



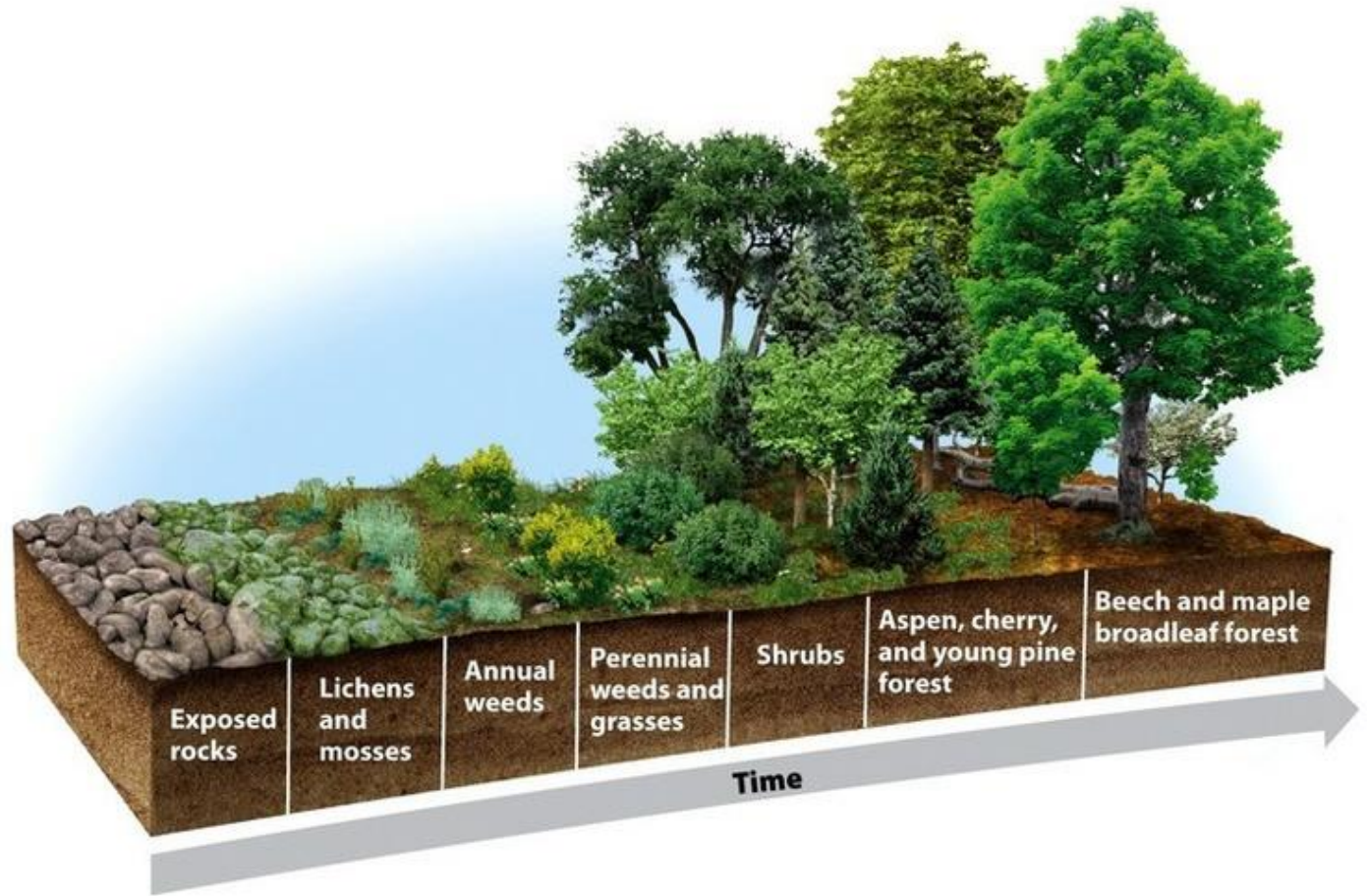
Ecological succession

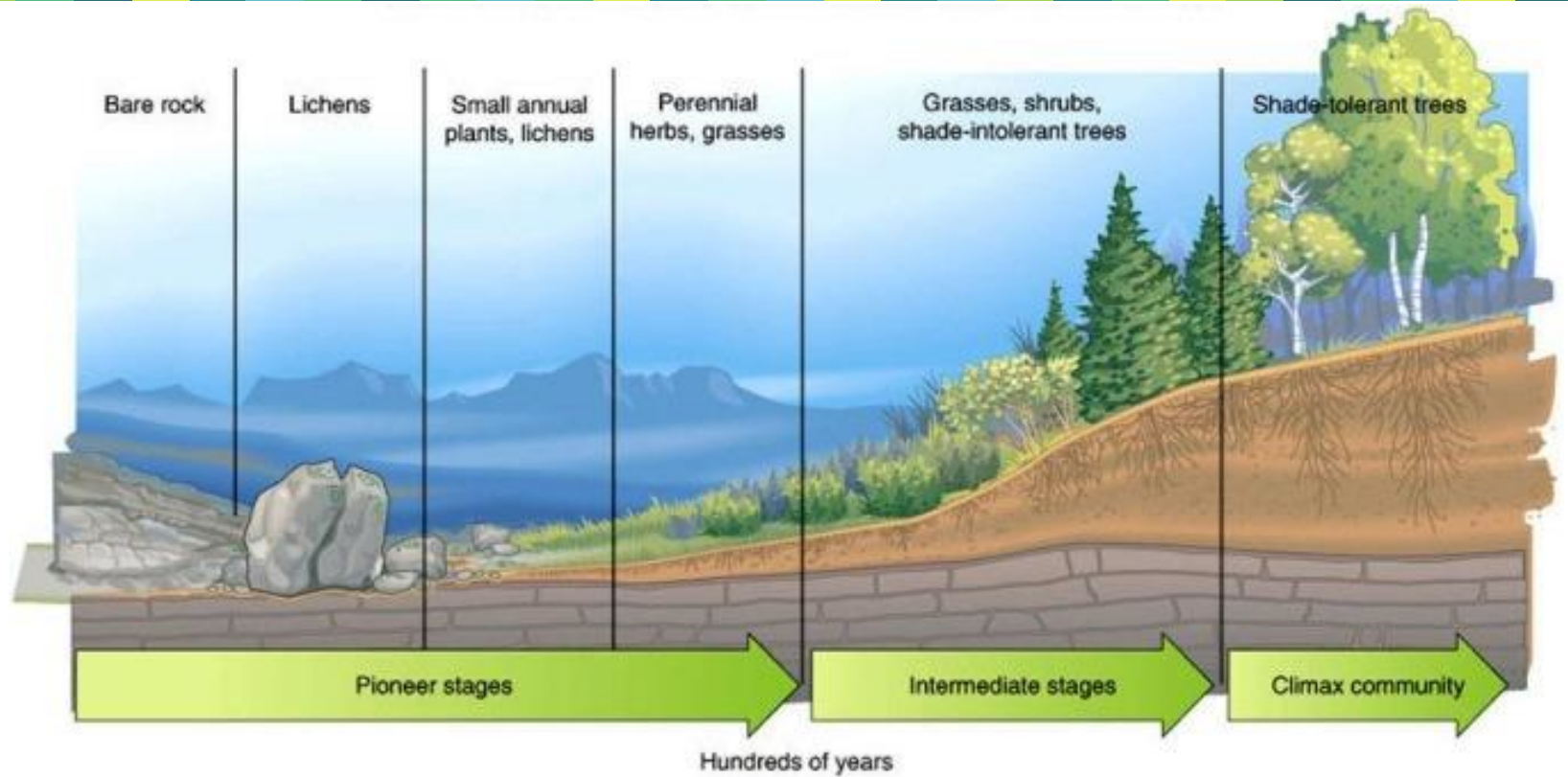
- It is the **process by which one community is replaced by another community over a period of time.**
- The changes are **brought about by both the biotic and abiotic components** in the community.
- The extent of change is influenced by the **physical environment.**

अनुक्रमण: समुदाय में परिवर्तन

इस क्रिया में समुदाय और पर्यावरण में पारस्परिक क्रिया से जो परिवर्तन उत्पन्न होते हैं उसके फल स्वरूप क्रमशः है एक समुदाय दूसरे के द्वारा प्रतिस्थापित होते हैं यह एक कल पथ गामी पारिस्थितिक समय में होने वाला वानस्पतिक परिवर्तन है

- The first plant to colonize an area is called the **pioneer community**. नवीन समुदाय
- The final stage of succession is called the **climax community**. चरम समुदाय
- A climax community is stable, mature, more complex and long-lasting.
- The stage leading to the climax community is called **successional stages or seres**.
- Each transitional community that is formed and replaced during succession is called a **stage in succession or a seral community**. क्रम की समुदाय





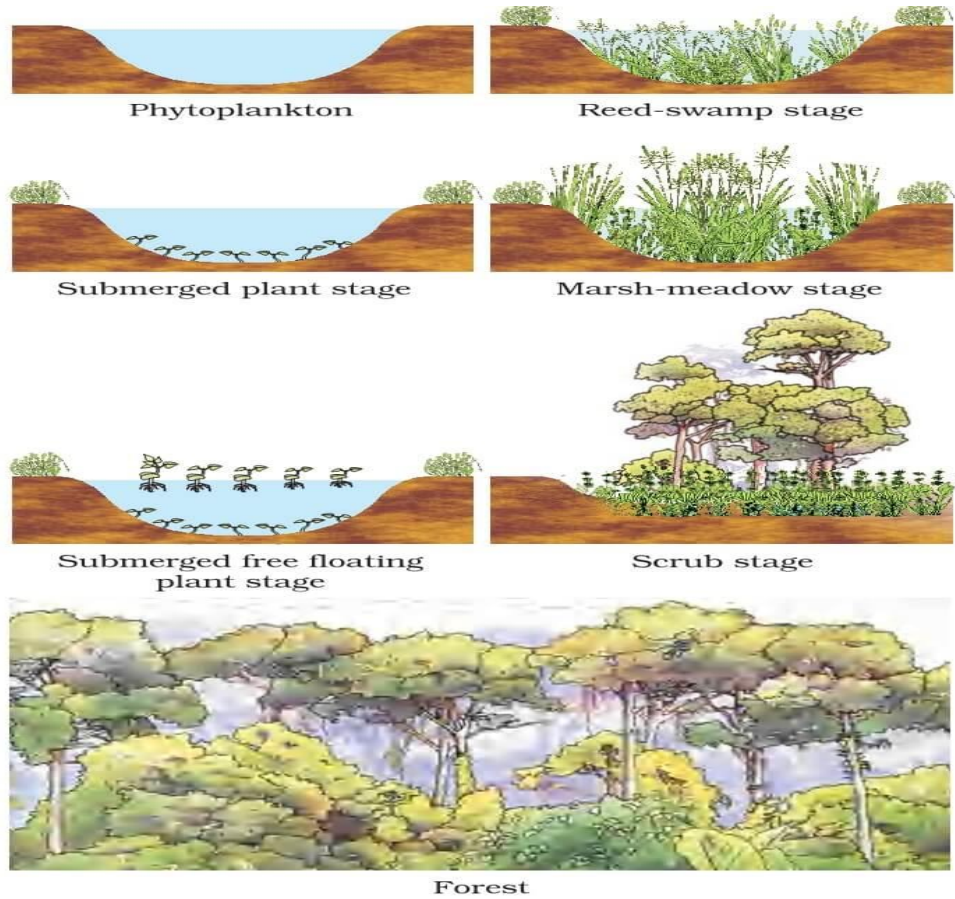


Figure 14.5 Diagrammatic representation of primary succession

Types of Seres	Explanation
Hydrosere	Succession in aquatic habitat.
Xerosere	Succession in dry habitat.
Lithosere	Succession on a bare rock surface.
Psammosere	Succession initiating on sandy areas.
Halosere	Succession starting in saline soil or water.
Senile	Succession of microorganism on dead matter.
Eosere	Development of vegetation in an era.

