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 final examinations
Q1. Write a detailed note on Roles and regulation of microbes in natural and manmade environment ?Answer*: Roles and regulation of microbes in natural and manmade environment ;*  other human activities produce pollutants, which accumulate in soils or aquatic environments, contaminating them Not only is human well-being at risk, but also environmental health. Currently, recycling, land-filling, incineration and pyrolysis are being used to reduce the concentration of toxic pollutants from contaminated sites, but too have adverse effects on the environment, producing even more resistant and highly toxic intermediate compounds.Moreover, these methods are expensive, and are difficult to execute for soil, water, and air decontamination.
Fifty years ago, the “green revolution” (a large increase in crop production in developing countries achieved by the use of artificial fertilizers, pesticides, and high-yield crop varieties) was launched, combining high-yielding cultivars, inorganic fertilizers, and pesticides to foster food production. The impacts were great, albeit, today, to maintain healthy environments, new technologies need to be applied, including microbial inoculations. These can either replace or reduce agrochemicals, and also clean areas heavily affected by pollution.

 Although green revolution and industrialization generally made human life easier and improved world's economy, effluents from industry also affected the health of soil, water and atmosphere leading to overall environmental degradation. Heavy metal contamination from industries poses deleterious effects not only on soil fertility and plant growth but also a serious serious threat to vulnerable human health.

 ***Following is the main points of role and regulation of microbes in natural and manmade environment*** ;
***1. Microorganisms as Plant Growth Promoters.***
Plants are entirely dependent upon soil microorganisms to utilize soils as a growth medium The rhizosphere has the greatest concentration of microorganisms Root exudates dictate the microbial communities . A wide range of microscopic organisms inhabits the rhizosphere: bacteria, algae, fungi, protozoa and actinomycetes.Of these, bacteria is the most abundant and important group of microorganisms regarding plant growth and productivityThey either live freely in rhizosphere, or in inter and intracellular spaces of root tissues, forming symbiotic associations with plants.Fungi play an important role in organic matter decomposition, and therefore nutrient cycling. Among soil fungi, arbuscular mycorrhizal fungi (AMF) are the most important and widely studied group as potential biofertilizers and biopesticides

Plants continually secrete synthesized food through their roots, nourishing a diverse community of soil rhizobacteria that in turn can strongly influence plant development by performing vital functions for plant Important functions of plant growth promoting rhizobacteria (PGPR) is phosphorus (P) solubilization in the soil heterotrophic bacteria that secrete organic acids, which solubilize fixed forms of P and release available forms into the soil solution.
 ***For example***, in many crops like sugarcane, tomato, and potato, inoculation by rhizobacterial strains resulted in complete prevention of pathogenic development due to the production of antibiotic substancesThe use of microorganisms as biopesticides is an environmentally friendly approach, as these microbes are very specific to their host pathogens. They could decrease agrochemical use, helping to foster environmental sustainability by reducing the harmful effects of toxic chemical compounds.

***2. Direct effects on plant growth;***
The most important direct effects involved in plant growth promoting include biological nitrogen fixation, phytohormone production, nutrient solubilization, siderophore production, and ACC deaminase activity

***Biological Nitrogen Fixation*** Atmospheric N is reduced to plant available form though natural or artificial means. When done artificially, N2 is reduced to ammonia,

in which natural gas (CH4) and N2 are converted to reduced forms of N at high temperature and pressure. In nature, N2 reduction is performed by N-fixing microorganisms that use the nitrogenase enzyme to reduce N2 to ammonia. This biological nitrogen fixation (BNF) is responsible for two-thirds of the total fixed N worldwide.
The microbes performing BNF can be generally categorized as symbiotic, associative symbiotic, and free-living. However, a number of free-living N fixing bacteria, such as Azotobacter, Gluconoacetobacter, and Azospirillum spp. are present in nature and fix N for plantsThe highest proportion of BNF is performed by symbiotic N2 fixers, i.e., rhizobia, which make symbiotic associations with the roots of leguminous plants

***Phytohormone Production***

Plants produce plant growth regulators/phytohormones, complex organic compounds that control plant growth and productivity.

