye, golden moles, mole rates, jumping hares, African flying squirrels,giraffes etc. this region is divided into east African, west African, south African and Malagasy sub-regions.

iii) **Oriental region**: This region includes all the tropical parts of Asia, like India, Sri Lanka,south China, Malaysia and Malayan islands located to the western side of Wallace's line, i.e. Java, Sumatra, Philippines, Borneo, Bali, etc. Climatic conditions of this region are much varied being desert in the north of Indian sub-region, tropical in southern portion of India and Sri Lanka, and temperate in Bhutan and Yang-tse-kiang. Major part of the region is occupied by luxuriant forest vegetation. The terrestrial verte brates are represented by about 153 families of which 10 are peculiar to the region, which include four mammals, one bird and five reptiles.

Oriental region is divided into the following four sub regions:

- **Indian sub region:** It includes whole of India from the Himalayan slopes to Cape Comorin.
- **Ceylonese sub region**: It comprises the island of Sri Lanka, whose physical characteristics are more or less similar to those of southern mountains of India.
- **Indo-Chinese region:** It includes China, south of Palaearctic boundary, Burma, Thailand and islands of Andaman, Formosa and Hainan.
- **Indo-Malayan sub region:** It includes the Malayan Peninsula and islands of Malayan Archipelago, i.e. Borneo, Java, Sumatra, Nicobar, etc.

(iv) Australian region: This includes the whole of Australian, New Zealand, New Guinea and adjoining islands, particularly those of Pacific Ocean. The oriental and Australian regions are separated from each other by an imaginary line, **Wallace's line**, that is supposed to run between the islands of Bali and Lombok. In various parts, the climate is of temperate as well as tropical type. The fauna is represented by 134 families of terrestrial vertebrates of which 30 are specific to the region including 8 families or mammals, 17 of birds, 3 of reptiles and 2 of amphibians. Among the mammals, all belong to Monotremta and marsupialia, placental ones being altogether absent.

(v) Neotropical region: It comprises southern Mexico, Central and South America, West Indies and Galapagos islands. It is a tropical region with luxuriant forests. The fauna is represented by155 families of terrestrial vertebrates of which 39 are peculiar to the region. These include 10 mammals, 23 birds, 2 reptiles and 4 amphibians. This region is divided into Chilean, Brazilian, Mexican and Artillian sub regions.

(vi) Neoarctic region: It comprises Greenland and North America up to the centre of Mexico. In the west, there are many large lakes and island seas. The terrestrial vertebrates are about 120, or which 26 are mammals, 59 birds, 21 reptiles and amphibians. Of these, 5 are peculiar, such as Haplodontidae and prong-buck among mammals the wren-tits among birds. Anillidae among reptiles and the Sirededae among amphibians. This region is divided into Californian, Rocky Mountain, Alleghany and Canadian sub regions.

Que. 3 Briefly explain the limits of tolerance.

Ans. 3 Ecology at the organism level is essentially physiological ecology which tries to understand how different organisms are adapted to their environments in terms of not only survival but also reproduction. *The key elements that lead to much variation in the physical and chemical conditions of different habitats* are temperature, water, light and soil(abiotic) and also – pathogens, parasites, predators and competitors – of the organism with which they interacts constantly(biotic components).Every living organism has limits to the environmental conditions it can endure Environmental factors must be within appropriate levels for life to persist.These factors are primarily responsible for determining the growth and/or reproduction of an organism or population. It may be a physical factor such as temperature or light, a chemical factor such as particular nutrient, or a biological factor such as a competing species. The limiting factor may differ at different times and places.

The Law of Limiting factors states that too much or too little of any abiotic factor can limit or prevent growth of a population of a species in an ecosystem. Examples of limiting factors of a population growth

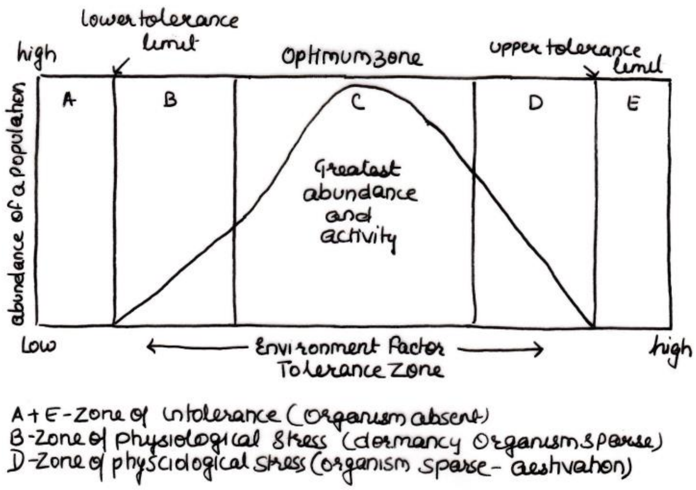
Terrestrial Ecosystem	**Marine Ecosystem**
1. Temperature	1. Salinity
2. Water	2. Temperature
3. Moisture	3. Sunlight
4. Soil nutrients	4. Dissolved Oxygen

Optimum, Zones of Stress, and Limits of Tolerance – In any study of ecology, a primary observation is that different species thrive under different conditions. This principle applies to all living things, both plants and animals. Some survive in warmth; others do best in cooler situations.

Some tolerate freezing; others do not. Some require bright sun; others do best in share. Aquatic systems are divided into fresh and salt water, each with its respective fish and other organisms.

Laboratory experiments clearly bear out the fact that different species are best adapted to different conditions. Organisms can be grown under controlled conditions where one factor is varied while other factors are held constant. Such experiments demonstrate that for every factor there is an **optimum**, a certain level at which the organisms do best. At higher or lower levels the organisms do less well, and at further extremes they may not be able to survive at all.

The point at which the best response occurs is called the optimum, but since this often occurs over a range of several degrees, it is common to speak of an optimal range. The entire span that allows any growth at all is called the **range of tolerance**. The points at the high and low ends of the range of tolerance are called the **limits of tolerance**. Between the optimal range and the high or low limit of tolerance, there are **zones of stress**. That, as the factor is raised or lowered from the optimal range, the organisms experience increasing stress, until, at either limit of tolerance, they cannot survive.



Of course, not every species has been tested for every factor; however, the consistence of such observations leads us to conclude that the following is a fundamental biological principle: ***Every species (both plant and animal) has an optimum range, zones of stress, and limits of tolerance with respect to every abiotic factor*.**

This line of experimentation also demonstrates that different species vary in characteristics with respect to the values at which the optimum and limits of tolerance occur. For instance, what may be an optimal amount of water for one species may stress a second and result in the death of a third. Some plants cannot tolerate any freezing temperatures, others can tolerate slight but not intense freezing, and some actually require several weeks of freezing temperatures in order to complete their life cycles. Also, some species have a very broad range of tolerance, whereas others have a much narrower range. While optimums and limits of tolerance may differ from one species to another, there may be great overlap in their ranges of tolerance.

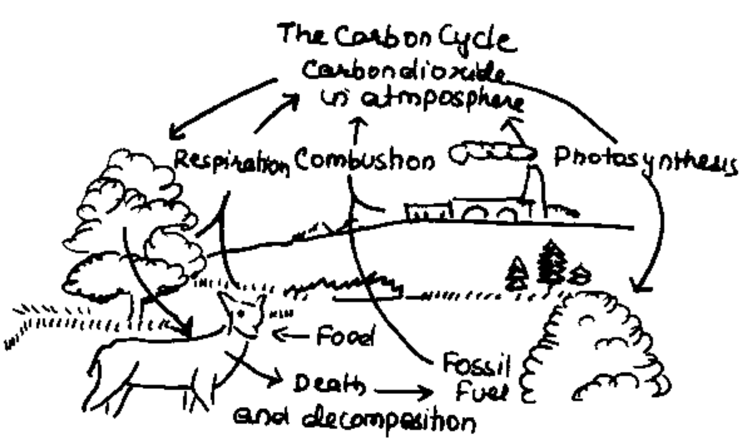
The concept of a range of tolerance does not just affect the growth of individuals; in so far as the health and vigor of individuals affect reproduction and survival of the next generation, the population is also influenced. That is, the population density (individuals per unit area) of a species will be greatest where all conditions are optimal, and population density will decrease as any one or more conditions depart from the optimum.

Que. 4 Write note on types of Nutrient Cycling.

Ans. 4 Looking at the various inputs and outputs of producers, consumers, detritus feeders, and decomposers, proves that they fit together. The products and byproducts of each group are the food and/or essential nutrients for the other. Specifically, the organic material and oxygen produced by green plants are the food and oxygen required by consumers and other heterotrophs. In turn, the carbon dioxide and other wastes generated when heterotrophs break down their food are exactly the nutrients needed by green plants.

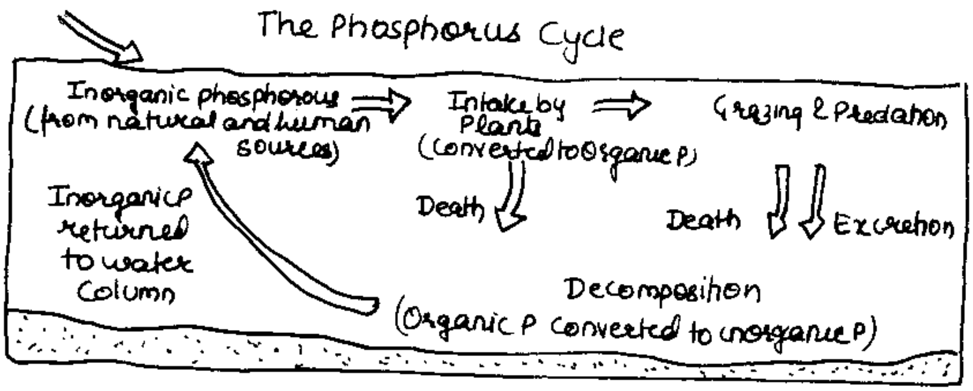
Such recycling is fundamental, for two reasons: (a) It prevents wastes, which would cause problems, from accumulating, (b) It assures that the ecosystem will not run out of essential elements. Important nutrient cycles are:

The Carbon Cycle – For descriptive purposes, it is convenient to start the carbon cycle with the 'reservoir' of carbon dioxide molecules present in the air and dissolved in water. Through photosynthesis and further metabolism, carbon atoms from carbon dioxide become the carbon atoms of all the organic molecules making up the plant's body. Through food chains, the carbon atoms then move into and become part of the tissues of all the other organisms in the ecosystem. However, it is unlikely that a particular carbon atom will be passed through many organisms in any one cycle, because at each step there is a considerable change that the consumer will break down the organic molecule in cell respiration. As this occurs, the carbon atoms are released back to the environment in molecules of carbon dioxide, which completes one cycle, but, of course, starts another. Likewise, burning organic material returns the carbon atoms locked up in the material to the air in carbon dioxide molecules.