Orderly Sequence of Primary Succession

Pioneers Stages

Pioneer Species/Community

High growth rate but short life span
Bare Rocks, Lichens

Intermediate Stages

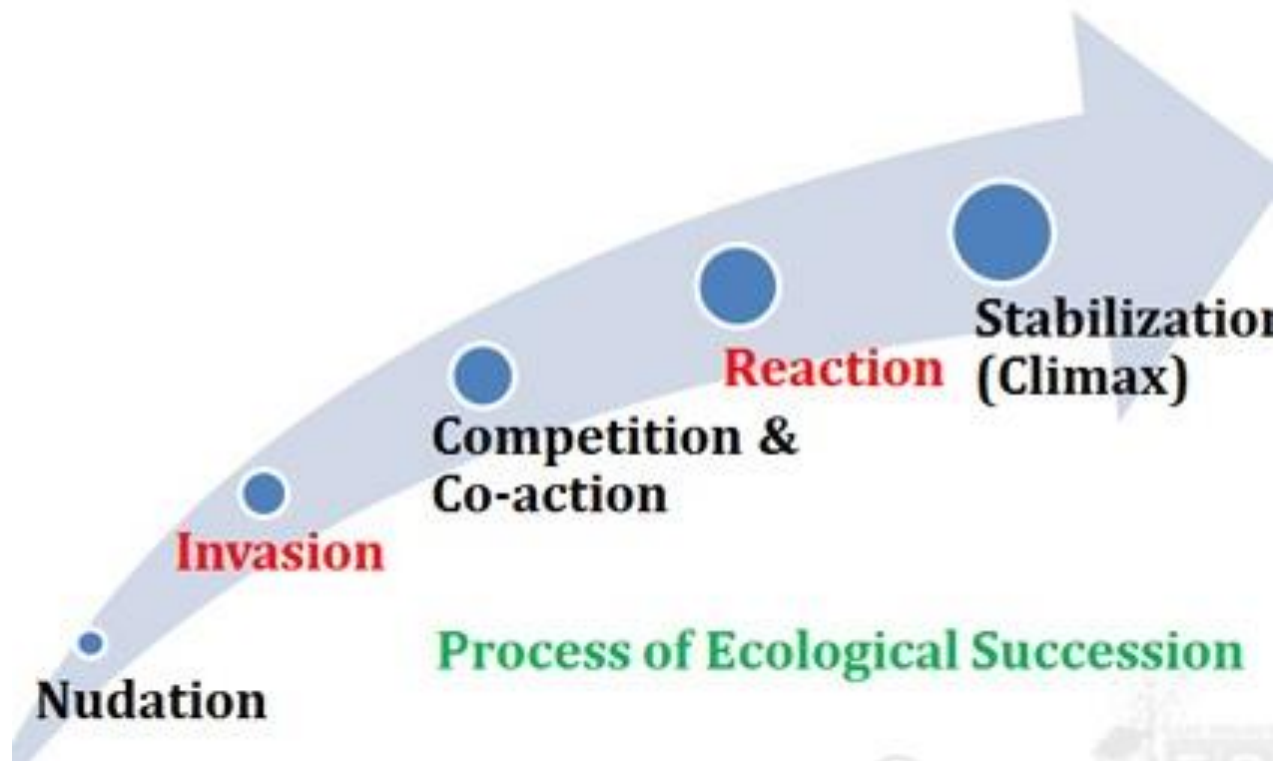
Seral Community: Temporary Community

Grasses, Shrubs

Climax Community

Terminal/Final Community

Stable, mature, more complex and long lasting. Shade tolerant trees



Nudation:

The development of bare area is the initial prerequisite. The cause of nudation may be topographic (soil erosion, landslide, volcanic activity, etc), climatic and biotic (human beings and pathogens).

न्यूडेशन

Invasion: आक्रमण

This is the successful establishment of a species in a bare area. The species actually reaches this new site from any other area..

Competition and coactions: स्पर्धा

After aggregation of a large number of individuals of the species at the limited place, there develops competition mainly for space and nutrition. Individuals of a species affect each other's life in various ways and this is called coactions. The species, if unable to compete with other species, if present, would be discarded.

Reaction: प्रतिक्रिया

This is the most important stage in succession. The mechanism of the modification of the environment through the influence of living organisms on it, is known as reaction. As a result of reaction, changes takes place in soil, water, light conditions, temperature etc. of the environment. Due to all these the environment is modified, becoming unsuitable for the existing community which sooner or later is replaced by another community (seral community). The whole sequence of communities that replaces one another in the given area is called a sere, and various communities constituting the sere as seral communities.

Stabilization (climax): चरम अवस्था

This is the final stage of development. Climax community is nearly stable and will not change so long as the climate and physiographic remain the same. However, the environment as well as the community are in a dynamic state.

Some ecologists (Gleason, 1929) have talked of retrogressive succession in which continuous biotic influences have some degenerating influence on the process. Due to destructive effects on organisms, sometimes the development of disturbed communities does not occur and the process of succession instead of progressive becomes retrogressive. As for example, forest may change to shrubby or grassland community. This is called retrogressive succession.

- Ecological succession is characterised by the following:
 - **increased productivity,**
 - **the shift of nutrients** from the reservoirs,
 - **increased diversity of organisms** with increased development of niche, and
 - a consequent increase in the **complexity of food webs.**
- Succession occurs **faster in areas existing in the middle part of a large continent.**
- This is because, here all communities and seeds of plants belonging to the different seres would reach much faster, establish, and ultimately result in the climax community.

- During succession, **some species colonise an area and their populations become more numerous**, whereas populations of **other species decline and even disappear**.
- There are **two types** of successions such as
 1. **Primary** succession and
 2. **Secondary** succession

Primary Succession

- It takes place in a region **where a community never existed previously.**
- Such regions include **emerging islands, newly formed deltas, newly created pond, reservoir, etc.**
- The species that invade a bare area are called **pioneer species.**
- A pioneer species have **a short lifespan though it may have a high growth rate.**
- The collection of pioneer species that form in a bare region is called the **pioneer community.**

Secondary Succession

- When an existing community is destroyed, another community forms at the same place. Such a **process through which a community develops after the destruction of an existing community** is called secondary succession.
- The removal or destruction of the existing community **takes place due to natural disasters** like forest fires, volcanoes, etc or **due to human activities** like tilling or harvesting.
- In secondary succession, the species that invade **depend on the condition of the soil, availability of water, the environment as also the seeds or other propagules present.**



Established
climax
community



Disturbance
destroys the
community



Biota removed
but the soil
remains



Fast growing
plants initially
dominant



Eventually climax
community is
re-established

Primary vs Secondary Succession

- It is **difficult to observe primary succession**, unlike secondary succession.
This is because there are **relatively very few places on earth** that do not already have communities of organisms.
- **Primary succession is very slow** as compared to secondary succession.
This is because **soil formation takes a long time in primary succession** while secondary succession starts on soil that is nutritious.

Seral Community

- In the succession process, **the pioneer community** after some time gets **replaced by another community with different species combinations.**
- This **second community** gets replaced by a **third community** and so on.
- This **process continues sequentially** in which a community replaced **previously by another community.**
- Each **transitional (temporary) community** that is formed and replaced during succession is called **a stage in succession** or **a seral community.**
- The **entire sequence of communities** that successively change in a given area is called **sere(s).**

Climax Community

- The **final community** which is established by ecological succession and is **in near equilibrium** with the environment is the climax community.
- The climax community that is established is **stable, mature, more complex, and long-lasting**.
- As long as it is undisturbed, a **climax community remains relatively stable in dynamic equilibrium** with the prevailing climate and habitat factors.

Different Types of Succession

Autogenic and Allogenic

When succession is **caused by living inhabitants** of that community itself, the process is called autogenic succession, while change brought about **by external forces** is known as allogenic succession. An allogenic succession can be brought about in a number of ways which can include:

- Volcanic eruptions
- Meteor or comet strike
- Flooding
- Drought

Xerarch and Hydrarch

- Succession that **occurs on land where moisture content is low** for e.g. on bare rock is known as Xerarch.
- Succession that **takes place in a water body**, like ponds or lakes is called Hydrarch.

Autotrophic and Heterotrophic

- Succession in which, the **green plants (initially) are much greater in quantity** is known as autotrophic succession and the ones in which the **heterotrophs are greater in quantity** are known as **heterotrophic succession**.

Biotic Interactions

सामुदायिक अंतः क्रियाएं

- The individuals in a biological community of an area or ecosystem **interact with one another in a number of ways.**
- The interactions that **occur among different individuals of the same species** are termed as **Intraspecific interaction.**
- The interactions **among individuals of different species** in a community are called **Interspecific interaction.**

'0' is no effect; '-' is detrimental; '+' is beneficial.

Types of Interaction		Result	
		Species 1	Species 2
Negative (at least one of the species is harmed)	Amensalism	-	0
	Predation	+	-
	Parasitism	+	-
	Competition	-	-
Positive (both species are benefited)	Commensalism	+	0
	Mutualism	+	+

1. Amensalism असहबोजी

- It is a type of **negative association**.
- In amensalism, **one species is harmed by the other species which remains unaffected by the presence of the other species**.
- For example, the **bread mould fungi Penicillium** produces penicillin an antibiotic substance that **inhibits the growth of a variety of bacteria**.
- **Penicillium** benefits apparently by having greater availability of **food** when the competition because of the bacteria is removed.

Amensalism (0/-)

- Ex: Black Walnut Trees produce chemicals which prevent other trees from growing near them



2. Predation पशुपक्षी

- Predators act as **conduits for transferring energy from one trophic level to another**. They keep prey populations under control.
- **The introduction of an exotic species into an area may become invasive** if there are no natural predators.
- Predators also help in **maintaining species diversity in a community**, by **reducing the intensity of competition** among competing for prey species.
- Prey species (plants and animals) are **adapted in various ways to prevent being captured by the predator**.



3. Parasitism परजीविता

- One species is harmed and the other benefits.
- The parasite lives in/on another living species called the host from which the parasite gets its nourishment and often shelter.
- The parasite is benefited and the host is harmed.
- Parasites have special adaptations to counteract and neutralise the mechanisms of the host species. Eg. Cuscuta plant has no leaves.
- Tapeworm, roundworm, malarial parasite, many bacteria, fungi, and viruses are common parasites of humans.



PARASITISM

- Example: Fleas and mosquitoes feed on blood from other organisms.
 - In this type of parasitic relationship, the host needs to stay alive and it is not damaged greatly



- **Ectoparasites-**

Parasites that **feed on the external surface of the host organism** are called ectoparasites. Eg. - lice on humans and ticks on dogs.

- **Endoparasites-**

Endoparasites are those that **live inside the host body at different sites** such as a tapeworm, that lives inside its host.

Brood Parasitism-

Brood parasitism in birds is **a fascinating example of parasitism** in which the parasitic bird lays its eggs in the nest of its host and lets the host incubate them. Eg. cuckoo and crows.

4. Competition प्रतिस्पर्धा

- This is an interaction between two populations in which **both species are harmed to some extent.**
- Competition occurs when two populations or species, **both need a vital resource that is in short supply.**
- The vital resource could be **food, water, shelter, nesting site, mates or space.**
- For instance, in some shallow South American lakes **visiting flamingoes and resident fishes compete** for their common food, the zooplankton in the lake.