Due to their complexity, plants need a considerable amount of energy and nutrients to synthesize them. Bacteria synthesize significant quantities of phytohormones, and release them into the plant, resulting in pronounced positive effects on plant growth and development.

It is reported that bacteria can produce up to 60 times more plant growth regulators than plants themselves Phytohormones, such as indole acetic acid (IAA), ethylene, abscisic acid, cytokinins, and gibberellins production by PGPR help to improve crop growth and performance. Phytohormones are involved in plant growth at different scales, such as cell division, cell enlargement, seed germination, root formation, and stem elongationthe production of auxins, cytokinin and gibberellins by many strains of Bacillus, Paenibacillus, Pseudomonas, and Azospirillum has been reported

***Nutrient Solubilisation***

Soil microorganisms are solely responsible for nutrient cycling. Around 50% of soil organic matter is composed of carbon, while the rest consists of N, P, S, and other nutrients.

In addition to the decomposition of soil organic matter, microbes also make chemically fixed nutrients, such as phosphorus (P), zinc (Zn), potassium (K), and iron (Fe) available. The main mechanism in the solubilization of P, K, Fe, and Zn is the lowering of pH from the production of organic acidsThe solubilizing soil bacteria include free living rhizobacteria, such as Pseudomonas, the symbiotic nitrogen fixers (rhizobia), and asymbiotic nitrogen fixers (Azotobacter).

***3. Indirect effect on plant growth;***Examples of indirect effects of using soil microorganisms for plant growth promotion are biological control of phytopathogens through competition for nutrients, production of antibiotics, hydrolytic enzymes, and siderophores,

PGPR can be used as a tool for biocontrol of plant pathogens as they indirectly improve plant growth by suppressing pathogenic microorganisms. The antibiotics produced are mostly effective against fungal pathogens The production of hydrolytic enzymes, such as lipases, proteases, glucanases and chitinases by PGPR is also an effective mechanism of biocontrol.

***4. Microbial remediation of environmental pollutions*;** There is an urgent need to treat industrial effluents to remove contaminants prior to discharge into the surrounding soil and water bodies. Attention has been given to remediation strategies of these pollutants due to their persistent nature and increased awareness among the global community

Several physicochemical methods have been used to detoxify industrial effluents. However, these methods are expensive and not environment friendly as they generate large amounts of sludge, which also requires safe disposal and can also cause secondary pollution. Microorganisms are being used for removing the pollutants from environment.

***5. Organic pollutions* ;** Persistant organic pollutants (POPs) include dyes used in textile and other inductries, pesticides and polycyclic aromatic hydrocarbons. These are toxic chemicals that have adverse effects on human health and environment around the world. Most of the POPs are generated in one country and affect human and wildlife far from where they are generated, used or released. Chemically these are complex compounds which are classified as xenobiotics thus barely removed from the environment. Microbial strains have been screened and identified that can degrade these POPs through their enzyme systems.
 recalcitrant compounds in industrial wastewater.

Fungal species are also reported to degrade/detoxify industrial effluents. Bacteria contain specific enzymatic/gene systems responsible for the degradation of toxic compounds found in industrial effluents. An azo-reductase enzyme has been isolated and characterized from bacterial species. Ago-dyes have strong bonding properties, but some bacteria have the ability to break them with the azo-reductase enzyme. Oxygenase and hydroxylase enzymes also degrade the intermediate products formed during decolorization|

Q2. Write a detailed note on Microorganisms in Terrestrial Environments ?
Answer; Terrestrial [Latin terra, earth] environments are dominated by inert solid materials. Organic substances, including microorganisms, are usually a minor part of a soil.

Soil is the habitat for a variety of organisms, including bacteria, fungi, protozoa, insects, nematodes, worms, and many other animals. Viruses also are present in soils. This complex biological community contributes to the formation, maintenance, and in some situations, the degradation and disappearance of soils.