No two successive cycles of a particular carbon atom are likely to be the same. Nor are the two cycles likely to be within the same ecosystem, because carbon in the atmosphere will be carried around the globe by wind. By calculating the total amount of carbon dioxide in the atmosphere and the amount of primary production (photosynthesis) occurring in the biosphere, scientists have concluded that about a third of the total atmospheric carbon dioxide is taken up in photosynthesis in a year, but an equal amount is returned to the atmosphere through cell respiration. This means that, on the average, a carbon atom makes a cycle from the atmosphere through one or more living things and back to the atmosphere every three years.

The Phosphorus Cycle – The phosphorus cycle is representative of the cycles for all the mineral nutrients – those required elements that have their origin in rock and soil minerals. We focus on phosphorus for both simplicity and because its shortage tends to be a limiting factor in a number of ecosystems.



Phosphorus exists in various rock and soil minerals as the inorganic ion phosphate. As rock gradually breaks down, phosphate and other ions are released. Phosphate dissolves in water, but does not enter the air. Plants absorb phosphate from the soil or from a water solution, and when it is bonded into organic compounds by the plant, it is referred to as **organic phosphate**. Moving through food chains, organic phosphate is transferred from producers to the rest of the ecosystem. As with carbon, at each step there is a high likelihood that the organic compounds containing phosphate will be broken down in cell respiration, releasing inorganic phosphate in urine or other waste. The phosphate may then be reabsorbed by plants to start another cycle.

There is an important difference between the carbon cycle and the phosphorus cycle. No matter where carbon dioxide is released, it will mix into and maintain the concentration of carbon dioxide in the air. Phosphate, however, which does not have a gas phase, is recycled only if the wastes containing it are deposited on the soil from which it came. The same holds true for other mineral nutrients. Of course, in natural ecosystems wastes (urine, detritus) are deposited in the same area so that recycling occurs efficiently. Humans have been extremely prone to interrupt this cycle, however.

A very serious case of humans disrupting the phosphorus cycle is the cutting of tropical rain forests. This type of ecosystem is supported by a virtually 100 percent-efficient recycling of nutrients. There are little or no reserves of nutrients in the soil. When the forest is cut and burned, the nutrients that were stored in the organisms and detritus are readily washed away by the heavy rains, and the land is thus rendered unproductive. Another human effect on the cycle is that much phosphate from agricultural crop lands makes its way into waterways – either directly, in runoff from the crop lands, or indirectly, in sewage effluents. Because there is essentially no return of phosphate from water to soil, this addition results in over-fertilization of bodies of water, which in turn leads to a severe pollution problem known as eutrophication. Meanwhile, the lost phosphorus must be replaced on the crop lands by mining phosphate rock – a process that will ultimately result in depletion of the phosphate.

When humans use manure, compost (rotted plant wastes), or sewage sludge on crops, lawns, or gardens, the foregoing natural cycle is duplicated. But in too many cases it is not, and the applied chemical fertilizers end up being leached (carried by water seepage) into waterways, resulting in eutrophication.

The Nitrogen Cycle – The nitrogen cycle is unique; it has aspects of both the carbon cycle and the phosphorus cycle. The main reservoir of nitrogen is the air, which is about 78% nitrogen gas (N2). Plants and animals cannot utilize nitrogen gas directly from the air. Instead, the nitrogen must be in mineral form, such as ammonium ions (NH4+), or nitrate ions (NO3-). A number of bacteria and cyanobacteria (bacteria that contain chlorophyll; formerly referred to as blue-green algae) can convert nitrogen gas to the ammonium form, a process called **biological nitrogen fixation**. For terrestrial ecosystems, the most important among these nitrogen-fixing organisms is a bacterium called Rhizogium, which lives in nodules on the roots of legumes, the plant family that includes peas and beans. This is another example of mutualistic symbiosis: The legume provides the bacteria with a place to live and with food (sugar), and gains a source of nitrogen in return.

From the legumes, nitrogen is passed down whatever food chains exist. At each step, as we have observed before, the nitrogen-containing compounds may be broken down in cell respiration. As this occurs, nitrogen-compounds are returned to the soil with excrements and may be absorbed by other plants. Thus, after it is fixed, nitrogen may be recycled in a manner similar to phosphorus and other mineral nutrients. However, nitrogen does not remain in this 'mineral phase' of the cycle indefinitely. Other kinds of bacteria in the soil gradually change the nitrogen compounds back to nitrogen gas. Consequently, nitrogen will not accumulate in the soil. Additionally, some nitrogen gas may enter the cycle by being converted to the ammonium form by discharges of lightning in a process known as atmospheric nitrogen fixation and by coming down with rainfall. This pathway is estimated to be only about 10 percent of the biological pathway.

All natural ecosystems, depend on nitrogen-fixing organisms; legumes, with their symbiotic bacteria are, by far, the most important. The legume family includes a huge diversity of plants, ranging from clovers (common in grasslands) through desert shrubs to many trees. Every major terrestrial ecosystem, from tropical rain forest to desert and tundra, has its representative legume species, and legumes are generally the first plants to re-colonize a burned –over area. Without them, all production would be sharply impaired because of lack of available nitrogen – precluding the formation of proteins, nucleic acids, and other building blocks of life.

Que. 5 Discuss the range of benthic resources.

Ans. 5 Physical resources result from the deposition, precipitation, or accumulation of useful substances in the ocean or seabed. Most physical resources are mineral deposits, but petroleum and natural gas, mostly remnants of once-living organisms, are included in this category. Fresh water obtained from the ocean is also a physical resource.

Petroleum and Natural Gas About 32% of the crude oil and 24% of the natural gas produced came from the seabed. About a third of known world reserves of oil and natural gas lie along the continental margins. Oil is a complex chemical soup containing perhaps a thousand compounds, mostly hydrocarbons. Petroleum is almost always associated with marine sediments, suggesting that the organic substances from which it was formed were once marine.Oil is less dense than the surrounding sediments, so it can migrate from its source rock through porous overlying formations. It collects in the pre spaces of reservoir rocks when an impermeable overlying layer prevents further upward migration of the oil. Drilling for oil offshore is far more costly than drilling on land because special drilling equipment and transport systems are required. Most marine oil deposits are trapped from offshore platforms resting in water less than 100 meters.

Methane Hydrate The largest known reservoir of hydrocarbons on Earth is not coal or oil, but methane-laced ice crystals – methane hydrate – in the sediments of some continental slopes. Little is known about their formation, but methane hydrates exist in thin layers 200 to 500 meters below the seafloor, where they are stable and long-lived. When brought to the warm, low-pressure conditions at the ocean surface, the sediment fizzes vigorously as the methane escapes. It burns vigorously if ignited. Though abundant, exploitation of this resource would be very costly and dangerous. Even if engineers could bring the sediment to the surface before the methane disappeared, extracting the methane from the sediment and liquefying it for efficient use would be prohibitively expensive.

Sand and Gravel Sand and gravel are not very glamorous marine resources, but they are second in dollar value only to oil and natural gas. Only about 1% of the world's total sand and gravel production is scraped and dredged from continental shelves each year, but the seafloor supplies about 20% of the sand and gravel used in the island nations of Japan and the United Kingdom. The world's largest single mining operation is the extraction of aragonite sand at Ocean Cay in the

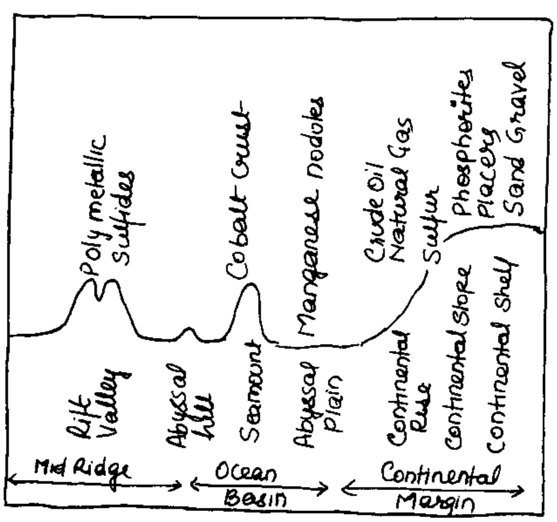
Bahamas. Sand is suction-dredged onto an artificial island and then shipped on specially designed vessels. This sand, about 97% calcium carbonate, is used in Portland cement, glass, and animal feed supplements and in the reduction of soil acidity.

Magnesium and Magnesium Compounds Magnesium, the third most abundant dissolved element, precipitates from seawater, mainly in the form of magnesium chloride (MgCl2) and magnesium sulfate (MgSO4) salts. Magnesium metal (a strong, lightweight material used in aircraft and structural applications) can be extracted by chemical and electrical means from a concentrated brine of these salts. Worldwide, about half the production of metallic magnesium is derived from seawater.

Magnesium compounds are also valuable. Magnesium salts are used in chemical processes, in foods and medicines, as soil conditioners, and in the lining of high-temperature furnaces.

Salts The ocean's salinity varies from about 3.3% to 3.7% by weight. When seawater evaporates, the remaining major constituent ions combine to form various salts, including calcium carbonate (CaCO3), gypsum (CaSO4), table salt (NaCl), and a complex mixture of magnesium and potassium salts. Table salt makes up slightly more than 78% of the total salt residue.

Seawater is evaporated in large salt ponds in arid parts of the world. Operators can segregate the various salts from one another by shifting the residual brine from pond to pond at just the right time during the evaporation process. The magnesium salts are used as a source of magnesium metal and magnesium compounds. The potassium salts are processed into chemicals and fertilizers. Bromine (a useful component of certain medicines, chemical processes, and antiknock gasoline) is also extracted from the residue. Gypsum is an important component of wallboard and other building materials. About a third of the world's table salt is currently produced from seawater by evaporation. Manganese Nodules Manganese nodules are the rounded black objects that litter the abyssal plants, particularly in the pacific. These slow-growing lumps were first seen in the bottom samples taken by scientists aboard HMS Challenger in 1874. The iron, manganese, copper, nickel, and cobalt content of the nodules makes them particularly attractive to industrial nations lacking onshore sources of thee crucial materials.



Manganese nodules have been dredged from the seabed in small-scale trials. Various recovery schemes have been proposed, including a system resembling a vacuum cleaner, but the difficulties of collecting large numbers of nodules from abyssal depths in excess of 4,000 meters have rendered these plans uneconomical – at least until prices for manganese, copper, and nickel rise as the terrestrial sources are consumed.

Phosphorite Deposits Also discovered the Challenger Expedition were irregular chunks of phosphorite, first collected from the continental rise off South Africa. Sedimentary phoshorite deposits, from which industrial chemicals and phosphate-rich agricultural fertilizers can be made, formed from the decaying remains of marine organisms that lived in areas of extensive upwelling. The richest deposits occur at depths between 30 and 300 meters. Post-Challenger investigations have revealed rich deposits of this important material off the coasts of Florida, California, western South America, and western Africa. Even though phosphorite deposits occur in much shallower water than manganese nodules do, the cost of recovering the resource from the ocean greatly exceeds that of recovery from land.