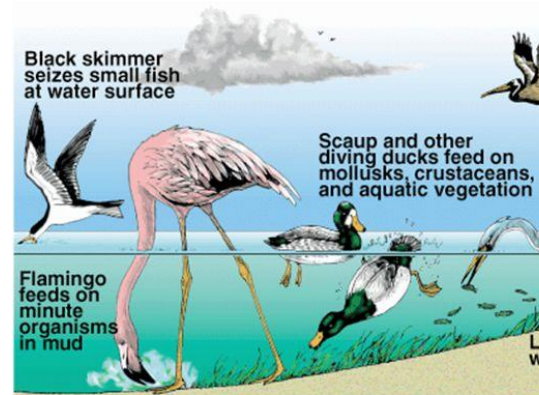


- **Two closely related species competing for the same resources cannot coexist indefinitely** and the competitively inferior one will be eliminated eventually. This may be true if resources are limiting, but not otherwise.
- It can not be ruled out the occurrence of interspecific competition in nature, but **species facing competition might evolve mechanisms that promote coexistence rather than exclusion.**
- Eg. - **resource partitioning.** If two species compete for the same resource, they could avoid competition by choosing, for instance, **different times for feeding or different foraging patterns.**

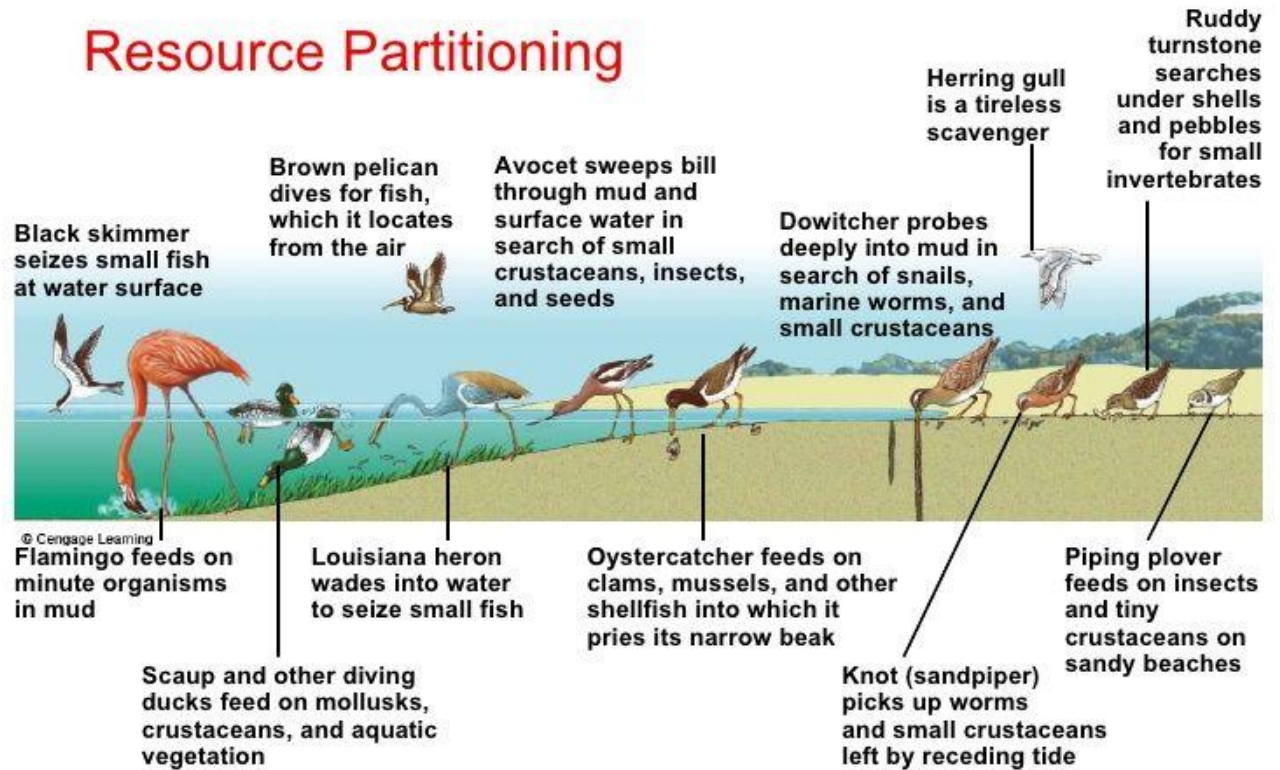
Resource Partitioning

Species with similar resource requirements can coexist because they use limited resources:

- at different times
- in different ways
- in different places



Resource Partitioning



Resource Partitioning

**Blakburnian
Warbler**



**Black-throated
Green Warbler**



**Cape May
Warbler**



**Bay-breasted
Warbler**



**Yellow-rumped
Warbler**



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5. Commensalism સહજીવિતા

- The interaction where **one species is benefitted** and the other is **neither benefitted nor harmed** is called commensalism.
- Some species benefit **by utilising the shelter or transport of another species**.
- For example, **epiphytes live on the surface of other plants** like ferns, mosses, and orchids and use the surface of trees for support and for obtaining sunlight and moisture. The tree does not benefit from this relationship and is not harmed as well.
- Other examples - **barnacles growing on the back of a whale, cattle egret and grazing cattle** in close association, **sea anemone and clownfish**, etc.



6. Mutualism

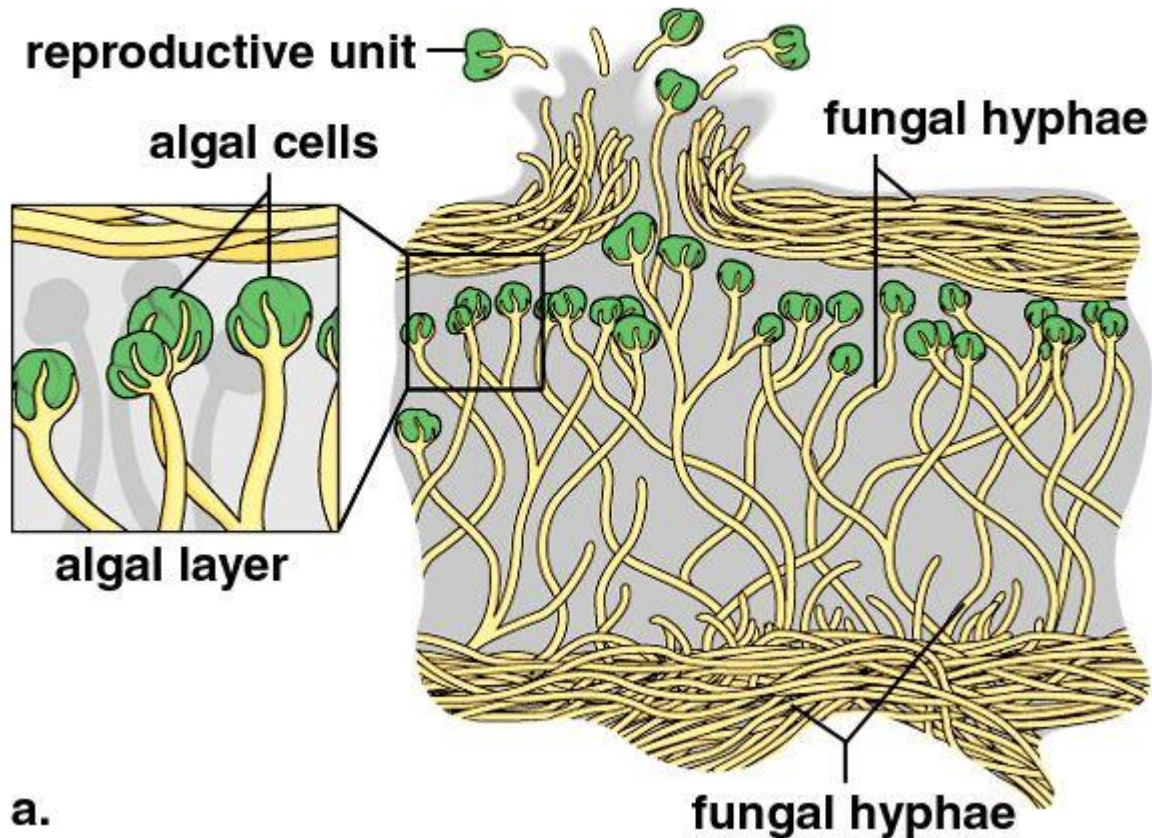
सहोपकारिता

- **Both the species are benefitted** in this interaction.
- In some interactions, mutualism is so strong that the **species involved in the interaction cannot survive without each other.**
- Such an association is called a **symbiotic relationship**. Some examples are such as
 - **Lichens** - algae and fungus
 - **Mycorrhizae** - fungus and roots of higher plants
 - **Plants and animals** - animals help in pollination and plants provide food



The ants obtain food and shelter, and the acacia depends on the ants for protection from browsing animals

Lichen morphology



Some Characteristics of Interactions

- **Both the species benefit in Mutualism and both lose in Competition** in their interactions with each other.
- **In both Parasitism and Predation, only one species benefits** (parasite and predator, respectively) and the interaction is **detrimental to the other species** (host and prey, respectively).
- **Predation, Parasitism, and Commensalisms** share a common characteristic— **the interacting species live closely together.**

Biogeochemical cycles

- The movement of nutrients from the environment into plants and animals and again back to the environment is known as nutrient cycling.
- Nutrients are absorbed from the soil by green plants which are passed onto primary consumers and thereafter to secondary and tertiary consumers.
- When the producers and consumers die, nutrients are released back into the soil by detritivores from the dead remains of organisms.

- Nutrient cycle can be of two types
 - **Gaseous** - atmosphere or the hydrosphere is the main reservoir
 - **Sedimentary** - earth's crust is the main reservoir.

1. Water cycle/hydrological cycle

- Water is essential for life.
- It not only provides transportation for nutrient cycling, but also acts as a solvent medium for the uptake of nutrients by various organisms.
- Precipitation (rain, snow, slush dew etc.) is the only source of water on the earth.
- Water received from the atmosphere on the earth returns back to the atmosphere as water vapour resulting from direct evaporation and through evapotranspiration.

- This continuous movement of water in the biosphere is called water cycle (hydrological cycle).
- The driving forces for water cycle are solar radiation and gravity.
- Evaporation and precipitation are two main processes involved in water cycle. These two processes alternate with each other.
- Water from oceans, lakes, ponds, rivers and streams evaporates by sun's heat energy. Plants also transpire huge amounts of water.
- Water remains in the vapour state in air and forms clouds which drift with wind.
- Clouds meet with the cold air in the mountainous regions above the forests and condense to form rain precipitate which comes down due to gravity.

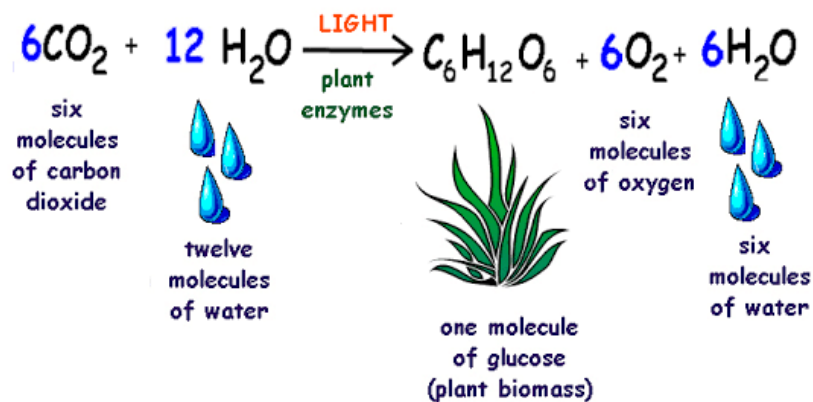
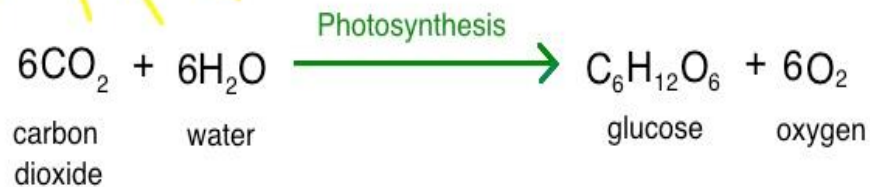
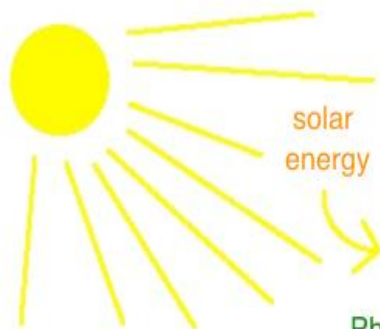
2. Carbon cycle

- Almost all the carbon in nature is derived from carbon dioxide present in the atmosphere.
- It is highly soluble in water. Therefore, oceans also contain large quantities of dissolved carbon dioxide.
- It is vital for the production of carbohydrates through photosynthesis by plants.