***1. Microorganisms in soil environment;*** Most soil bacteria are located on the surfaces of soil particles and require water and nutrients that must be located in their immediate vicinity. Bacteria are found most frequently on surfaces within smaller soil pores (2 to 6 µm in diameter). Here they are probably less liable to be eaten by protozoa, unlike bacteria that are located on the exposed outer surface of a sand grain or organic matter particle. Terrestrial filamentous fungi bridge across open areas between soil particles or aggregates called peds, and are exposed to high levels of oxygen These fungi will tend to darken and form oxygen-impermeable structures including sclerotia and hyphen cords.
Protozoa also can influence nutrient cycling by feeding on “palatable” microorganisms. This process of microbivory, or use of microorganisms as a food source, results in higher rates of nitrogen and phosphorus mineralization, thus increasing the availability of nutrients for plant growth. A significant part of the biological activity of soils arises from enzymes released by plants, insects, and other animals, and fromlyses microorganisms. These free enzymes contribute to many hydrolytic degradation reactions, such as proteolysis; catalase and peroxidase activities also have been detected. Apparently these free enzymes associate with clays and humic materials, which helps to protect them from denaturation and microbial degradation.

***2. Microorganisms and the formation of different soils;***Once they are formed, most soils are rich sources of nutrients. Nutrients are found in organic matter, microorganisms, soil insects, and other animals. Plants grow, senesce, and die—and at each of these phases, they provide nutrients for soil organisms. Different plant parts vary in their nutrient content and biomasses. In addition, the turnover times for the various plant parts are quite different. The components in the plant-soil system with the lowest carbon-nitrogen ratios (most nutrient-rich) are soil organic matter, microorganisms, soil insects, and other soil animals.
In water-saturated bog areas, bacteria are more important than fungi in decomposition processes, and there is decreased degradation of lignified materials.

As in other soils, the nutrient cycling processes of nitrification, denitrification, nitrogen fixation, and methane synthesis and utilization, although occurring at slower rates, can have major impacts on global gaseous cycles Soils of hot and cold arid and semiarid deserts are dependent on periodic and infrequent rainfall When these rainfalls occur, water can puddle in low areas and be retained on the soil surface by microbial communities called desert crusts. These consist of cyan bacteria and associated communalistic microbes, including Anabaena, Micro coleus, Notec, and Scytonema. The depth of the photosynthetic layer is perhaps 1 mm, and the cyan bacterial filaments and slimes link the sand particles.
Geologically heated soils are found in such areas as Iceland and the Kamchatka peninsula in eastern Russia, and such heated soils

also occur at many mining waste sites. An important microorganism found in heated mining wastes is Thermo plasma. These soils are populated by bacterial and archaeal procaryotes, many of which are chemolithoautotrophs. A wide variety of chemoorganotrophic genera also are found in these environments; these include the aerobes Thermomicrobium, Thermoleophilum, and also the anaerobes Thermosipho and Thermo toga. Such geothermal soils have been of great interest as a source of new microbes to use in biotechnology, and the search for new, unique microorganisms in these areas is intensifying all over the world.

***3. Microorganisms and human health;*** Humans are in constant contact with soils. This occurs directly as when children or adults play in the “dirt,” or even when leafy and root vegetables, covered with soil dust, are eaten. In most cases the contact with soil is harmless. However, soils do contain a wide variety of pathogenic organisms. What is needed is an entry point and favorable conditions within or on the human body. A wide variety of anaerobes, including Clostridium, are present in soils. Unless there is a deep puncture wound that will provide the anaerobic environment required for their growth, anaerobes are of little concern. Soils contain other pathogens. Organisms such as Acanthamoeba, which can be inhaled from dust, may cause primary amebic meningoencephalitis.

When soils are used for surface disposal of human wastes without sewage treatment, the transmission of a wide variety of pathogens, including protozoa such as Acanthamoeba and Cyclospora can occur.
Soil and soil-related microorganisms also are of concern when they grow in buildings. This increasingly common problem, often linked to the flooding of houses located in low-lying districts or to moisture accumulation in sink and bathroom areas (even in large and modern homes), has led to major health problems. In a recent article it was noted that 50% of homes have mold problems, a major source of chronic sinus (sinus infection occurs when your nasal cavities become infected, swollen, and inflamed) infections. These molds also have been related to increases in asthma rates. The major responsible fungi are Stachybotrys chartarum, Eurotium herbariorum, and Aspergillus versicolor. Fungal growth results in a black slime; when this fungal growth dries, a dry dusty layer remains and the spores can be dispersed into the air. These spores are particularly dangerous for infants, whose lungs are less developed.
 ***5. Human microbiota* ;** The human body is populated by a large number of microorganisms, being distributed in various tissues and organs. It is believed that the abundance of microorganisms is greater than the number of cells in the body .The gastrointestinal tract of mammals maintains a highly diverse microbial population that plays an important role in nutrition metabolism, protection against pathogens, and the development of the immune system.