Metallic Sulfides and Muds The recent discovery of metal-rich sulfides around hydrothermal vents has spurred interest among economists as well as oceanographers. Heated seawater carrying large quantities of metals and sulfur leached from the newly formed crust pours out through vents and fractures. The metals – mainly zinc, iron, copper, lead, silver, and cadmium – combine with the sulfur and precipitate from the cooler surrounding water as mounds, coatings and chimneys. While these deposits are certainly commercial-grade ores, they are neither large nor extensive. Also, they are subject to solution and oxidation on the seafloor and are not likely to be preserved in thick layers for long periods of time.

Que. 6 How many types of animal dispersals are identified?

Ans. 6 Dispersal of Animals Dispersal of animals may be defined as the spreading of animals from the places of their origin to other areas. Dispersal is a **three-stage process,** encompassing

- decision making in terms of departure,
- displacement and
- Settlement.

The social dominance hypothesis predicts emigration of individuals in an inferior physiological state

Factors of Animal Dispersal The spread and dispersal of animals is controlled by two factors:

1. **Physical environment:** Distribution of land and water and topography affect the dispersal of animals to a great extent. Terrestrial animals cannot swim, as such; water poses a great barrier to their dispersal. Saline oceanic water is harmful for fresh water animals. High mountains, widespread deserts, swamps, deep valleys, etc. also obstruct the dispersal of animals. Unfavorable climate and distance factor also affect the dispersal of animals in a great way.

2. **Innate ability:** Qualities of animals e.g. creeping, crawling, hopping, leaping, climbing, digging, borrowing, swimming, flying, etc. enable animals to move and migrate. These qualities of animals determine the type nature and rate of dispersal and migration. When animals become mobile and move out from their places motivated and stimulated by their innate qualities, the resultant dispersal is called "active dispersal'.

Mesosaurs (a Permain reptile), Glossopteris (Permain plant) and Cynognathus (a Late Triassic reptile) originated in South America, from where Cynognathus and Mesosaurs migrated to Africa, while Glossopteris plants migrated to Africa, Antarctica, India and Australia. Lystrosaurs (Late Triassic reptile) was originated in Africa from where it was dispersed to India and Australia.

Dear, saiga, sheep, bison, musk ox, mastodon, mammoths and man migrated from Asia to North America via Bering Bridge, while beavers, opossum, raccoon, horse, etc. migrated from North America to Asia (via the same bridge). Raccoons, cats, horses, tapirs, llamas, camels, etc. migrated from North America to South America via Central American Bridge, whereas capybaras, porcupines, armadillos, glyptodonts, ground sloths etc. were dispersed from South America to North America via Central American Bridge, Butterflies, moths, beetles, grasshoppers, locusts, bugs etc. were dispersed from Africa to Europe and Asia, whereas these animals were transported to South America by ships.

Dispersal may be of the following types:

Gradual dispersal: It involves longer period of time and very slow rate of migration. However, such dispersal covers large areas and results in widespread distribution of animals over time.
Rapid dispersal. It involves mass exodus of animals from one area to another. Such dispersal may not be a permanent one as they may not be allowed by man or local environmental conditions to settle down in new habitats. Such dispersal involves certain animals only, e.g. locusts, lemmings, butterflies, moths, dragonflies, etc.
Seasonal dispersal: It involves the migration of those animals which leave their habitat due to seasonal extreme weather conditions every year and migrate to areas of favourable weather conditions. These migratory animals and birds return to their native places when conditions become

favourable. Migration of Arctic birds during winter to sub-tropical and tropical areas and the return to their native places next summer season proves this fact. Some of the Greenland wheatears birds fly directly to Spain covering a distance of 3200 km. Similarly, Blackpoll Warbler (a sparrow like small bird) flies from New England (USA) during winter to Venezuela (South America). Arctic terns cover the longest distance (over 35,000 km) each year. Like Volcanic eruptions, recurrent floods, forest fires, prolonged droughts, etc.

Forced dispersal: It occurs when sudden events force the animals to leave their native places. In such conditions, scarcity of food leads to famine, and causes their migration. Serious forest fires in Siberia in 1915 caused many animals to migrate.

Anthropogenic dispersal: Man has been a major factor in the dispersal of animals. He has introduced diversifications in the regional fauna and has caused several ecological problems. For example, the introduction of deers and rabbits in New Zealand by the Europeans caused large scale destruction of natural vegetation. It led to accelerated soil erosion.

Sometimes due to phenomenal increase in the population of animals, they do not find sufficient breeding places and therefore tend to migrate.

Sometimes the animal dispersal is effected by external carriers; it is called 'passive dispersal'.

Passive dispersal occurs when animals are carried by man or by various means of transport (man made as well as natural). Such carriers are of four types:

Eolian Carriers: e.g. air masses, air currents and winds, which transport micro-organisms from one place to another without the willingness of the organisms.

Aquatic Carriers: e.g. sea waves, tidal currents, and oceanic currents which can carry larger animals to distant places.

Organism Carriers: Symbiotic animals (those dependent on each other and live together) also transport animals to distant places. It happens when small animals are attached and stuck to the bodies of the carrier animals and thus these are transported to various destinations. Birds also help in such dispersal. Parasitic organisms, such as virus are hidden in the stomach or mixed with blood, spatum and stool of animals, reach various destinations. Worms living in the stomach of man are also carried away to far off places when overseas journeys are under taken.

Anthropogenic Carriers: These are the most powerful and effective means of passive dispersal and migration of animals. It is caused by man deliberately or accidentally. For example, lions were transported from Africa to Great Britain and rabbits were introduced into Australia from Europe. European starling was brought to North America and African snails were transported to various parts of the world.

Dispersal of animals is not always positive. It becomes unsuccessful when the animals reaching new habitats are unable to adapt to new environmental conditions and ultimately perish.

Que. 7 Discuss the factors that regulates determiners of ocean heat budget.

Ans. 7 About half the solar energy reaching Earth is absorbed by the ocean and land, where it is temporarily stored near the surface. Only about a fifth of the available solar energy is directly absorbed by the atmosphere. Of the energy absorbed by the ocean, most is released locally to the atmosphere, mostly by evaporation and infrared radiation. The remainder is transported by currents to other areas especially mid latitudes. The thermal energy transported by ocean currents is not steady, and significant changes in the transport.

Changes in energy stored in the upper layers of the ocean result from a local imbalance between input and output of heat through the sea surface. This transfer of heat through the surface is called a heat flux. The flux of heat and water also changes the density of surface waters, and hence their buoyancy. As a result, the sum of the heat and water fluxes is often called the buoyancy flux.

The flux of energy to deeper layers is usually much smaller than the flux through the surface. And, the total flux of energy into and out of the ocean must be zero, otherwise the ocean as a whole would heat up or cool down. The sum of the heat fluxes into or out of a volume of water is the heat budget.

The major terms in the budget at the sea surface are:

- Insolation the flux of sunlight into the sea;
- Net Infrared Radiation net flux of infrared radiation from the sea;
- Sensible Heat Flux the flux of heat out of the sea due to conduction;
- Latent Heat Flux the flux of heat carried by evaporated water; and
- Advection heat carried away by currents.

Factors Influencing Insolation Incoming solar radiation is primarily determined by latitude, season, time of day, and cloudiness. The polar regions are heated less than the tropics, areas in winter are heated less than the same area in summer, areas in early morning are heated less than the same area at noon, and cloudy days have less sun than sunny days.

The following factors are important: The height of the sun above the horizon, which depends on latitude, sea-son, and time of day.

- The length of day, which depends on latitude and season.
- The cross-sectional area of the surface absorbing sunlight, which depends on height of the sun above the horizon.
- Attenuation, which depends on: Clouds, which absorb and scatter radiation, Path length through the atmosphere, Gas molecules which absorb radiation in some bands. H2O, O3, and CO2 are all

important, Aerosols which scatter and absorb radiation. Both volcanic and marine aerosols are important, Dust, which scatters radiation, especially Saharan dust over the Atlantic.

- Reflectivity of the surface, which depends on solar elevation angle and roughness of sea surface. Solar inclination and cloudiness dominate. Absorption by ozone, water vapor, aerosols, and dust are much weaker.

Factors influencing Infrared Flux

The sea surface radiates as a blackbody having the same temperature as the water, which is roughly 290K. The distribution of radiation as a function of wavelength is given by Planck s equation. Sea water at 290K radiates most strongly at wavelengths near 10 µm. These wavelengths are strongly absorbed by clouds, and somewhat by water vapor. A plot of atmospheric transmittance as a function of wavelength for a clear atmosphere but with varying amounts of water vapor shows the atmosphere is nearly transparent in some wavelength bands called windows.

The transmittance on a cloud-free day through the window from 8 μm to 13 μm is determined mostly by water vapor. Absorption in other bands, such as those at 3.5 μm to 4.0 μm depends on CO2 concentration in the atmosphere. As the concentration of CO2 increases, these windows close and more radiation is trapped by the atmosphere.

Because the atmosphere is mostly transparent to incoming sunlight, and somewhat opaque to outgoing infrared radiation, the atmosphere traps radiation. The effect is known as the *greenhouse effect*. If the earth were in radiative equilibrium, with an atmosphere, the surface temperature would be 77°C. This does not happen because water evaporates from the surface, mostly from tropical seas, cooling the surface.

The net infrared flux depends on:

- Clouds thickness. The thicker the cloud deck, the less heat escapes to space.
- Cloud height, which determines the temperature at which the cloud radiates heat back to the ocean. High clouds are colder than low clouds.
- Atmospheric water-vapor content. The more humid the atmosphere the less heat escapes to space.
- Water Temperature. The hotter the water the more heat is radiated.
- Ice and snow cover. Ice emits as a black body, but it cools much faster than open water. Ice-covered seas are insulated from the atmosphere.

Water vapor and clouds are more important for determining the net loss of infrared radiation than are changes in surface temperature. Hot tropical regions lose less heat than cold polar regions.

Factors influencing Latent-Heat Flux Latent heat flux is influenced primarily by wind speed and relative humidity. High winds and dry air evaporate much more water than weak winds with relative humidity near 100%. In polar regions, evaporation from ice covered oceans is much less than from open water. In the arctic, most of the heat lost from the sea is through leads (ice-free areas). Hence the percent open water is very important for the arctic heat budget.

Factors influencing Sensible-Heat Flux

Sensible heat flux is influenced primarily by wind speed and air-sea temperature difference. High winds and large temperature differences cause high fluxes. Think of this as a wind-chill factor for the oceans.

Meridional Heat Transport

Overall, Earth gains heat at the top of the tropical atmosphere, and it loses heat at the top of the polar atmosphere. The atmospheric and oceanic circulation together must transport heat from low to high latitudes to balance the gains and losses. This north-south transport is called the *meridional transport*.