Steps in global Carbon cycle

1. Photosynthesis:

- Green plants in the presence of sunlight utilize CO_2 in the process of photosynthesis.
- A part of the food made is used by plants for their own metabolism.
- Rest of the food is stored as their biomass which is available to various herbivores, heterotrophs, including human beings and microorganisms as food.
- Forests act as reservoirs of CO_2 as carbon fixed by the trees remain stored in them for long due to their long life cycles.



- A very large amount of CO_2 is released through forest fires.

2. Respiration:

- Respiration is a metabolic process where food is oxidized to liberate energy, CO_2 and water.
- The energy released from respiration is used for carrying out life processes by living organisms (plants, animals, decomposers etc.).
- Thus CO_2 is released into the atmosphere through this process.

Adenosine triphosphate (ATP), energy-carrying molecule found in the cells of all living things. **ATP** captures chemical energy obtained from the breakdown of food molecules and releases it to fuel other cellular processes.

Cellular Respiration Equation



- Requirements:

- $\text{C}_6\text{H}_{12}\text{O}_6$ – organic sugar comes from digested foods eaten
- 6O_2 – oxygen comes from air you breathe

- Products:

- 6CO_2 – carbon dioxide is released by breathing out
- $6\text{H}_2\text{O}$ – water is released as a waste in your urine, sweat or breath
- Energy – chemical ATP energy is released

3. Decomposition:

- All the food assimilated by animals or synthesized by plants is not metabolized by them completely.
- A major part is retained by them as their own biomass which becomes available to decomposers on their death.
- The dead organic matter is decomposed by microorganisms and CO_2 is released into the atmosphere by decomposers.

4. Combustion:

Burning of biomass releases carbon dioxide into the atmosphere.

5. Impact of human activities:

Since the industrial era, large scale deforestation and ever growing consumption of fossil fuels by growing numbers of industries, power plants and automobiles are primarily responsible for increasing the emission of carbon dioxide.

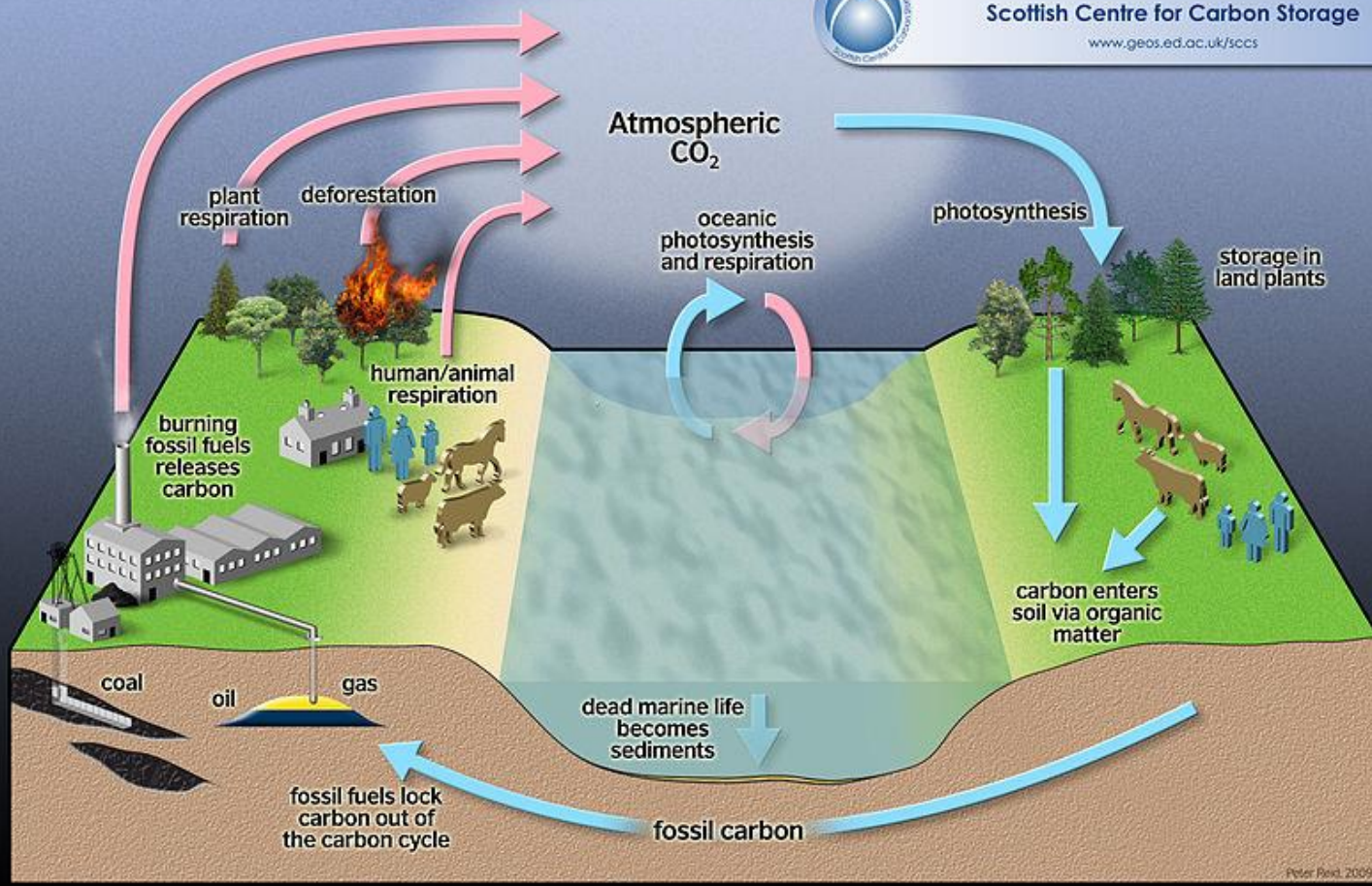
6. Storage in long term cycle:

- Some carbon accumulates as un-decomposed organic matter in marshy soil or as insoluble carbonates in ocean bottom where it remains buried for millions of years.
- The carbonate rocks may be uplifted geologically and exposed to erosion, releasing the carbon compounds into streams and rivers.



Scottish Centre for Carbon Storage

www.geos.ed.ac.uk/sccs

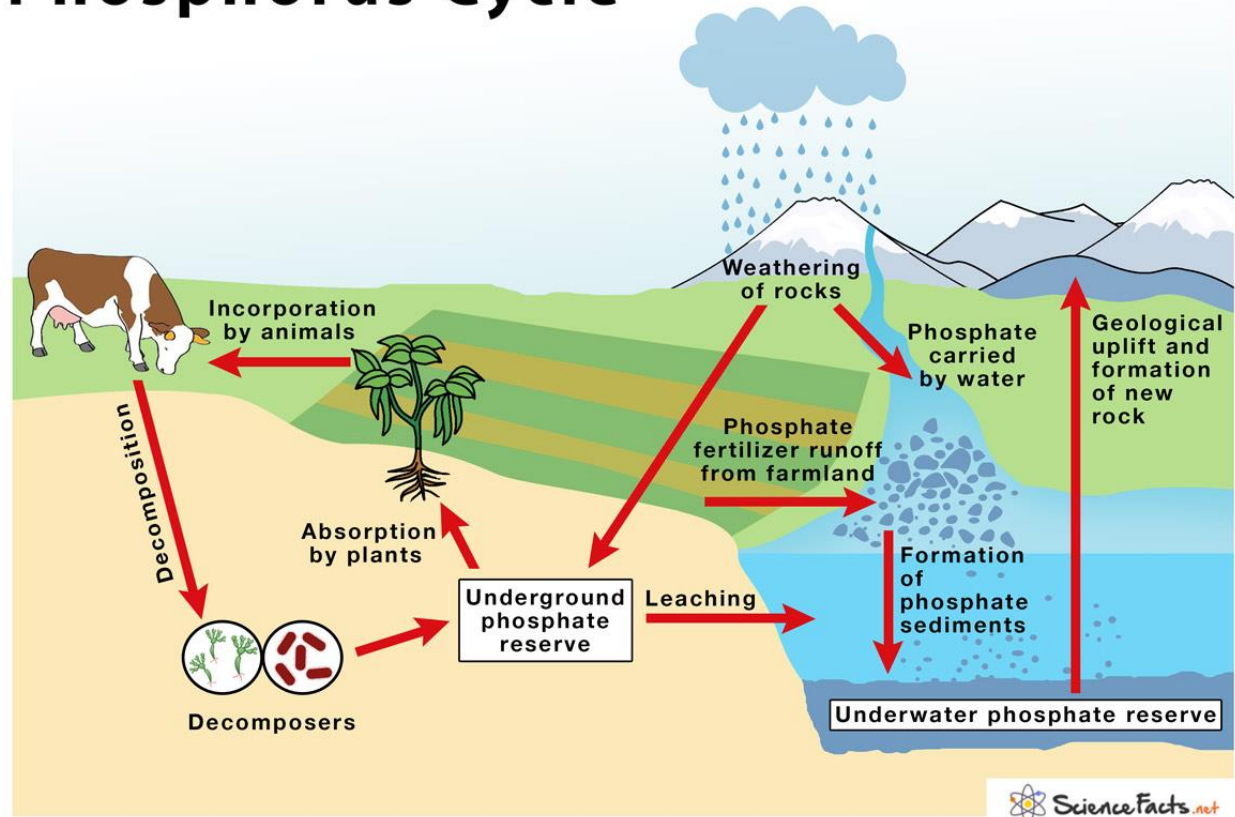


- When fossil fuels such as coals, oil and natural gas etc. are burned, the carbon stored in them is released back into the atmosphere as carbon-dioxide.

C. Phosphorus cycle

- Phosphorus is a major constituent of biological membranes, nucleic acids and cellular energy transfer systems.
- Many animals also need large quantities of this element to make shells, bones and teeth.
- The natural reservoir of phosphorus is rock, which contains phosphorus in the form of phosphates.
- When rocks are weathered, minute amounts of these phosphates dissolve in soil solution and are absorbed by the roots of the plants .
- Herbivores and other animals obtain this element from plants.