It is estimated that at least 1000 different bacterial species coexist the human intestinal tract. Although often considered as pathogens, the majority of microorganisms in intestinal tract have beneficial effects. They play multiple roles in the human host, as they are directly involved in the synthesis of vitamins and cofactors, help to degrade complex lipids and polysaccharides and also have detoxifying action.

Q3. Write a detailed note on the following ;
commensalism & predation ?
Answer; Commensalism ; Commensalism [Latin com, together, and mensa, table] is a relationship in which one symbiont, the commensal, benefits while the other (sometimes called the host) is neither harmed nor helped This is a unidirectional process. Often both the host and the commensal “eat at the same table.” The spatial proximity of the two partners permits the commensal to feed on substances captured or ingested by the host, and the commensal often obtains shelter by living either on or in the host.

 The commensal is not directly dependent on the host metabolically and causes it no particular harm. When the commensal is separated from its host experimentally, it can survive without being provided some factor or factors of host origin. Commensalistic relationships between microorganisms include situations in which the waste product of one microorganism is the substrate for another species.

 *An example* is nitrification, the oxidation of ammonium ion to nitrite by microorganisms such as Nitrosomonas, and the subsequent oxidation of the nitrite to nitrate by Nitrobacter and similar bacteria Nitrobacter benefits from its association with Nitrosomonas because it uses nitrite to obtain energy for growth. Commensalistic associations also occur when one microbial group modifies the environment to make it more suited for another organism.

***For example*,** in the intestine the common, nonpathogenic strain of Escherichia coli lives in the human colon, but also grows quite well outside the host, and thus is a typical communal. When oxygen is used up by the facultatively anaerobic E. coli, obligate anaerobes such as Bacteroides are able to grow in the colon The anaerobes benefit from their association with the host and E. coli, but E. coli derives no obvious benefit from the anaerobes. In this case the commensal E. coli contributes to the welfare of other symbionts. Commensalism can involve other environmental modifications. The synthesis of acidic waste products during fermentation stimulate the proliferation of more acid tolerant microorganisms, which are only a minor part of the microbial community at neutral pHs. A good example is the succession of microorganisms during milk spoilage.

When biofilms are formed , the colonization of a newly exposed surface by one type of microorganism (an initial colonizer) makes it possible for other microorganisms to attach to the microbially modified surface. Commensalism also is important in the colonization of the human body and the surfaces of other animals and plants.

***2. Predation*;** Predation is a widespread phenomenon where the predator engulfs or attacks the prey, The prey can be larger or smaller than the predator, and this normally results in the death of the prey. An interesting array of predatory bacteria are active in nature. Several of the best examples are including Bdellovibrio, Vampirococcus, and Daptobacter. Each of these has a unique mode of attack against a susceptible bacterium. Bdellovibrio penetrates the cell wall and multiplies between the wall and the plasma membrane, a periplasmic mode of attack, followed by lysis of the prey and release of progeny. Nonlytic forms also are observed. Vampirococcus attaches to the surface of the prey (an epibiotic relationship) and then secretes enzymes to release the cell contents. Daptobacter penetrates a susceptible host and uses the cytoplasmic contents as a nutrient source Ciliates are excellent examples of predators that engulf their prey,and based on work with fluorescently marked prey bacteria, a single ciliate can ingest 60 to 70 prey bacteria per hour!