How much heat is carried by the ocean and how much by the atmosphere? The sum of the meridional heat transport by the ocean and atmosphere together is calculated accurately from the divergence of the zonal average of the heat budget measured at the top of the atmosphere by satellites. To make the calculation, we assume steady state transports over many years so that any long-term net heat gain or loss through the top of the atmosphere must be balanced by a meridional transport and not by heat storage in the ocean or atmosphere. So let's start at the top of the atmosphere.

Heat Budget at the top of the Atmosphere

Heat flux through the top of the atmosphere is measured by radiometers on satellites.

- Insolation is calculated from the solar constant and observations of reflected sunlight made by meteorological satellites and by special satellites such as the Earth Radiation Budget Experiment Satellite.
- Back radiation is measured by infrared radiometers on the satellites.
- The difference between insolation and net infrared radiation is the net heat flux across the top of the atmosphere.

Errors arise from calibration of instruments, and from inaccurate information about the angular distribution of reflected and emitted radiation. Satellite instruments tend to measure radiation propagating vertically upward, not radiation at large angles from vertical, and radiation at these angles is usually calculated not measured.

The sum of the meridional heat transported by the atmosphere and the oceans is calculated from the top of the atmosphere budget. First average the satellite observations in the zonal direction, to obtain a zonal average of the heat flux at the top of the atmosphere. Then calculate the meridional derivative of the zonal mean flux to calculate the north-south flux divergence. The divergence must be balanced by the heat transport by the atmosphere and the ocean across each latitude band.

Oceanic Heat Transport

Oceanic heat transport are calculated three ways:

- *Surface Flux Method* calculates the heat flux through the sea surface from measurements of wind, insolation, air, and sea temperature, and cloudiness using bulk formulas. The fluxes are integrated to obtain the zonal average of the heat flux .Finally, the meridional derivative of the net flux gives the flux divergence, which must be balanced by heat transport in the ocean.
- *Direct Method* calculates the heat transport from values of current velocity and temperature measured from top to bottom along a zonal section spanning an ocean basin. The flux is the product of northward velocity and heat content derived from the temperature measurement.
- *Residual Method* first calculates the atmospheric heat transport from atmospheric measurements or the output of numerical weather models. This is the direct method applied to the atmosphere. The atmospheric trans-port is subtracted from the total meridional transport calculated from the top-of-the-atmosphere heat flux to obtain the oceanic contribution as a residual .

Temperature

The oceanic temperature is defined as the amount of heat present in ocean water. The sources of this heat are designated to be insolation and volcanic activities. As the constituent of ocean water, its extent depth varies from one place to other and similarly prevailing winds, oceanic currents and climate also shows variability. The oceanic temperature develops a complex profile of distribution. The various factors are as follows: Latitudes, Salinity, Oceanic currents& Planetary winds:

Que. 8 What are the principal soil components? Briefly describe the soil water.

Ans. 8 The formation of soils depends on a large number of factors. But the dominant influence of climate on soils is unmistakable when viewed on a worldwide scale. The climate-soil relationship and the association of soils with climate-controlled vegetation were both obvious as climatic regions were considered.

Principal Soil Component

1. Inorganic Materials

Soil is made up of both insoluble mineral material - that is, minerals that will not dissolve in water to form a solution and soluble minerals or chemicals in solution. The most common minerals found in soils are combinations of the most common elements of Earth’s crust: silicon, aluminum, oxygen, and iron. In fact, most of the known chemical elements are found in soils in some form. Some of these occur in chemical combinations; others are found in the air and water that are also part of soil. A large number of these elements are necessary to sustain the flora and fauna of Earth's ecosystems. Important among these, in addition to the four elements listed previously, are carbon, hydrogen, nitrogen, sodium, potassium, zinc, copper, and iodine.

The elements and chemical compounds that form a part of soil material come from many sources. Some are derived from the weathering of underlying rocks or from accumulations of loose sediments. Others enter in solution in water or as a part of the chemical structure of water itself. Still others are part of the air found in soils or are derived from organic activity, some of which helps to disintegrate rocks, release gases, or create new chemical compounds.

2. Soil water

Plants need air, water, and minerals to function, live, and grow. They depend upon the soil in which they are rooted for much of their supply of these necessities. Soil water is not pure water; rather, it is a solution bearing traces of many soluble nutrients. Not only does soil water supply the moisture necessary for the chemical reactions that sustain life, but it also provides the nutrients in such a form that they can be extracted and used.

The original source of soil moisture is, of course, precipitation. When precipitation falls on the land surface, it is either absorbed or it runs off down slope to a stream that eventually channels it into a larger body of water. The water absorbed by the soil washes over and through various soil materials, dissolving some of these materials and carrying them through the soil.

Water is found in soil in different circumstances.

(i) The water that percolates downward through the soil, pulled by the force of gravitation, is called **gravitational water.** Gravitational water moves downward through the spaces between the individual soil particles and the clumps of soil toward the ***water table*** -the level below which all the spaces between the soil particles and clumps are filled with water. As a consequence, the water cannot percolate any further.

As we might expect, the amount of gravitational water in a soil is related to several conditions, including the amount of rainfall that has occurred, the length of time since the last rainfall, the ease with which the water moves through the soil, and the amount of space available for water storage.

Gravitational water functions in the soil in several ways. First, as gravitational water moves down through a soil, the water takes with it the finer particles from the upper layer of soil. This removal of soil components from the topsoil is called **eluviations**. Eventually, as the gravitational water percolates downward, it begins to deposit some of the clay and silt particles it removed from the topsoil. Such deposit in the subsoil of soil components is called **illuviation.** Gravitational water therefore serves as an agent of transportation and mixing as it moves soil particles from one level to another. The result of eluviations is that the texture of the topsoil becomes coarser as the finer particles are removed. Consequently, the topsoil's ability to retain water is reduced, while illuviation enhances the subsoil's water retention capability. This process may be carried to such extremes that the subsoil becomes extremely dense and compact, forming a clay **hardpan.**

Gravitational water also affects the chemical composition of a soil and, as a result, its color, texture, structure, and ability to provide plant nutrients. As gravitational water moves downward, it dissolves the soluble inorganic soil components and carries them into the deeper levels of the soil, perhaps to the zone where all open spaces are saturated. This depletion of the nutrients in the upper soil is called **leaching**. When extensive, as it is under conditions of heavy precipitation, leaching can rob a topsoil of all but the most inert substances.

The process of leaching and eluviations are a major cause f the characteristics stratification found in soils. The upper portions are composed of coarse material and are somewhat impoverished in soluble nutrients. Both fine material and some of the substances dissolved from the upper soil come to rest in the lower portion, which becomes dense and sometimes is strongly colored by accumulated iron compounds.

(ii) Some soil water is held to the surface of the individual soil particles and soil clumps by surface tension (the same property that causes small droplets of water to form rounded beads instead of spreading out in a thin film). This soil water, called **capillary water,** serves as the storage supply of water for plants. Capillary water can move in all directions through soil, its migration determined by its tendency to move from areas with more water to areas with less. Thus, during the periods between rainfalls when there is no gravitational water flowing through the soil, capillary water can move upward or horizontally to supply plant roots with the necessary moisture and dissolved nutrients.

When capillary water moves upward in a soil toward the surface, it carries with it minerals from the subsoil. If this water is evaporated in the upper soil layers, the minerals are left behind as alkaline or saline deposits in the topsoil. Such deposits can be detrimental to the plants and animals existing in the soil. Lime deposits formed in this way may produce a cement-like layer, called ***caliche***, which, like clay hardpan, prevents the downward percolation of rainwater.

(iii) Soil water is also found in a very thin film, invisible to the naked eye, which is bound to the surface of all soil particles. This water, called **hygroscopic water,** is held by strong electrical forces to the surfaces of the soil particles. Because it does not move through the soil, it cannot supply plants with the water they need.

3. Soil Air A large part of soil, in some cases as much as 50 percent, is made up of the voids between individual soil particles and between clumps or congregates of soil particles. When not filled with water, these spaces are filled with air. Soil air is much like the air of the atmosphere above earth's surface, through it is likely to have less oxygen, more carbon dioxide, and a fairly high relative humidity because of the presence of capillary and hygroscopic water.

For most of the microorganisms and plants that live in the soil, sol air supplies the oxygen and carbon dioxide necessary for life processes. Thus, the problem with water-saturated soils is not so much the excess water itself but the fact that, with all the pores filled wit water there is no supply of air. It is because of the lack of air, then, that many plants and animals find it difficult survive in water-saturated soils.

4. Organic Matter

In addition to various chemical compounds (both soluble and insoluble), air, other gases and water, soil also contains organic matter. The decayed remains of plant and animal material, partially transformed by bacterial action, are called **humus.** Humus is important to soils in several ways, but it is most important for its role as a catalyst in the chemical reactions by which plants extract nutrients from the soil and for its role in restoring minerals to the soil. Humus also improves soil structure, making it more workable and increasing its capacity to retain water. Humus serves, too, as a source of food for the enormous variety of microscopic organisms that live in soil.

Que. 9 Explain Allen-Bergmann rules on adaptability of organisms.

Ans. 9 The organism, in order to maintain the constancy of its internal environment (a process called homeostasis) despite varying external environmental conditions that tend to upset its homeostasis generates following responses

Regulate: Some organisms are able to maintain homeostasis by physiological (sometimes behavioural also) means which ensures constant body temperature, constant osmotic concentration, etc. All birds and mammals, and a very few lower vertebrate and invertebrate species are indeed capable of such regulation (thermoregulation and osmoregulation). Evolutionary biologists believe that the 'success' of mammals is largely due to their ability to maintain a constant body temperature and thrive whether they live in Antarctica or in the Sahara desert. Plants, on the other hand, do not have such mechanisms to maintain internal temperatures.

Conform: An overwhelming majority (99 per cent) of animals and nearly all plants cannot maintain a constant internal environment. Their body temperature changes with the ambient temperature. In aquatic animals, the osmotic concentration of the body fluids changes with that of the ambient water osmotic concentration. These animals and plants are simply conformers.

Thermoregulation is energetically expensive for many organisms. This is particularly true for small animals like shrews and humming birds. Heat loss or heat gain is a function of surface area. Since small animals have a larger surface area relative to their volume, they tend to lose body heat very fast when it is cold outside; then they have to expend much energy to generate body heat through metabolism. This is the main reason why very small animals are rarely found in polar regions. During the course of evolution, the costs and benefits of maintaining a constant internal environment are taken into consideration. Some species have evolved the ability to regulate, but only over a limited range of environmental conditions, beyond which they simply conform.If the stressful external conditions are localised or remain only for a short duration, the organism has two other alternatives.

Migrate : The organism can move away temporarily from the stressful habitat to a more hospitable area and return when stressful period is over.