Phosphorus Cycle



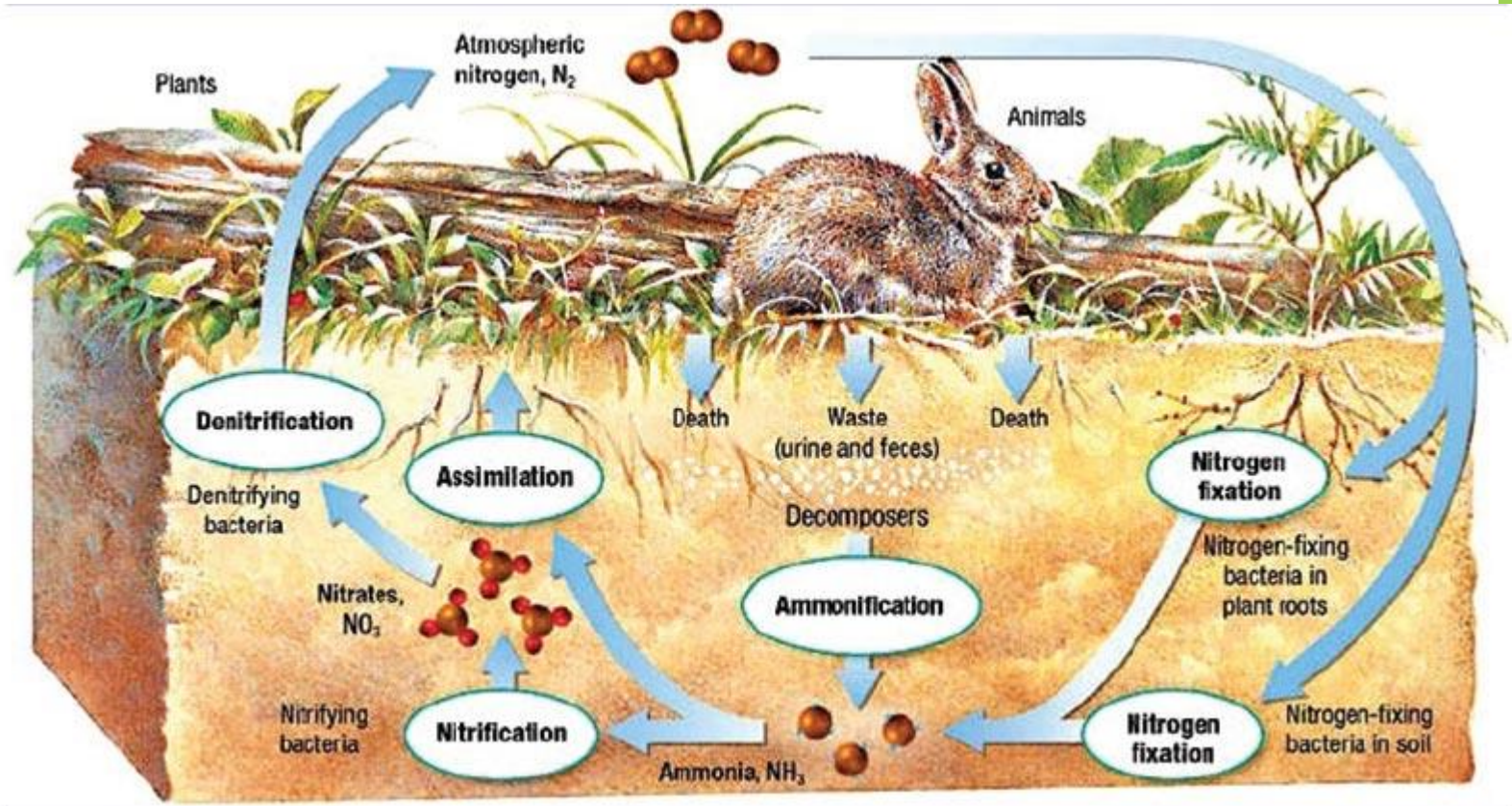
- The waste products and the dead organisms are decomposed by phosphate-solubilising bacteria releasing phosphorus.

Differences between carbon cycle and phosphorus cycle

- Unlike carbon cycle, there is no respiratory release of phosphorus into atmosphere.
- Atmospheric inputs of phosphorus through rainfall are much smaller than carbon inputs.
- Gaseous exchanges of phosphorus between organism and environment are negligible.

Nitrogen cycle

- Nitrogen is an essential component of protein required by all living organisms including human beings.
- Our atmosphere contains nearly 78% of nitrogen but it cannot be used directly i.e in its elemental form by the majority of living organisms.
- Therefore, the atmospheric nitrogen needs to be fixed i.e converted to ammonia, nitrites and nitrates so that it is taken by various organisms.
- Like carbon dioxide, nitrogen also cycles from gaseous phase to solid phase then back to gaseous phase through the activity of a wide variety of organisms.



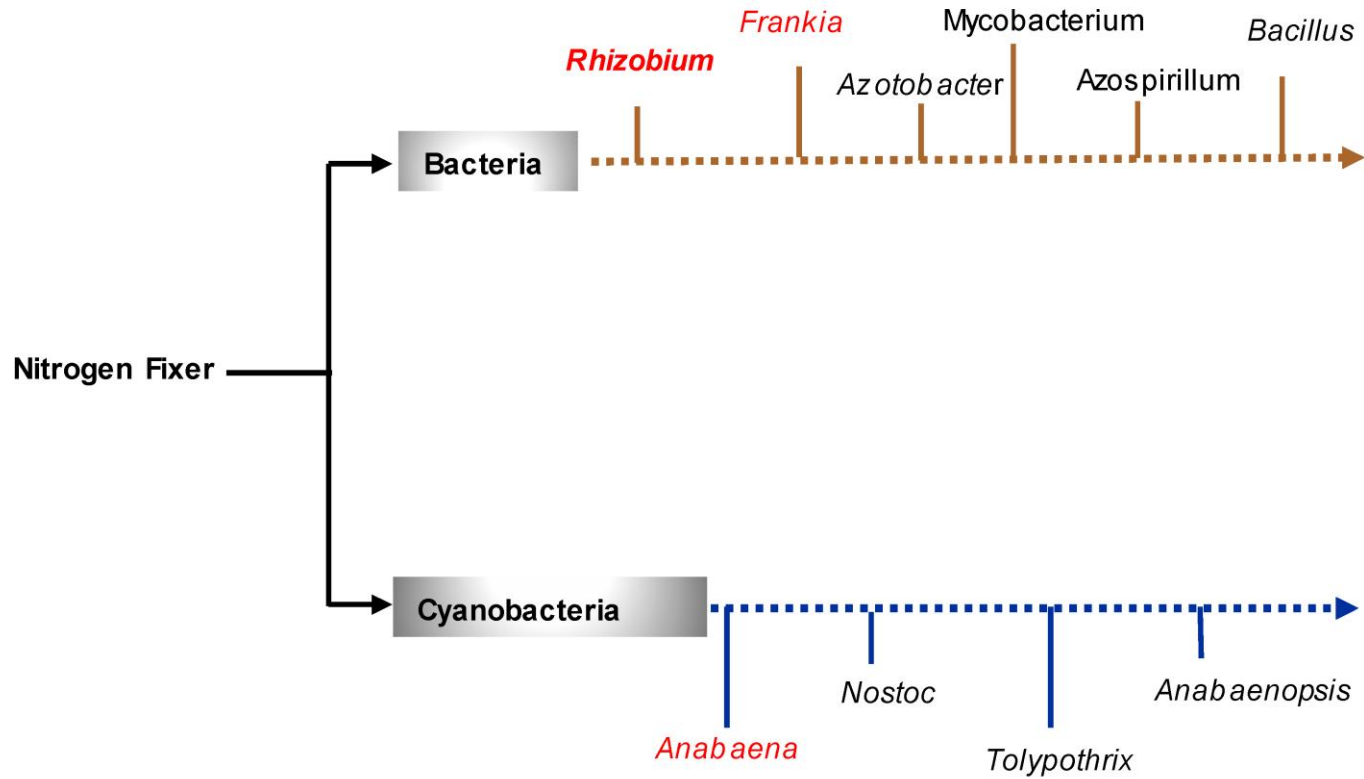
Agents of nitrogen fixation

Atmospheric nitrogen is fixed mainly by three agents:

1. Bacterial fixation: There are two types of bacteria-
 - a. Symbiotic bacteria e.g. Rhizobium in the root nodules of leguminous plants.
 - b. Free Living e.g. 1. Nostoc 2. Azotobacter 3. Cyanobacteria
2. Industrial activities e.g. manufacture of nitrogenous fertilizers
3. Atmospheric phenomena such as thunder and lightning

Processes in nitrogen cycle

- **Nitrogen fixation:** This process involves conversion of gaseous nitrogen into Ammonia, nitrites and nitrates.
- **Nitrification:**
 - It is a process by which ammonia is converted into nitrates or nitrites by Nitrosomonas and Nitrococcus bacteria respectively.
 - Another soil bacteria Nitrobacter can convert nitrite into nitrate



- (a) क्लॉस्ट्रिडियम (Clostridium)—
अवायवीय, मुक्तजीवी व मृदोत्पन्न।
- (b) एजोटोबैक्टर (Azotobacter)—
वायवीय, मुक्तजीवी, मृतोपजीवी व मृदोत्पन्न।
- (c) राइजोबियम (Rhizobium)—
सहजीवी, मृतोपजीवी व मृदोत्पन्न।
- (d) क्लेबसिएला (Klebsiella)—
सहजीवी, मृतोपजीवी व वायोत्पन्न।
- (e) क्लोरोबियम (Chlorobium)—
अवायवीय, आत्मपोषी व मुक्तजीवी।
- (f) रोडोस्पिरिलम (Rhodospirillum)—
अवायवीय, आत्मपोषी व मुक्तजीवी।
- नाइट्रोजन स्थिरीकारक नीले-हरे शैवाल
निम्नलिखित हैं—
- (i) नोस्टॉक (Nostoc), (ii) ऐनाबीना (Anabaena), (iii) ऑल्लोसिरा (Aulosira), (iv) ग्लीयोट्राइकिया (Gleotrichia), (v) कैलोथ्रिक्स (Calothrix), (vi) रिवुलेरिया (Rivularia)।

Assimilation:

- In this process, nitrogen fixed by plants is converted into organic molecules such as proteins, DNA, RNA etc.
- These molecules make the plant and animal tissue.

Ammonification:

- Living organisms produce nitrogenous waste products such as urea and uric acid.
- These waste products as well as dead remains of organisms are converted back into inorganic ammonia by the bacteria. This process is called ammonification.
- Ammonifying bacteria help in this process.

Examples of ammonifying bacteria contain bacillus, proteus, clostridium,

Denitrification:

- Conversion of nitrates back into gaseous nitrogen is called denitrification.
- Denitrifying bacteria (e.g. pseudomonas) live deep in soil near the water table as they like to live in oxygen free medium.
- Denitrification is reverse of nitrogen fixation.

Biomes

- Biome is an abbreviation for biological home.
- Biome means an assemblage of plant and animal communities with minimum common characteristics.
- All the areas of biomes are characterized by more or less uniform environmental conditions such as climate, soil etc.

Factors affecting biomes

- (i) Day and night hours which is responsible for duration of photosynthesis.
- (ii) Mean temperature as diurnal and annual variation which decides the extreme conditions.
- (iii) Length of growing season.
- (iv) Precipitation, its total amount and spatio-temporal variation
- (v) Wind speed, direction, duration and frequency.
- (vi) Soil types
- (vii) Slope
- (viii) Drainage