 Predation on bacteria is important in the aquatic environment and in sewage treatment where the ciliates remove suspended bacteria that have not settled. Predation also can provide a protective, high nutrient environment for particular prey Ciliates ingest Legionella and protect this important pathogen from chlorine, which often is used in an attempt to control Legionella in cooling towers and air- conditioning units. The ciliate serves as a reservoir host. Legionella pneumophila also has been found to have a greater potential to invade macrophages and epithelial cells after predation, indicating that ingestion not only provides protection but also may make the bacterium a better pathogen. A similar phenomenon of survival in protozoa been observed for Mycobac terium avium, a pathogen of worldwide concern. These protective aspects of predation have major implications for survival and control of diseasecausing microorganisms in the biofilms present in water supplies and airconditioning systems.
 In marine systems the ingestion of nanoplankton by zooplankton provides a nutrientrich environment that allows nanoplankton reproduction in the digestive tract and promotes dissemination in the environment. A similar process occurs after bacteria are ingested by polychaetes (segmented worms found mostly in marine environments).
Q4. Write a detailed note on microbial habitat and functions ?
Answer; ***Aquatic environment and microorganisms*;** A major factor in aquatic environments is the movement of materials, whether they be gaseous, solid, or in the dissolved phase. These changes in concentration are part of the world of aquatic microorganisms; these microorganisms are able to respond rapidly to select their most suitable environment. The mixing and movement of nutrients, O2, and waste products that occur in freshwater and marine environments are the dominant factors controlling the microbial community.***For example*,** in deep lakes or oceans, organic matter from the surface can sink to great depths, creating nutrient-rich zones where decomposition takes place.

Gases and soluble wastes produced by microorganisms in these deep marine zones can move into overlying waters and stimulate the activity of other microbial groups.
Similar processes take place on a lesser scale in nutrient-rich lakes, biofilms, and in microbial mats, where gradients are established on a scale of micrometers

Aquatic environments have varied surface areas and volumes. They are found in locations as diverse as the human body; drinks and beverages; and the usual places one would expect—rivers, lakes, and the oceans. They also occur in water-saturated zones in materials we usually describe as soils! These environments can range from alkaline to extremely acidic. The temperatures within which microorganisms function in aquatic environments can range from 5 to 15°C at the lower range, to at least 113°C in geothermal areas. Some of the most intriguing microbes have come from the study of high-temperature environments, including the now-classic studies of T. D. Brock and his coworkers at Yellowstone National Park which led to the discovery of Thermus aquaticus, the source of Taq polymerase. Hyperthermophilic microorganisms, including Pyrolobus fumarii, also have been isolated from hydrothermal vents in deep marine environments.

***2. Gasses and aquatic microorganisms;*** In aquatic environments the distance (on a microbial scale) from an air bubble or the water surface limits oxygen diffusion. Thus aquatic environments are termed low oxygen diffusion environments. Oxygen not only diffuses slowly through waters, its solubility is further decreased at higher temperatures and with lower pressure Because of limited solubility and the low oxygen diffusion in waters, oxygen can be used by aerobic microorganisms faster than it can be replenished This frequently leads to the formation of hypoxic or anoxic zones in aquatic environments. These zones allow specialized anaerobic microbes, both chemotrophic and phototrophic, to grow in the lower regions of lakes where light can penetrate. In contrast, if the microorganisms are functioning in an extremely thin water film and oxygen containing air is close to them, they are in high oxygen diffusion environments.

The second major gas in water, CO2, plays many important roles in chemical and biological processes. The carbon dioxidebicarbonate-carbonate equilibrium can control the pH in weakly buffered waters, or it can be controlled by the pH of strongly buffered waters When autotrophic microorganisms such as algae use CO2, the pH of many waters will be increased. Other gases also are important in aquatic environments. These include nitrogen gas, used as a nitrogen source by nitrogen fixers; hydrogen, which is both a waste product and a vital substrate; and methane (CH4).

These gases vary in their water solubility, and methane is the least soluble of the three. Methane thus is an example of an ideal microbial waste product: once it is produced under anaerobic conditions, it leaves the microorganism’s environment by diffusing up in the water column and being released to the atmosphere. This eliminates the problem of toxic waste accumulation that occurs with many microbial metabolic products, such as organic acids and ammonium ion.