Suspend: In bacteria, fungi and lower plants, various kinds of thick walled spores are formed which help them to survive unfavourable conditions – these germinate on availability of suitable environment. They do so by reducing their metabolic activity and going into a date of 'dormancy'. In animals, the organism, if unable to migrate, might avoid the stress by escaping in time. The familiar case of bears going into hibernation during winter is an example of escape in time. Under unfavourable conditions many zooplankton species in lakes and ponds are known to enter diapause, a stage of suspended development

Adaptations While considering the various alternatives available to organisms for coping with extremes in their environment, we have seen that some are able to respond through certain physiological adjustments while others do so behaviourally (migrating temporarily to a less stressful habitat). These responses are also actually, their adaptations. So, we can say that adaptation is any attribute of the organism (morphological, physiological, behavioural) that enables the organism to survive and reproduce in its habitat. Many adaptations have evolved over a long evolutionary time and are genetically fixed.Some organisms show behavioural responses to cope with variations in their environment. Desert lizards lack the physiological ability that mammals have to deal with the high temperatures of their habitat, but manage to keep their body temperature fairly constant by behavioural means.

They bask in the sun and absorb heat when their body temperature drops below the comfort zone, but move into shade when the ambient temperature starts increasing. Some species are capable of burrowing into the soil to hide and escape from the above-ground heat

Ecogeographic rules developed by Karl Bergmann and Joel Asaph Allen in the nineteenth century were derived from a geometric evaluation of the most efficient form for maintaining core body temperature under varying thermal conditions. Bergmann's rule states that within a wide ranging morphologically variable homeothermic (warm blooded) species, larger body size variants will be found in the colder parts of the range and smaller variants will be found in the warmer parts of the range. Allen's rule similarly states that in wide ranging homeotherms, the length of appendages (arms, legs, etc.) is shorter in variants from colder climates, while they are longer in those from warmer climates. Several studies comparing populations globally appear to confirm that human morphological variation conforms to Bergmann's and Allen's rules. Fossil hominins appear to follow the rules as well. Results from most but not all physiological functional studies also support the rules.

Bergmann's rule is an ecogeographical rule that states that within a broadly distributed taxonomic clade, populations and species of larger size are found in colder environments, while populations and species of smaller size are found in warmer regions. Although originally formulated in terms of species within a genus, it has often been recast in terms of populations within a species. It is also often cast in terms of latitude. It is possible that the rule also applies to some plants.

The rule is named after nineteenth century German biologist Carl Bergmann, who described the pattern in 1847, although he was not the first to notice it. Bergmann's rule is most often applied to mammals and birds which are endotherms, but some researchers have also found evidence for the rule in studies of ectothermic species. While Bergmann's rule appears to hold true for many mammals and birds, there are exceptions.

Larger-bodied animals tend to conform more closely to Bergmann's rule than smaller-bodied animals, at least up to certain latitudes. This perhaps reflects a reduced ability to avoid stressful environments, such as by burrowing. In addition to being a general pattern across space, Bergmann's rule has been reported in populations over historical and evolutionary time when exposed to varying thermal regimes. In particular, temporary, reversible dwarfing of mammals has been noted during two relatively brief upward excursions in temperature during the Paleogene: the Paleocene-Eocene thermal maximumand the Eocene Thermal Maximum .

Allen's rule is an eco geographical rule formulated by Joel Asaph Allen in 1877, broadly stating that animals adapted to cold climates have shorter limbs and bodily appendages than animals adapted to warm climates. More specifically, it states that the body surface area-to-volume ratio for homeothermic animals varies with the average temperature of the habitat to which they are adapted (i.e. the ratio is low in cold climates and high in hot climates).Allen's rule predicts that endothermic animals with the same body volume should have different surface areas that will either aid or impede their heat dissipation.

Because animals living in cold climates need to conserve as much heat as possible, Allen's rule predicts that they should have evolved comparatively low surface area-to-volume ratios to minimize the surface area by which they dissipate heat, allowing them to retain more heat. For animals living in warm climates, Allen's rule predicts the opposite: that they should have comparatively high ratios of surface area to volume. Because animals with low surface area-to-volume ratios would overheat quickly, animals in warm climates should, according to the rule, have high surface area-to-volume ratios to maximize the surface area through which they dissipate heat

To conclude. Mammals from colder climates generally have shorter ears and limbs to minimise heat loss. (This is called the Allen's Rule.) In the polar seas aquatic mammals like seals have a thick layer of fat (blubber) below their skin that acts as an insulator and reduces loss of body heat. Some organisms possess adaptations that are physiological which allow them to respond quickly to a stressful situation. In most animals, the metabolic reactions and hence all the physiological functions proceed optimally in a narrow temperature range (in humans, it is – 370C). But there are microbes (archaebacteria) that flourish in hot springs and deep sea hydrothermal vents where temperatures far exceed 1000C.

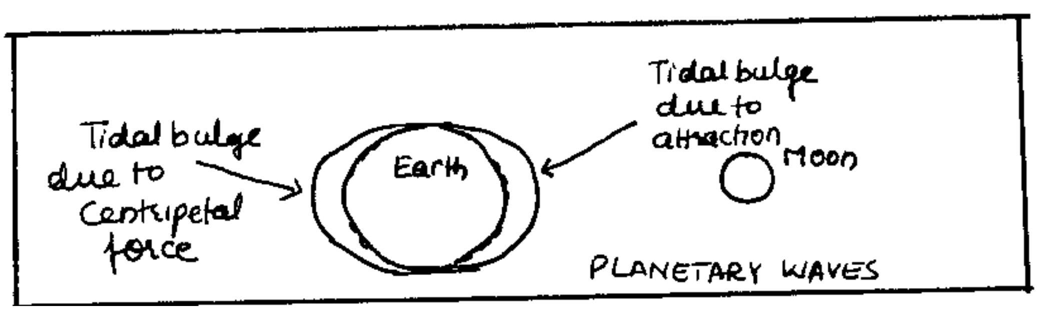
Que. 10 Describe the factors that complicates size of tides.

Ans. 10 Tides are defined as periodic, short-term changes in the height of the ocean surface caused by the moon and sun's gravitational forces and the rotation of the earth. Tides can be considered waves – the largest on Earth's surface. But tides are considered forced waves (ocean waves are free waves) because they are never free from the forces that cause them.

Tides are generated by two main energy sources – **gravitational forces and centripetal forces**.

The Equilibrium Theory of Tides assumes the Earth is completely covered with water, that interaction with the seafloor does not influence the tides and that the ocean is always in equilibrium with the tidal forces.

Under these idealized conditions, we find that the moon's gravity attracts the surface of the ocean toward the moon. This creates a tidal bulge on the side of the Earth that faces the moon, like in the image below.



Complicating Factors

Two other factors also influence the size of tides: the declination of the moon and sun and the elliptical (oval) shape of the Earth and Moon's orbits.

Declination. It is the angular distance of the sun and moon above or below Earth's equator. Over the course of a month, the moon moves from a position 28° above the equator to a position 28° below the equator. The tides caused by the moon follow this angle. Similarly, over the course of a year, the sun moves from a position 23° above the equator to a position 23° below the equator (this is why we have seasons). The solar tides also follow this movement. Watch the animation from your reading again to better understand this concept.

Elliptical orbits. The moon-earth and sun-earth orbits are not perfect circles; rather they are more elongate like ovals. This means that at some points during their orbits, the moon and sun are closer to the Earth. This closeness will result in a more extreme tide because gravitational forces will increase.

The equilibrium theory of tides provides the foundation for us to understand tidal patterns. A purely ocean-covered Earth would experience tidal bulges due to the gravitational pulls of the Sun and Moon on its oceans. This gravitational force, combined with the centripetal force of the Moon-Earth and Sun-Earth orbits creates tidal bulges both on the side of the Earth facing the Moon and Sun and on the opposite side of the Earth.

The ocean water will always be pulled towards the sun and moon and the Earth rotates beneath these bulges. The bulges are not always centered at the equator because the angle of the Sun and Moon with the Earth's equator changes on a yearly (sun) and monthly (moon) timescale. With the equilibrium theory of tides we would expect any location on Earth's surface to have two high and two low tides each day as the location rotates into and out of the tidal bulges.

The most extreme tides are created when the sun, moon and Earth are in a straight line and the tidal bulges from the Sun and Moon add to one another. The least extreme tides occur when the sun and moon form a right angle with the earth. These are called spring and neap tides, respectively, and the Earth's ocean experiences two of each per month. The position of the sun and moon within their orbits will also affect the extremeness of the tide – when they are closer to the Earth more extreme tides will occur.

A more realistic approach involves a dynamic rather than a static ocean. It also involves the consideration of the effects on tides of the size and shape of ocean basins of the Coriolis effects. Based on our equilibrium theory of tides, ocean water always stayed in direct line with the sun and moon, meaning that in theory the waves traveled at the speed of rotation of the Earth. However, if we calculate the maximum speed tides can reach (being shallow water waves) we find that they travel slightly slower. This means that the bulge created by the gravitational pulls and centripetal force actually lags somewhat behind the moon as the moon orbits the earth. So when the moon is directly overhead a certain location, that location is not experiencing its high tide at that moment, it comes later.

Continents and the Coriolis Effect Landmasses on Earth's surface prevent the Earth from simply rotating into and out of tidal bulges. When the tidal bulge "hits" the side of a continent some of its energy is dissipated, and some of the energy is reflected back into the ocean basin. This reflection, coupled with the Coriolis Effect causes water to be rotated around an ocean basin.

This oscillation of water around an ocean basin is called an amphidromic system and causes the high tide wave crests and low tide wave troughs to move around ocean basins in a clockwise (S. Hemisphere) or counterclockwise (N. Hemisphere) pattern. In the center of this rotating wave is a node where the tidal range is zero. These systems have been found to occur in all the ocean basins except the Southern Ocean, where tide crests and troughs simply move east to west.

The dynamic method treats tides as waves that can be separated mathematically into several components; each component can be treated individually. The tide-generating forces exerted by the Sun and the Moon can also be resolved into be related to the effects of the Sun or Moon and the interactions. Four principal constituents account for about 70% of the tidal range.

The tide for any location thus can be predicted by combining partial tides, just as complicated waves in a sea can be reconstructed by combining several simple wave trains. When predicting tides using the dynamic model, the first step is to analyze tidal, using computers. Today's more powerful computers permit the use of more sophisticated tidal models, resulting in more accurate predictions.

Tides are very-long-period waves. Neglecting Earth's curvature, we see that the two water bulges are the crests of a simple wave and the intervening low areas are its trough. Because of their immense size relative to the ocean basins, tides behave as shallow-water waves. For tide waves to move as fast enough at the equator to keep up with the Moon, the ocean would need to be about 22 kilometers deep. Because it is much shallower, the tidal bulge move as forced waves the speed of which is determined by the movements of the Moon. The position of tidal bulges relative to the Moon is determined by a balance between the attraction of the Sun and Moon and frictional effects of the ocean bottom. Because the tides behave as shallow-water waves, they are felt on the bottom of the deepest ocean basins. Twice a day, the deep-ocean bottom experiences strong currents.