Types of biomes

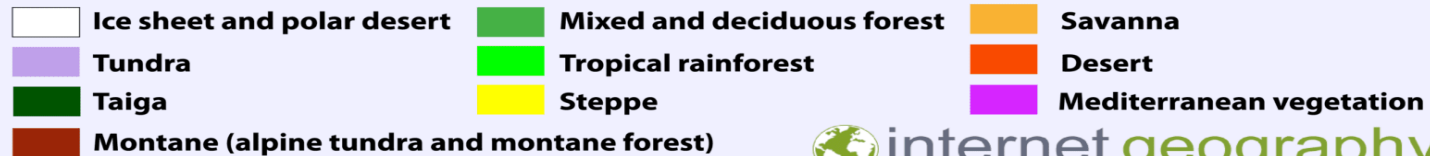
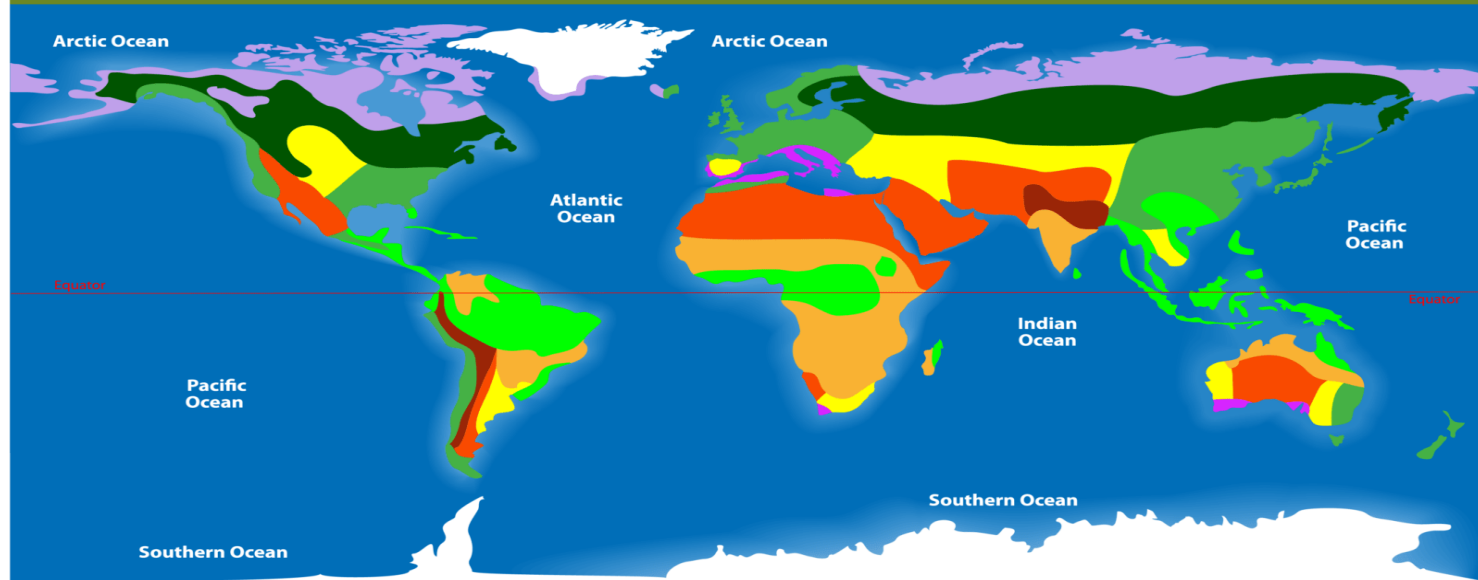
Biomes are classified in various ways. There are five major biomes in the world are

1. Forests
2. Grasslands
3. Deserts
4. Tundra
5. Aquatic

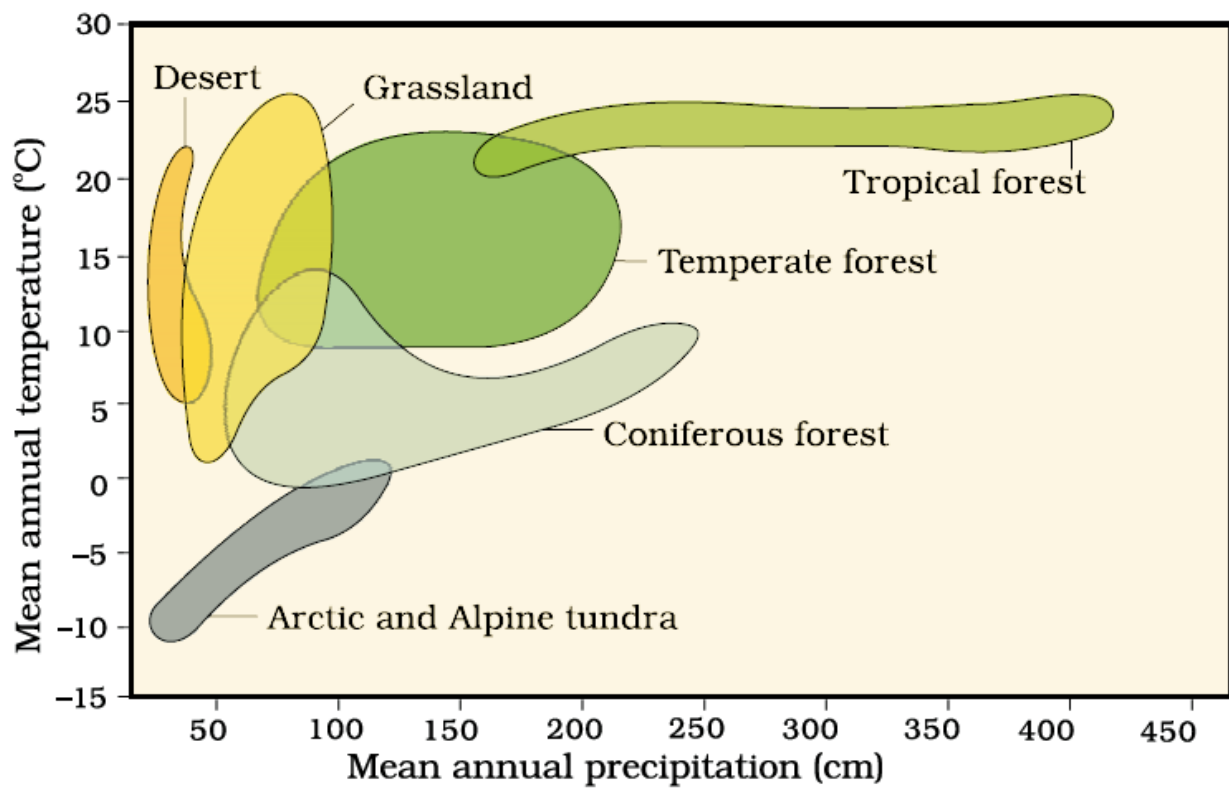
- **Forest**

- Taiga or Boreal Biome (Evergreen Coniferous forests)
- Temperate Deciduous Biome (North Western Europe – British Type Climate)
- Sub-Tropical Deciduous Biome in Eastern China, South Eastern USA
- Temperate Deciduous Biome (Mediterranean Climate)
- Tropical Deciduous Biome (Monsoon Climate)
- Tropical Rain Forest Biome

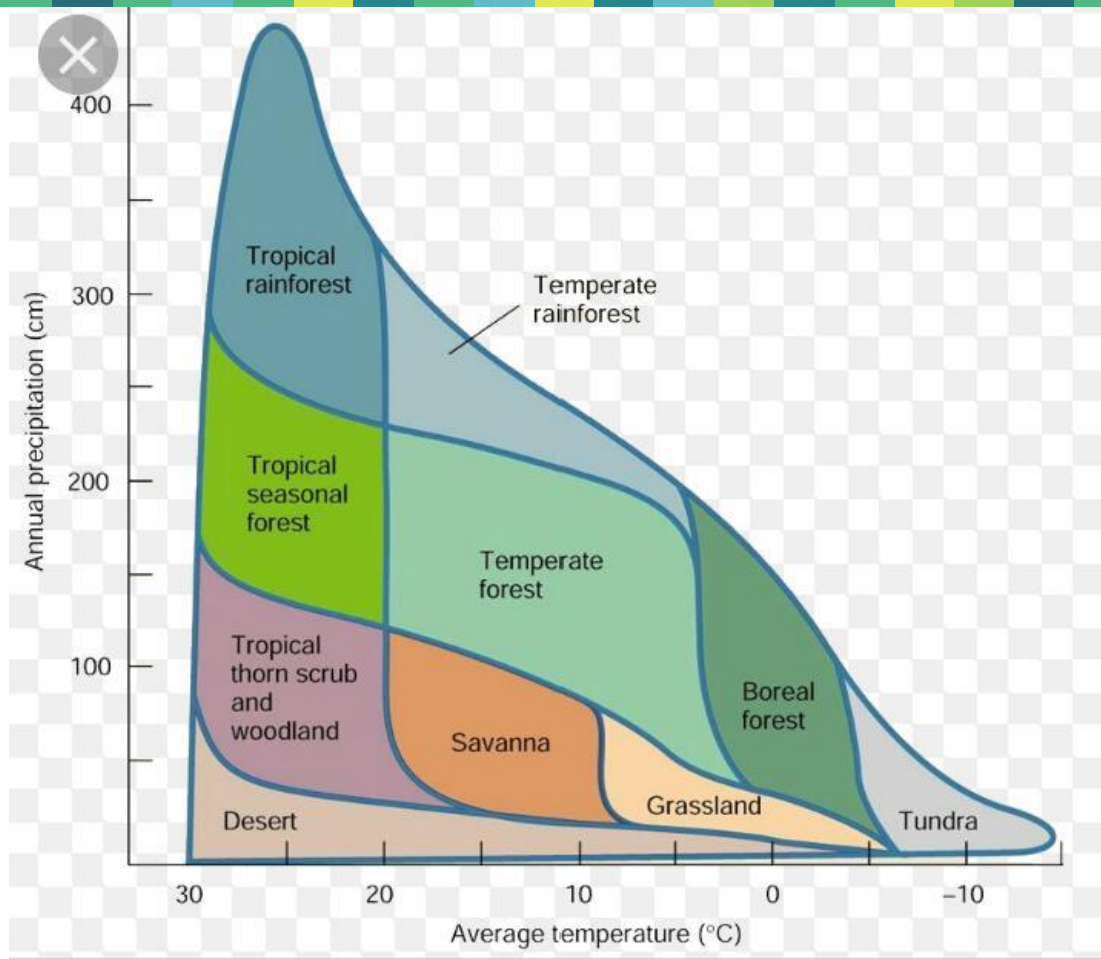
The main biomes in the world



internet geography



Biome distribution with respect to annual temperature and precipitation



- **Tundra**

- Arctic and Alpine Tundra Biome

- **Grassland**

- Steppe or Temperate Grassland Biome
- Savanna or Tropical Wet and Dry Biome (Tropical Shrublands and Grasslands)

- **Desert**

Tropical and Mid Latitude Desert Biome

- **Tundra Biome**

- There are two types of tundra – arctic and alpine.
- Alpine tundra occurs at high mountains above the tree line. E.g. High ranges of the Himalayas, Andes, Alps etc.
- There are **no trees** in the tundra (due to **permafrost**).
- The lowest form of vegetation like **mosses, lichens** are sparsely found on bare rocks.
- Animals like the reindeer, arctic fox, wolves, musk-ox, polar bear, lemming, arctic hare, arctic willow live in tundra region.
- **Reptiles and amphibians are almost absent.**
- Mammals **have a large body size and small tail and ear** to avoid the loss of heat from the surface.
- It occupies the northern fringe of Canada, Alaska, European Russia, Siberia and island group of Arctic Ocean.

Climate:

1. Long winters with little daylight.
2. Short summers with long daylight hours.
3. Precipitation is less (25 cm or less per year), that too mostly in the form of snow

- **Taiga or Boreal Biome**

- Boreal forest soils are characterized by thin **podzols** and are rather poor. This is because:
 - ✓ **The weathering of rocks proceeds slowly** in cold environments
 - ✓ **the litter derived from conifer needle (leaf) is decomposed very slowly** and is not rich in nutrients (humus content is low).
- conifers do not shed their leaves frequently. The predominant vegetation is an evergreen coniferous forest with species such as spruce, fir and pine.
- The conifers require little moisture are best suited to this type of sub-Arctic climate.
- The productivity of boreal forest is lower than those of any other forest ecosystem.
- Animals found in this region include Siberian tiger, wolverine, lynx, wolf, bear, red fox, squirrel, and amphibians like Hyla, Rana, etc.

- **Temperate Deciduous Biome (North-Western Europe – British Type Climate)**

- Soils of temperate forests are **podzolic** and fairly deep.
- The natural vegetation of this climatic type is **deciduous**.
- The trees shed their leaves in the cold season.
- This is an adaptation for protecting themselves against the winter snow and frost.
- Shedding begins in autumn, the 'fall' season. Growth begins in spring.
- Some of the common species include oak, elm, ash, birch, beech, and poplar.

- **Sub-Tropical Deciduous Biome in Eastern China, South Eastern USA**

- Supports luxuriant vegetation.
- The lowlands carry both evergreen broad-leaved forests and deciduous trees (hardwood).
- On the highlands, various species of conifers such as pines and cypresses are important.
- Perennial plant growth is not checked by either a dry season or a cold season.