***3. Nutrients & aquatic environment*;** Nutrient concentrations in aquatic environments can vary from extremely low High nutrient levels are found in polluted environments and sewage treatment plants, for example. With changes in nutrient levels, shifts between lownutrient responsive and high-nutrient responsive microorganisms can occur

Nutrient turnover rates also vary. In marine environments the turnover time for nutrient processing may range from hundreds to thousands of years. In contrast, marsh and estuarine areas may have rapid rates of nutrient turnover, and a complex, diverse microbial community of rapidly responding microorganisms is present. The Winogradsky column, usually constructed using a glass graduated cylinder, illustrates many interactions and gradients that occur in aquatic environments.

In this glass cylinder a layer of reduced mud is mixed with sodium sulfate, sodium carbonate, and shredded newspaper—a cellulose source—and additional mud and water are placed in the column, which is then incubated in the light. A series of reactions occurs as the column begins to mature, with particular members of the microbial community developing in specific microenvironments in response to chemical gradients.

***4. Nutrient cycle in aquatic environment;***

The major source of organic matter in illuminated surface waters is photosynthetic activity, primarily from phytoplankton [Greek phyto, plant and planktos, wandering]. A common planktonic genus is Synechococcus, which can reach densities of 104 to 105 cells per milliliter at the ocean surface. Picocyanobacteria (very small cyanobacteria) may represent 20 to 80% of the total phytoplankton biomass upon which grazers depend

As they grow and fix carbon dioxide to form organic matter, the phytoplankton acquire needed nitrogen and phosphorus from the surrounding water.
If too much organic matter is added to a water, an anaerobic foul-smelling body of water is created that will not support top consumers such as fish. Once a body of water reaches this point, only major remediation efforts to limit nutrient inputs will restore it to its original condition and allow fish and other oxygen-requiring aquatic animals to survive.

***5. Global level movements of air;*** Global-level movements of air also affect marine microorganisms. The atmospheric movement of soils and industrial activities influence phytoplankton growth and their Redfield ratio.

In the northern Pacific, the water is iron-limited, and iron is being added to these waters by desertification and dust storms in central Asia, thus increasing primary production. In contrast, the northern Atlantic Ocean is nitrogen-limited, and a transition from N- to P-limitation is occurring with increased depositions of atmospheric nitrogen from human activities. The N:P ratio in the deep North Atlantic is increasing and altering the phytoplankton Redfield ratio**.

*6. Fresh water environment* ;** Most fresh water that is not locked up in ice sheets, glaciers, or ground waters is found in lakes and rivers. These provide microbial environments that are different from the larger oceanic systems in many important ways.

For example, in lakes, mixing and water exchange can be limited. This creates vertical gradients over much shorter distances. Changes in rivers occur over distance and/or time as water flows through river channels Lakes Lakes vary in nutrient status. Some are oligotrophic or nutrientpoor, others are eutrophic or nutrient-rich.

Q5. Define the following terms;
Answer; (a) ***Phytoplankton***
Phytoplankton) are the [autotrophic](https://en.wikipedia.org/wiki/Autotrophic) (self-feeding) components of the [plankton](https://en.wikipedia.org/wiki/Plankton) community and a key part of oceans, seas and freshwater basin [ecosystems](https://en.wikipedia.org/wiki/Aquatic_ecosystem). The name comes from the [Greek](https://en.wikipedia.org/wiki/Greek_language) words (*phyton*), meaning "[plant](https://en.wikipedia.org/wiki/Plant)", and), meaning "wanderer" or "drifter".[[1]](https://en.wikipedia.org/wiki/Phytoplankton#cite_note-1) Most phytoplankton are too small to be individually seen with the [unaided eye](https://en.wikipedia.org/wiki/Naked_eye). However, when present in high enough numbers, some varieties may be noticeable as colored patches on the water surface due to the presence of [chlorophyll](https://en.wikipedia.org/wiki/Chlorophyll) within their cells and accessory pigments (such as [phycobiliproteins](https://en.wikipedia.org/wiki/Phycobiliprotein) or [xanthophylls](https://en.wikipedia.org/wiki/Xanthophyll)) in some species. About 1% of the global [biomass](https://en.wikipedia.org/wiki/Biomass_%28ecology%29) is due to phytoplankton.