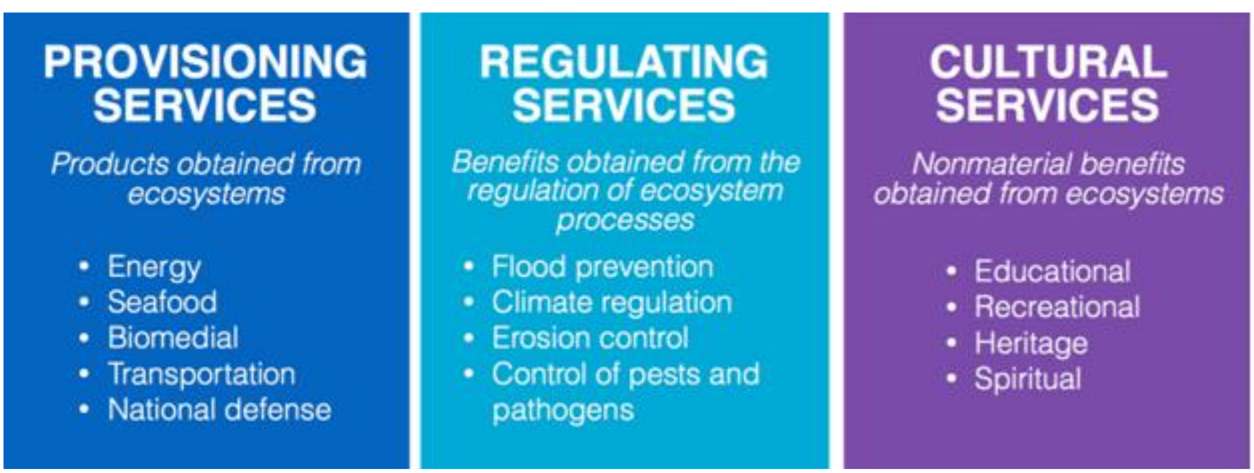
Que. 11 Discuss the significance of bio diversity and fundamentals of sustainability.

Ans. 11 Biospheres refers to the narrow zone of the earth in which all life forms exist. It is because this is the zone in which all the three essentials things which are required for sustenance of life are found in a right mixture. They are land (lithosphere), air (atmosphere) and water (hydrosphere). In other words, this narrow zone is a place where lithosphere, atmosphere and hydrosphere meet. Within this framework, those characterized by broadly similar geography and climate, as well as communities of plant and animal life can be divided for convenience into different bio geographical realms.

Biodiversity – 'biological' (living) and 'diversity' - is the variety and variability of all life on Earth, including plants, animals, bacteria and microorganisms, and humans. The concept was introduced in 1980 by renowned conservation biologist Thomas Lovejoy

Ecosystem services are the environmental, economic, social, cultural and spiritual benefits that are made available due to complex species interactions on Earth. We as humans rely on these benefits every single day. Biodiversity is responsible for the production of oxygen, the filtration of natural drinking water, the fertility of our soil, the pollination of plants that allow us to produce crops, the protection of coastlines from erosion, and more. Lovejoy estimates that these services provide trillions of dollars of benefits to the human economy.

Biodiversity also provides social and emotional benefits to humans. Spending time in nature or green spaces like parks and beaches supports mental health. Many individuals also associate positive memories as well as their heritage and ancestry with particular species or places in nature. This can be as unique and personal as a childhood association with a summer camp or as deep and embedded as places of worship. "A lot of indigenous cultures revere pieces of land and wild spaces because of their cultural history," Schmitz says. "These places are where their ancestors existed, and it gives people a sense of place and that sense of belonging."



SUPPORTING SERVICES

Services necessary for the production of all other ecosystem services

- Biological diversity maintenance
- Nutrient recycling
- Primary productivity

Principles of Ecosystem Function

The preceding examination of how ecosystems function reveals that three common denominators underlie them all:

- recycling of nutrients,
- using sunlight as a basic energy source, and
- Populations are such that overgrazing does not occur.

In turn, these common features reveal basic principles underlying the sustainability of ecosystems.

Nutrient Cycling

Looking at the various inputs and outputs of producers, consumers, detritus feeders, and decomposers, you should be impressed by how they fit together. The products and byproducts of each group are the food and/or essential nutrients for the other. Specifically, the organic material and oxygen produced by green plants are the food and oxygen required by consumers and other heterotrophs. In turn, the carbon dioxide and other wastes generated when heterotrophs break down their food are exactly the nutrients needed by green plants. Such recycling is fundamental, for two reasons: (a) It prevents wastes, which would cause problems, from accumulating; (b) It assures that the ecosystem will not run out of essential elements. Thus, we uncover the ***first basic principle of ecosystem sustainability***:

> ***For sustainability, ecosystems dispose of wastes and replenish nutrients by recycling all elements.***

Running on Solar Energy

We have seen that no system can run without an input of energy, and living systems are no exception. For all major ecosystems, both terrestrial and aquatic, the initial source of energy is sunlight absorbed by green plants through the process of photosynthesis. (The only exceptions are ecosystems near the ocean floor or in dark caves, where the producers are bacteria that derive energy from the oxidation of hydrogen sulfide in those locations. These bacteria use that energy to make organic compounds, in a manner similar to that of higher plants. The process is called chemosynthesis, because it runs on chemical energy rather than light).

Using sunlight as the basic energy source is fundamental to sustainability for two reasons: it is both nonpolluting and non depletable.

Nonpolluting – Light from the Sun is a form of pure energy; it contains no substance that can pollute the environment. All the matter and pollution involved in the production of light energy are conveniently left behind on the Sun some 93 million miles (150 million kilometers) away in space.

Non depletable – The Sun's energy output is constant. How much or how little of this energy is used on Earth will not influence, much less deplete, the Sun's output. For all practical purposes, the sun is an everlasting source of energy. True, astronomers tell us that the Sun will burn out in another 3-5 billion years, but we need to put this figure in perspective. One thousand is only 0.0001 percent of a billion. Thus, even the passing of millennia is hardly noticeable on this time scale.

Hence, we uncover the ***second basic principle of ecosystem sustainability***:

For sustainability, ecosystems use sunlight as their source of energy.

From the preceding discussion, you should be impressed with the importance of chemical nutrients and light as the major prerequisites for the functioning of every ecosystem. Yet, rainfall and temperature (climate) are the primary limiting factors determining different terrestrial biomes. Basically, this is because every region that is above water receives abundant light, and most soils contain a modicum of nutrients or retain their nutrients through recycling. Therefore, light and nutrients are generally not limiting factors on land. But the situation is different in aquatic and marine environments, where light and nutrients dominate as the determining factors.

Prevention of Overgrazing

In the concept of the food or biomass pyramid, a consumer cannot gain an amount of weight equal to what it eats because first, 60-90 percent of what is consumed is broken down for energy and second, another portion passes through without being digested. These two facts by themselves would result in the declining biomass at each higher trophic level – the biomass pyramid observed. However, there is a third reason for the observed decline. It is the following.

In a grazing situation, it is readily apparent that if the animals eat the grass faster than the grass can re-grow, sooner or later, the grass will be destroyed, and all the animals will starve. This situation is known as **overgrazing**. The same holds true in the case of carnivores and their prey. Basically, a sustainable situation demands that, on average, consumption cannot exceed production. It follows, then, that a large portion of the producer must remain intact to maintain that production. This portion, or population, that is not consumed, and which must remain intact to assure continued production, is called the **standing biomass**. In natural ecosystems, which are sustainable, we observe that consumers eat no more than a small proportion of the total biomass available; most is left as standing biomass. We can readily see that this is another feature that is fundamental to sustainability. Hence, here is the ***third basic principle of ecosystem sustainability***:

For sustainability, the size of consumer populations is maintained so that overgrazing or other overuse does not occur.

For not, it is sufficient to appreciate that such regulation is mandatory for sustainability. Recognizing principles of ecosystem sustainability, many attempts to make artificial ecosystems have been initiated worldwide.

Over the past few decades, sustainability research and literature has landed us at a general conceptual understanding of sustainability: the balancing of the environment, economy, and society. These can be thought of as the **three pillars of sustainability.**

The environment is typically top of mind when thinking about sustainability – and rightfully so. The environment has direct impacts on nearly everything we do in our day-to-day lives. So maintaining the environment through natural resource management, pollution prevention, and biodiversity management is important for sustainability.

In addition, **the economic-side** of sustainability is also important to take into account. How can we make sure that people's livelihoods are maintained and businesses continue to see profit?

Finally, one aspect of sustainability that might not be as prominent is **social sustainability**. This is making sure that societies and communities are not negatively impacted by changes. This means that access to resources and the well-being of the community is taken into account and maintained.

In order for sustainability to be viable in a system, the environment, economics, and society must be balanced. Without balance, one area might outweigh others making the system unsustainable.

While the three pillars are important areas to consider when thinking about sustainability, it is also important to where they overlap. This can help to further one's understanding of what sustainability is.

Socio-Eco is the intersection of society and the environment. This can be thought of as how the community interacts with their environment. This intersection highlights the importance of environmental justice, natural resource stewardship, and environmental health and safety.

Eco-Economic is the intersection of the environment and economics. This can be thought of as how the environment can influence economics. For example, some concepts in this intersection are the economic incentives or subsidies for environmental stewardship or markets for ecosystem services.

Socio-Economic is the intersection of society and economics. This can be thought of as how our economic position impacts society and vice versa. This intersection is where topics such as workers' wages and rights exist. Additionally, this intersection is where corporate social responsibility (CSR) falls.

Que. 12 What is meant by Ecological succession? Write the details of aquatic succession.

Ans. 12 The phenomenon of orderly transition from one biotic community to another is called **ecological** or **natural succession**. Natural succession occurs because the physical environment may be gradually modified by the growth of the biotic community itself, such that the area becomes more favourable to another group of species and less favourable to the present occupants.

Autogenic succession: the replacement of one community by the next results from changes in the physical environment that have been produced by the resident organisms. These changes tend to render the site less optimal for the organisms producing the change and more optimal for those organisms that replace them.

Allogenic succession: it occurs when geological processes cause changes in the physical environment, which in turn lead to changes in the biota.

Biogenic succession: it occurs when there is a sudden interference with an autogenic or allogenic succession by a living organism which becomes the major agent of successional change, at least temporally. A sudden change in herbivore pressure on the plant community or the sudden removal of a segment of the plant community by a pathogen could be two good examples.

Although, change in the composition of the biota over time is a fundamental characteristic of all ecosystems, the rate of changes varies widely in different seres and between the different stages of a single sere. In most areas, change does not continue indefinitely. Communities development in which rates of change become exceedingly slow, or in which the composition of the biota remains approximately constant for a long period of time, are called **climax**. These stable communities represent either the final or an indefinitely prolonged stage of a sere.

Succession occurs as the result of either autogenic processes (associated with the living community) or allogenic processes (associated with the physical environment).

Examples of allogenic succession can be observed along the banks of a meandering river in a valley floodplain, where succession starts on recently deposited sandbars. Such examples are less common than the products of autogenic succession, which is the result of three major biotic mechanisms:

Colonization It is a process with two components: invasion and survival. The rate at which a site is colonized depends on both the rate (numbers per unit time) at which individual organisms (seed, spores, immature or mature individuals) arrive at the site, and on their success at becoming established and surviving.