- **Temperate Deciduous Biome (Mediterranean Climate)**

- Trees with small broad leaves are widely spaced and never very tall.
- Regions with adequate rainfall are inhabited by low, broad-leaved evergreen trees (mostly evergreen oaks).
- **Fire** is an important hazardous factor in this ecosystem, and the adaptation of the plants enable them to regenerate quickly after being burnt.
- Plants are in a continuous struggle against heat, dry air, excessive evaporation and prolonged droughts.
- They are, in short **xerophytic (drought tolerant)**.

- **Tropical Deciduous Biome (Monsoon Climate)**

- Tropical Monsoon Forests are also known as a drought-deciduous forest; dry forest; dry-deciduous forest; tropical deciduous forest.

Teak, neem, bamboos, sal, shisham, sandalwood, khair, mulberry are some of the important species

• Tropical Rain Forest Biome

- High temperature and abundant rainfall support a luxuriant tropical rain forest.
- The equatorial vegetation comprises a multitude of evergreen trees, e.g. mahogany, ebony, dyewoods etc.
- In the coastal areas and brackish swamps, mangrove forests thrive.
- All plants struggle upwards (most epiphytes) for sunlight resulting in a peculiar layer arrangement (canopy).
- Epiphyte (**commensalism** – epiphyte benefits without troubling the host): An epiphyte is a plant that grows harmlessly upon another plant (such as a tree) and derives its moisture and nutrients from the air, rain, and sometimes from debris accumulating around it.

- **Desert Biome**

- The predominant vegetation of both hot and mid-latitude deserts is **xerophytic or drought-resistant**.
- This includes the cacti, thorny bushes, long-rooted wiry grasses and scattered dwarf acacias.
- Most desert shrubs have **long roots and are well spaced out** to gather moisture, and search for ground water.
- Plants have **few or no leaves, and the foliage is either waxy, leathery, hairy or needle-shaped to reduce the loss of water through transpiration**.
- The seeds of many species of grasses and herbs have **thick, tough skins** to protect them while they lie dormant.

Grasslands

- Grasslands are characterized as lands dominated by grasses rather than large shrubs or trees.
- There are two main divisions of grasslands:
 - (1) tropical grasslands or savannas
 - (2) temperate grasslands

Tropical Grassland (Savannah)

- A savanna or savannah is a mixed woodland grassland ecosystem.
- They are also known as tropical grasslands and found in a wide band on either side of the equator on the edges of tropical rainforests.
- Savannah can also be said to be a transitional zone between forest and desert or grassland.
- Primarily they are situated in South America, Africa and Australia.

Distribution

- African Savannah- West african Region surrounding Sudan.
- South American Savannah- Called Cerrado (Brazil), Llanos (Colombia and Venezuela) and Campos (Southern Brazil).
- Australian Savannah- Situated adjacently in southward to Northern monsoon line of Australia.
- Indian Savannah- Parts of North Karnataka, Telangana and South Maharashtra region

Temperate grasslands

Distribution:

- They are also called Granaries of the world.
- The temperate grasslands in different regions are called by different names. They are
 - The US prairies.
 - Russian steppes,
 - Veldts of Africa,
 - Pampas of South America (mostly located in Argentina and Uruguay),

- Steppes of Eurasia
- Downs of Australia
- Pustaz of Hungary
- Canterbury of New Zealand

Deserts

- Almost 33% of the earth's surface area is desert, getting less than 25 cm precipitation (Overall- It include both hot and cold desert, not necessarily as a continuous belt like Taiga)
- Around 20% of these are sandy deserts are located between 25-30 degree north and south latitude.
- The desert biome is characterised by very low rainfall (usually less than 25 cm per year) that comes as short, hard showers.
- This biome covers almost 20% of the earth.
- True Desert~ 14%, another ~ 15 % earth land surface possesses some desert like characteristics.

Hot vs cold deserts

- Deserts that receive rain as the main form of precipitation are called as hot deserts while those which receive snow as their main form of precipitation are called as cold deserts.
- The hot deserts of the world are located in the south-west U.S.A., Mexico, Chile, Peru, Africa (Sahara desert), Asia (Rub' Al Khali, Thar etc) and central and Western Australia (Tanami Desert, Gibson Desert, Great Victoria Desert, Simpson Desert etc).
- Cold deserts are found in the Antarctic, Greenland, Iran, Northern and Western China.
- Some famous cold deserts are: – Antarctica, Atacama, Gobi, Great Basin, Namib, Iranian, Taklamakan, Patagonia etc.

Hot desert

Climate:

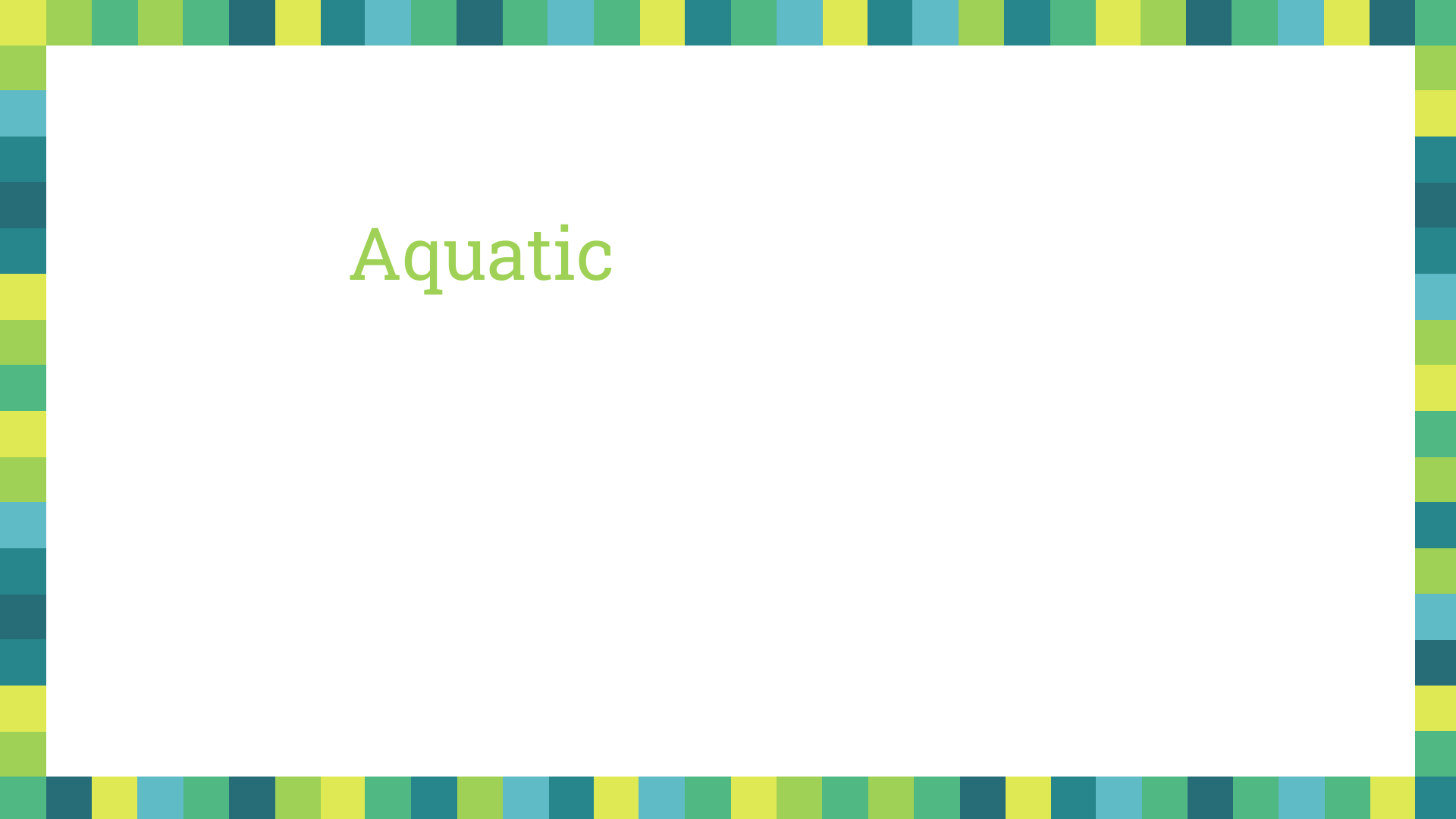
- Hot and dry summers, warm temperatures throughout the year.
- Average temperature: 20-25 degrees Celsius.
- The extreme maximum temperature for Hot Desert ranges from 43.5 to 49°C.

Flora:

- Plant life is rare in hot and dry deserts; mostly small trees and shrubs.
- The plants must adapt themselves for harsh conditions and be able to obtain and conserve water.
- The examples of important desert plants are—yuccas, acacias, euphorbias, cacti, many other succulents and hardy grasses.
- Many of the small plants are annuals.

Plant adaptations include-

- Small or no leaves
- reduced leaf surface area to reduce evaporation from the plants,
- loss of leaves during long dry spell,
- small hairs on the leaf surfaces,
- Succulent leaves and stems
- Ability to store large amount of water.
- Well developed root system
- Annuals germinate, bloom and reproduce only during the short rainy season
- Waxy/Thick skin to prevent water loss

A decorative border composed of small squares in various shades of green, yellow, and blue, arranged in a repeating pattern around the edges of the slide.

Aquatic

Aquatic

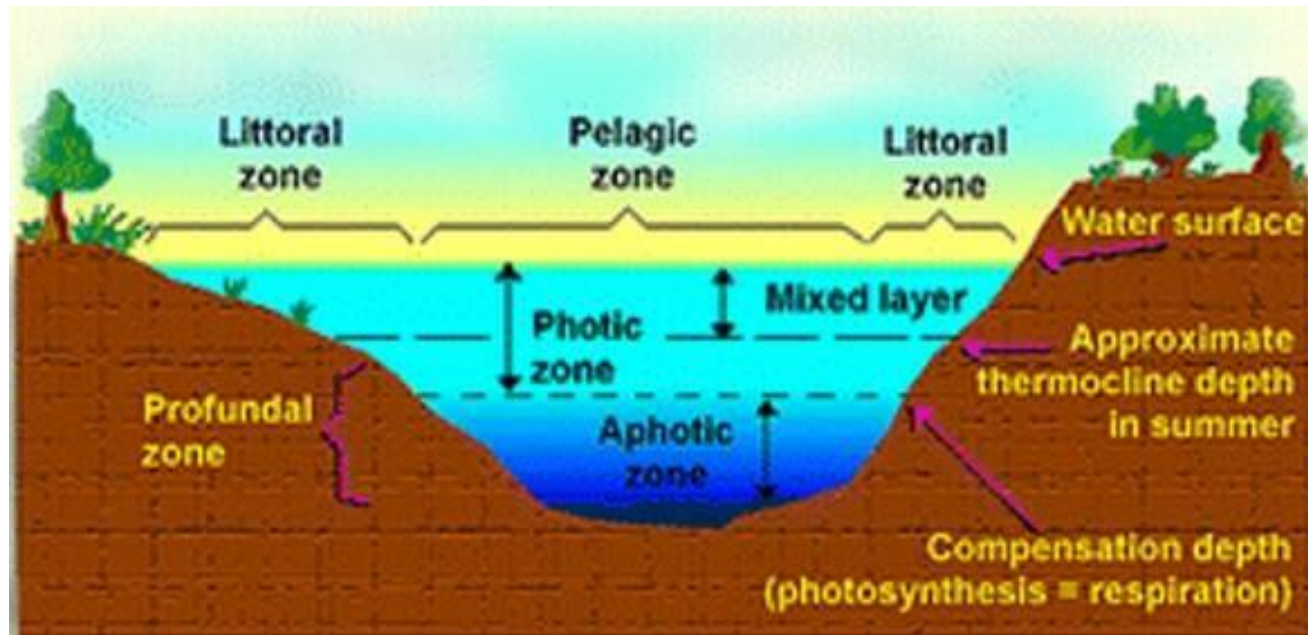
- This biome covers nearly 75% of the Earth's surface.
- It links all the other biomes.
- This is one of the most important biomes for the survival of species.
- Without water, Earth would have been a large desert.
- It can be classified as
 - Freshwater
 - Marine

Freshwater regions

- Such regions have salinity less than 1%.
- The species which are adapted to survive in freshwater cannot survive in other water bodies which have more salinity.
- Freshwater regions can be again divided into
 - Ponds and lakes
 - Streams and rivers
 - Wetlands

Ponds and Lakes

- These regions range in size from just a few square meters to thousands of square kilometers.
- Most of the ponds are seasonal unlike lakes.
- Ponds and lakes may have limited species diversity since they are often isolated from one another and from other water sources like rivers and oceans.
- According to depth and distance from the shoreline, lakes and ponds are divided into three different “zones”.