***(b) Mirioplankton***; Meroplankton are a wide variety of aquatic organisms which have both [planktonic](https://en.wikipedia.org/wiki/Plankton) and [benthic](https://en.wikipedia.org/wiki/Benthic_zone) stages in their life cycles. Much of the meroplankton consists of [larval](https://en.wikipedia.org/wiki/Larva) stages of larger organism Meroplankton can be contrasted with [holoplankton](https://en.wikipedia.org/wiki/Holoplankton), which are planktonic organisms that stay in the [pelagic zone](https://en.wikipedia.org/wiki/Pelagic_zone) as plankton throughout their entire life cycle

After a period of time in the plankton, many meroplankton graduate to the [nekton](https://en.wikipedia.org/wiki/Nekton) or adopt a [benthic](https://en.wikipedia.org/wiki/Benthos) (often [sessile](https://en.wikipedia.org/wiki/Sessility_%28zoology%29)) lifestyle on the [seafloor](https://en.wikipedia.org/wiki/Seafloor). The larval stages of benthic [invertebrates](https://en.wikipedia.org/wiki/Invertebrate) make up a significant proportion of planktonic communities.  The planktonic larval stage is particularly crucial to many benthic invertebrate in order to [disperse](https://en.wikipedia.org/wiki/Dispersal_vector) their young.

***(c) Barophiles*** An [organism](https://www.biologyonline.com/dictionary/organism) that grows in high-pressure [environment](https://www.biologyonline.com/dictionary/environment)s

A barophile is an [organism](https://www.biologyonline.com/dictionary/organism) that needs a high-pressure environment in order to grow. Barophiles are a type of an [extremophile](https://www.biologyonline.com/dictionary/extremophile). An example of a high-pressure habitat is the deep-sea environment, such as ocean floors and Dee lakes where the pressure can exceed 380 atm. Another is the subsurface rocks with high litho static pressures.

***(d) Epitimnion ;*** The **e**pilimnion or surface layer is the top-most layer in a thermally [stratified](https://en.wikipedia.org/wiki/Lake_stratification) [lake](https://en.wikipedia.org/wiki/Lake), occurring above the deeper [hypolimnion](https://en.wikipedia.org/wiki/Hypolimnion). It is warmer and typically has a higher [pH](https://en.wikipedia.org/wiki/PH) and higher [dissolved oxygen](https://en.wikipedia.org/wiki/Dissolved_oxygen) concentration than the hypolimnion.

Being exposed at the surface, it typically becomes turbulently mixed as a result of surface wind-mixing. It is also free to exchange dissolved gases such as [O2](https://en.wikipedia.org/wiki/Oxygen) and [CO2](https://en.wikipedia.org/wiki/Carbon_dioxide) with the atmosphere. Because this layer receives the most sunlight it contains the most [phytoplankton](https://en.wikipedia.org/wiki/Phytoplankton). As they grow and reproduce they absorb nutrients from the water, when they die they sink into the hypolimnion resulting in the epilimnion becoming depleted of nutrients.

***(e) Thermocline***; A thermocline (also known as the thermal layer or the metalimnion in lakes) is a thin but distinct layer in a large body of fluid (e.g. water, as in an ocean or lake; or air, e.g. an atmosphere) in which temperature changes more rapidly with depth than it does in the layers above or below. In the ocean, the thermocline divides the upper mixed layer from the calm deep water below.

Depending largely on [season](https://en.wikipedia.org/wiki/Season), [latitude](https://en.wikipedia.org/wiki/Latitude), and [turbulent](https://en.wikipedia.org/wiki/Turbulence) mixing by [wind](https://en.wikipedia.org/wiki/Wind), thermoclines may be a semi-permanent feature of the [body of water](https://en.wikipedia.org/wiki/Body_of_water) in which they occur, or they may form temporarily in response to phenomena such as the radiative [heating/cooling](https://en.wikipedia.org/wiki/Diurnal_temperature_variation) of surface water during the day/night. Factors that affect the depth and thickness of a thermocline include [seasonal weather variations](https://en.wikipedia.org/wiki/Seasonal_lag), latitude, and local environmental conditions, such as [tides](https://en.wikipedia.org/wiki/Tide) and [currents](https://en.wikipedia.org/wiki/Current_%28fluid%29).

 THE END