Alteration of the Physical Characteristics of the Ecosystem Occupying the site, a species inevitably changes the site conditions, and the changes are frequently not favorable to the continued occupancy of the site by that species. The changes may either reduce the competitive abilities of the resident species or increase those of the invading species, or both. The net result is the replacement of one group of species by another group.

Displacement of Species by Antibiosis, Autoxicity and Competition. Not only do plants alter the microclimate and the physical and inorganic chemical characteristics of the soil, they also alter their organic chemical environment. The plants produce a wide variety of chemicals to inhibit germination and/or growth of other species (allelopathic substances). In fact, allelopathy may serve to accelerate succession, whereas in others it impedes it.

Rate of Successional Change depend on

The degree of environmental change that must occur before one community can be replaced by another: the greater the change, the more prolonged the stage.

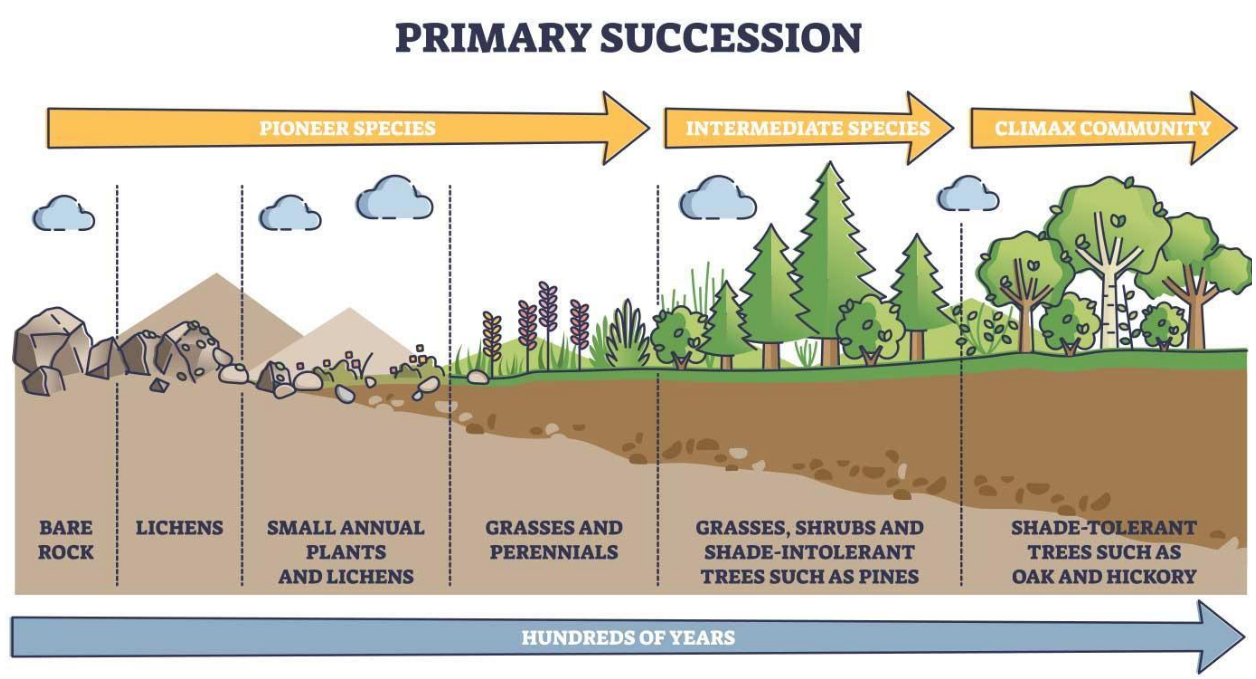
The typical primary hydrosere or xerosere involve extensive change. In a xerosere, one starts with a completely unmodified microclimate, and little soil or unconsolidated soil parent material. There is little or no soil moisture storage capacity, nutrient retention capacity or available nutrient capital, therefore the degree of environmental change is enormous. In case of hydrosere, it starts from a nutrient-poor aquatic environment through semiterrestrial condition to a forested condition. The ecological conditions between the start and finish of the sere are enormously different.

The productivity of the organisms and the efficiency with which they produce environmental change: more productive and efficient the organisms, the shorter the duration of the seral stages.

The living community in early xerarch and hydrarch is composed of small organisms that either grow very slowly or are very short-lived and accumulate very little biomass. The extensive ecological changes that are necessary early in xerarch and hydrarch succession are associated with diminutive and frequently slow-growing life forms. Consequently, rates of autogenic succession are very slow in these seral stages.

The situation in mesarch succession is quite different, with very much less environmental alteration involved and a productive, rapidly growing community of plants involved in causing it. Most mesarch seral stages involve a single generation of plants, whereas most xerarch and hydrarch seral stages involve many generations.

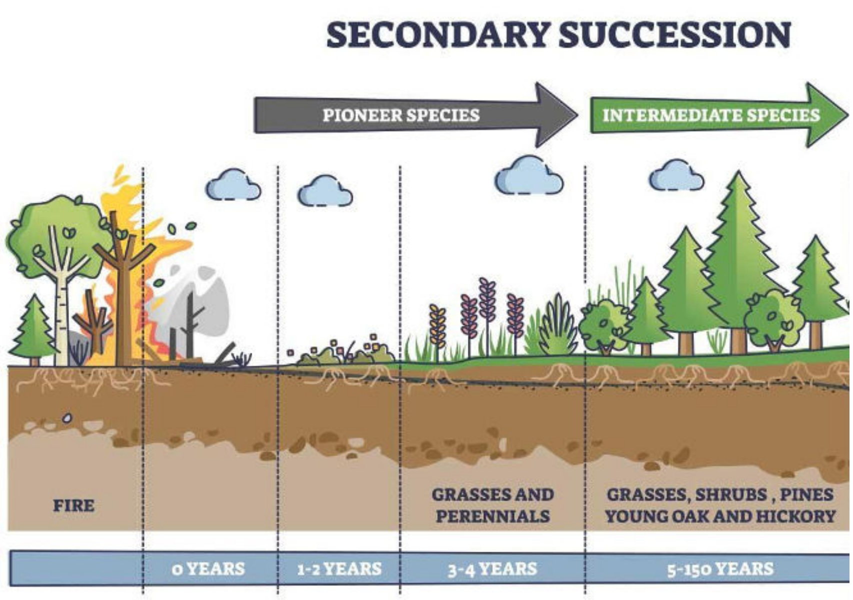
The longevity of the organisms dominating each seral stage: the longer lived the organisms, the longer the stage may last.In mesarch succession, the length of a seral stage is partly determined by the longevity of the organisms involved, especially in midseral and subclimax stages. The subclimax Douglas-fir stage in the western hemlock zone of British Columbia can last for many centuries before it is replaced by the climax western hemlock-western red cedar, simply because of the great age reached by Douglas-fir.

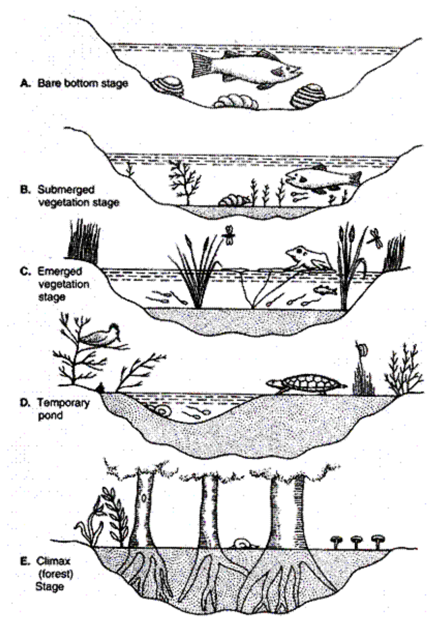


The degree to which communities at any particular stage occupy and dominate the site and resist invasion by other species: the better developed the community, the more resistant to invasion and the longer lasting.

Variable combinations of these four determinants of the rate succession and duration of particular seral stages precludes any reliable general statement about rates and durations. Anyway, there are some points to be considered:

- Rates of succession are generally slower in primary than in secondary succession because of the greater degree of environmental alteration that is involved.
- Rates of succession are much faster in mesarch.
- Rates of succession in the earlier stages of xeroseres and hydroseres are slower than in later stages. The opposite is true for mesarch succession.
- The duration of any particular stage will be greatly influenced by the timing and rate of invasion of the site by reproductive propagules of individuals of the subsequent seral stage. Where such invasion is slow or delayed, a seral plant community may become very well stablished, resist invasion and consequently, lasts very much longer than where such invasion is rapid and immediate (relay floristics & initial vegetative composition).
- Succession will be much faster in climates that promote high rates of NPP and biomass accumulation than in climates that limit plant growth.





Community succession in an open pond.

Aquatic Succession example of natural succession is seen as lakes or ponds are gradually filled and taken over by the surrounding terrestrial ecosystem.

This process occurs because of certain quantity of soil particles is inevitably eroded from the land and settles out in ponds or lakes, gradually filling them. Aquatic vegetation produces detritus that also contributes to the filling process. As the buildup occurs, terrestrial species can advance, and aquatic species move farther out into the lake. In short, the shoreline gradually advances toward the center of the lake until, finally, the lake disappears together.

Succession is recognizable only if the colonization of plant communities takes place in artificial small and shallow ponds, lakes, etc. where wave action speeds up the process by allowing the erosion of soil towards edge regions. In this way, the filling process also speeds up quickly and consequently the body of water disappears within few years time. The process of aquatic succession completes in the following stages

- Phytoplankton stage
- Submerged stage
- Floating stage
- Reed-swamp stages:
- Sedge Marsh or Meadow stage
- Woodland stage

Que. 13 What are the challenges faced by coral reefs? Examine the requirement of coral reef protection

Ans. 13 Zillions of coral calcium carbonate skeletons, cemented together over a period ranging from a few thousand to millions of years, have made up such reefs. Corals have a symbiotic relationship with plant-like cells called zooxanthellae. The zooxanthellae provide corals with food through photosynthesis, and in return, the coral provides them with shelter and nutrients. It is these zooxanthellae that give most corals (and therefore, the reefs) their rainbow-like colours.

Coral reefs are typically located in tropical oceans near the equator and generally grow at depths shallower than 70 m. They are extremely sensitive temperature; the optimal temperature for them to survive is 23 C – 25 C. The Great Barrier Reef off the coast of Queensland, Australia, is arguably the world's most well-known coral reef. India too is home to many beautiful coral reefs. The mainland coast of India has two widely separated areas containing reefs: the Gulf of Kutch in the northwest and the Palk Bay and the Gulf of Mannar in the southeast.

Coral reefs are home to an estimated 25 percent of all marine life and have been rightly dubbed as the 'rainforest of oceans'. Over 4,000 species of fish have been recorded as inhabiting coral reefs. Home to sponges, sea slugs, oysters, clams, crabs, shrimps, sea worms, starfish, sea urchins, sea birds, jellyfish, and sea anemones, each reef in the world is a universe of biodiversity by itself. They form an important source of protein and livelihood for the communities living along coastlines; about 500 million people are believed to have some level of dependence upon coral reefs. They also serve as a barrier against natural disasters such as hurricanes and typhoons.Independent research supported by the World Wildlife Fund (WWF) shows that coral reefs provide annually in net benefits in goods and services to world economies, including, tourism, fisheries and coastal protection.

Challenges to coral reefs

For their survival, coral reefs have to face many challenges. They are fragile ecosystems that have been bearing the onslaught of **coral mining, pollution, diseases, blast fishing, overfishing, rampant tourism, and most recently, climate change.**

Corals have been traditionally used as raw material (calcium carbonate) by the cement and lime industry in India. Extensive areas were leased by the Indian government for coral mining. Black corals have traditionally been made into amulets, worn to ward off the evil eye and illnesses.. Although trade has mainly focussed on species that are in huge demand by the jewellery sector.

Tourism-derived damage is caused by trampling of corals by snorkelers and divers. Heavy boat anchors can smash even the sturdiest corals. Anchor chains and lines have been known to scrape coral and wrap around them, breaking off pieces of coral colonies as the boats sway back and forth and pull on the line.

Perhaps one of the greatest threats to coral reefs is the **aquarium trade**. Recent decades have recorded a dramatic rise in the export of both live and dead coral reef fish. Parrotfishes from the Seychelles and Persian Gulf are now sold by fish retailers in London. The unprecedented demand for live reef fish looked on as ornamentals in home aquariums is alarming.. Herbivores fishes, including three groups – bio-eroders, scrapers, and grazers – play different and complementary roles in ensuring healthy coral reefs, but they constitute a large component of the live fish trade today. Bio-eroders, like the parrotfish, remove dead corals, exposing the hard, reef matrix for the settlement, growth, and survival of coralline algae and corals.

Climate change is the greatest global threat to coral reef ecosystems. Scientific evidence now clearly indicates that the Earth's atmosphere and ocean are warming, and that these changes are primarily due to greenhouse gases derived from human activities.
As temperatures rise, mass coral bleaching events and infectious disease outbreaks are becoming more frequent. Additionally, carbon dioxide absorbed into the ocean from the atmosphere has

already begun to reduce calcification rates in reef-building and reef-associated organisms by altering seawater chemistry through decreases in pH. This process is called ocean acidification.Climate change will affect coral reef ecosystems, through sea level rise, changes to the frequency and intensity of tropical storms, and altered ocean circulation patterns. When combined, all of these impacts dramatically alter ecosystem function, as well as the goods and services coral reef ecosystems provide to people around the globe.

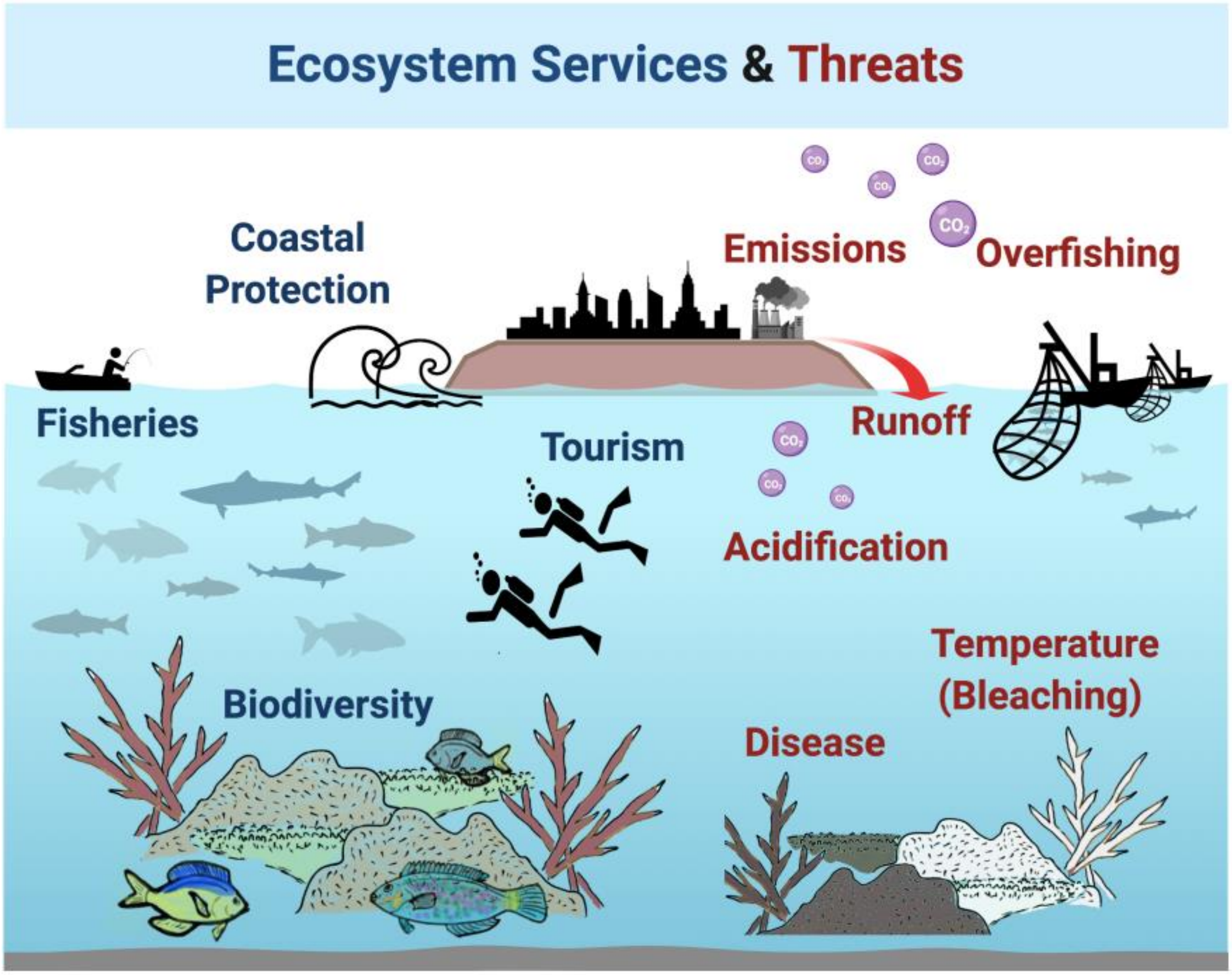
Impacts from land-based sources of pollution—including coastal development, deforestation, agricultural runoff, and oil and chemical spills—can impede coral growth and reproduction, disrupt overall ecological function, and cause disease and mortality in sensitive species. It is now well accepted that many serious coral reef ecosystem stressors originate from land-based sources, most notably toxicants, sediments, and nutrients.

Many of these issues are made worse because of the geographic and climatic characteristics found in tropical island areas. Together they create unique management challenges.

Globally, the main factor attributing to the death of coral has been '**coral bleaching'**. During such episodes, the sea surface temperature in the tropics rises by 1 C – 2 C above the seasonal maximum, which is enough to stress the corals. They expel all or some of their colour-providing zooxanthellae, which leads to a lighter or completely white appearance; hence the term 'bleached'.

Certain coral reefs survive partially and go on to make good recoveries after some time, while others are permanently wiped out. Not enough is known about what factors contribute to good recoveries (i.e. a flip over from 'dead cover' to 'live cover'), but maintaining 'no-take areas' (where fishing and other human activities are prohibited) appears to allow Mother Nature enough time to get back on her feet. The timescale for natural recovery of reefs from major coral loss, such as the mass bleaching and mortality experienced in the Indian Ocean in 1998, appears to be at least 10 years. However, even the largest 'no-take areas' in the world are not self-sustaining, because they are too small relative to the scale of natural and human disturbances, and to the dispersal distances of many larvae and migrating adults. Most no-take areas are a few square kilometres or less in size, and they are invariably surrounded by vastly larger areas that are often already badly degraded.

It is particularly alarming that models based on the Intergovernmental Panel on Climate Change's Scenario (doubling of atmospheric carbon dioxide levels by 2100) predict that the temperature tolerances of reef-building corals will exceed permanently within the next few decades. In order, to conserve coral reefs, it is vital to have an understanding of the ecology of the coral reefs, and by extension, the relationship between local populations, and reef resources.



Importance of Coral Reefs

It is often said that coral reefs are the rainforests of the sea. In addition to being one of the world's most bio-diverse ecosystems, they are also home to a vast variety of marine life. We rely heavily on coral reefs to keep our oceans and planet healthy. Take a look at these reasons why coral reefs are so important in the world.

Provide Shelter to Various Species Coral reefs provide food and safe shelter to many species of water kingdoms, such as shrimps, small fishes, and many other predators. From algae to fish, they provide a home for a wide range of species.

Protecting the Coastal Areas Coral reefs play an essential role in slowing down the flow of water waves near coasts. In coastal areas, they serve as a natural barrier, which can reduce the impact of storms and high tides. One of the interesting facts is that corals are more likely to be found in the area where the ocean waves are quite high.

Natural Water Filtration by Coral Reefs Coral reefs cannot survive in misty and polluted water. When water passes over and through coral reefs, they trap impurities and filter them from the water. This is why they consume particles mixed with ocean water and naturally filter the water. Clean and clear water help to survive coral for long life, and it also helps to make the beaches more attractive.

Controlling Carbon Levels with Coral Reefs Coral limestone is the result of the ocean processing carbon in the water. Carbon dioxide levels in the ocean water increase to their maximum levels when corals are absent. As a result of this increase in carbon dioxide levels in ocean water, other creatures in the marine ecosystem may suffer. As coral reefs grow, they absorb large amounts of carbon dioxide from the seawater around them. It reduces the amount of carbon dioxide in the ocean, which helps prevent climate change.

Food from Corals Many people consume fish and other seafood. Corals give food to millions of humans in the form of fishes and other sea creatures. Many coastal communities eat fish that live on or near coral reefs. Hence corals are vital to fulfilling the seafood requirement of humans.

Tourism and Corals Importance The coral reef tourism industry contributes greatly to the economy by providing food and jobs for people living nearby. Reefs are one of the most attractions that attract tourists to visit beaches. Furthermore, coral reefs are a source of employment for fishermen, tour guides, and others in the tourism industry. This is why they take the protection of beaches as a top priority so that more tourists come to visit these beaches every year.

Coral transplantation

Coral transplantation is a fairly new idea in this field. About two decades ago, the well-established scientific field of terrestrial forestation led scientists to propose a new coral reef restoration concept, deriving its rationale from silviculture. This concept involves two steps: rearing coral ‘seedlings’ in specially designed nurseries to plantable size; and then, transplanting the seedlings in damaged coral reef areas. The key lesson is that the cost of active rehabilitation of coastal habitats is substantial and likely to be far more than the costs of implementing effective protection of the habitat that may in time allow natural recovery.

*********End*********