Lotic

Running water



Lentic

Standing water



Zone	Definition	Flora	Fauna
Littoral zone	topmost zone near the shore	several species of algae (like diatoms), rooted and floating aquatic plants	grazing snails, clams, insects, crustaceans, fishes, and amphibians
Limnetic zone	near-surface open water surrounded by the littoral zone	phytoplankton	zooplankton, freshwater fish
Profundal zone	deep-water part	vegetation-free	heterotrophs

Streams and rivers

- They have waters which are flowing or in constant motion.
- They change their characteristics during their journey from the source to the mouth.
- The water at the source is cooler and clearer at the source with high oxygen levels. Therefore it has freshwater fish such as trout and heterotrophs.
- At the mouth, water is murky and has fish that require less oxygen, such as catfish and carp.

Wetlands

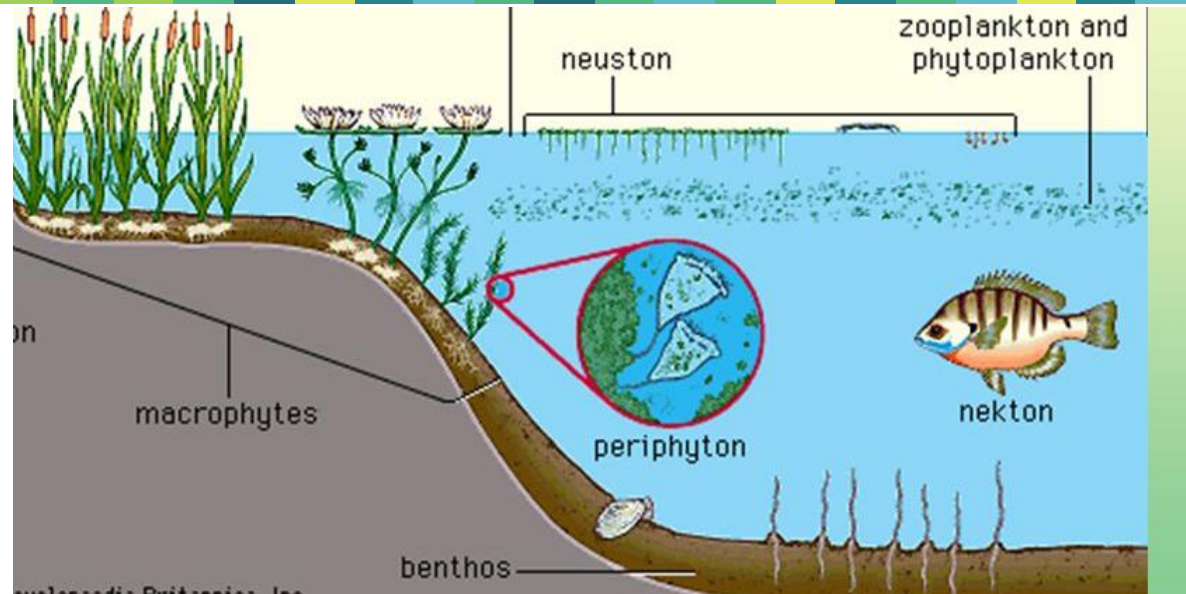
- Areas of standing water that support aquatic plants are called wetlands.
- These include marshes, swamps, and bogs.
- Flora include hydrophytes which are plants adapted to moist and humid conditions such as pond lilies, cattails, sedges, tamarack, and black spruce.
- Marsh flora also include such species as cypress and gum.
- Fauna include many species of amphibians, reptiles, birds (such as ducks and waders), and furbearers.

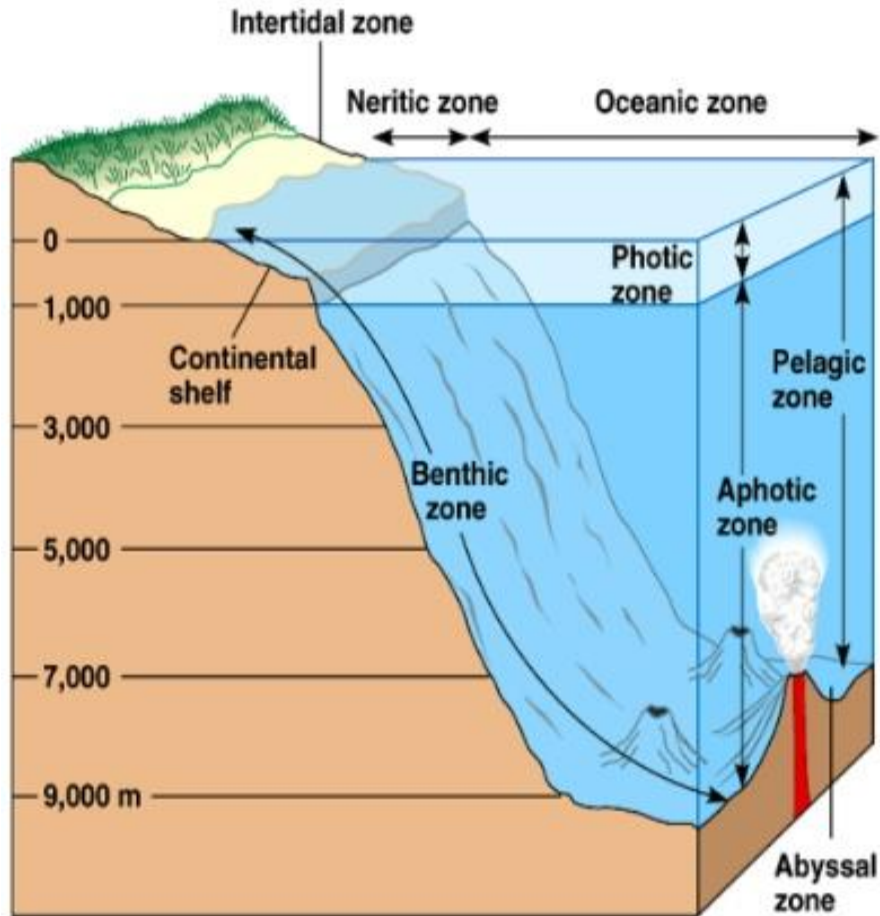
Marine regions

- Such regions cover about three-fourths of the Earth's surface.
- Marine regions include the oceans, coral reefs and the estuaries.
- The algae present in the marine regions absorb a lot of the atmospheric CO₂ and contribute to the oxygen supply on Earth,
- Almost all the rainfall on Earth is due to the evaporation of water from the marine regions.

Oceans

- They are the largest of the water bodies.
- Oceans have four zones - intertidal, pelagic, abyssal, and benthic.
- All four zones have a great diversity of species.





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MARINE ZONATION

Like lakes, the marine environment is generally classified on the basis of:

1. LIGHT PENETRATION

- Photic Zone
- Aphotic Zone

2. DISTANCE FROM THE SHORE AND WATER DEPTH

- Intertidal Zone
- Neritic Zone
- Oceanic Zone

3. OPEN

BOTTOM

- Pelagic Zone
- Benthic Zone
- Abyssal Zone

Zone	Definition	Flora	Fauna
Intertidal	meeting of ocean and land	algae	small animals, such as herbivorous snails, crabs, sea stars, and small fishes
Pelagic	waters further from the land or the open ocean	surface seaweeds	many species of fish and some mammals, such as whales and dolphins
Benthic	area below the pelagic zone	seaweeds	bacteria, fungi, sponges, sea anemones, worms, sea stars, and fishes
Abyssal	deep ocean		Chemosynthetic bacteria in vents, many species of invertebrates and fishes
Neritic zone	is the relatively shallow part of the ocean above the drop-off of the continental shelf, approximately 200 meters (660 ft) in depth	coral reefs	

Coral Reefs & Concerns

By Sudarshan Gurjar

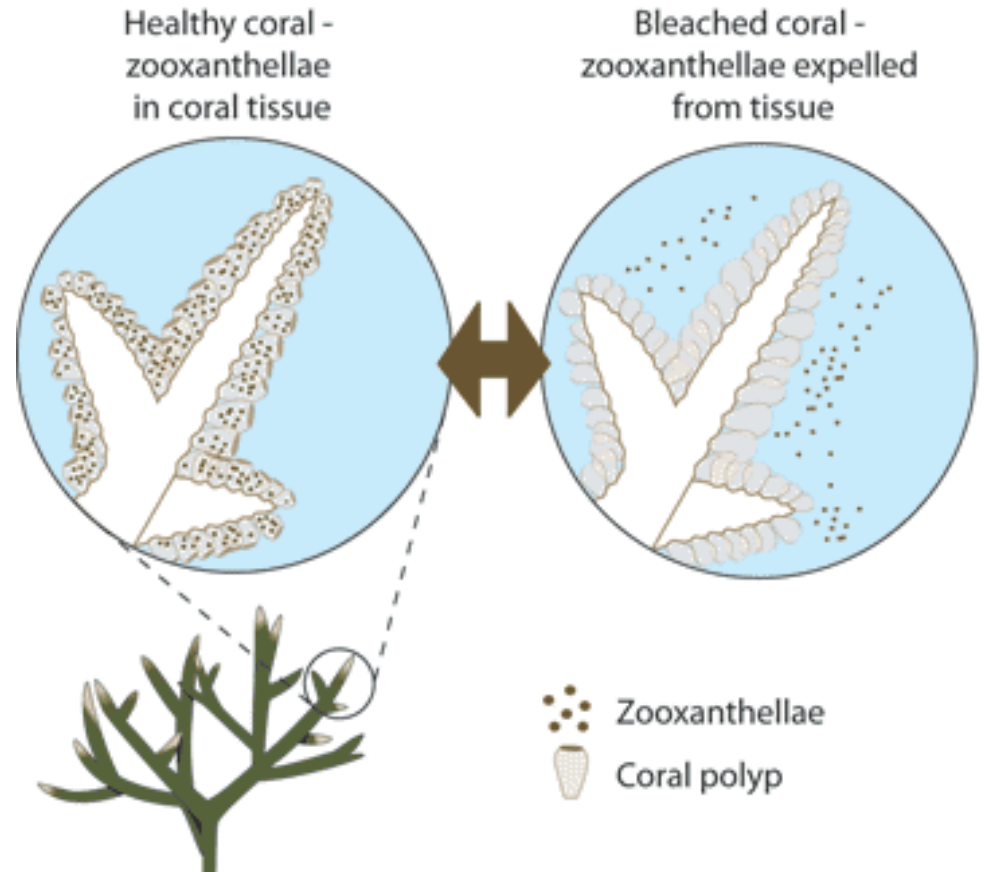
Corals

- Coral polyps are small (0.25-12 inches), soft-bodied marine organisms.
- They belong to the group cnidaria
- **Note:** other cnidarians include hydras, jellyfish, and sea anemones
- The coral polyps share a symbiotic relationship with algae called zooxanthellae.
- The zooxanthellae(algae) live inside the coral polyps and perform photosynthesis, producing food & oxygen which is shared with the coral.
- In exchange the coral provides the algae with protection and access to light, which is necessary for photosynthesis.



By Sudarshan Gurjar

- Coral Reef =
Coral Polyp + zooxanthalle

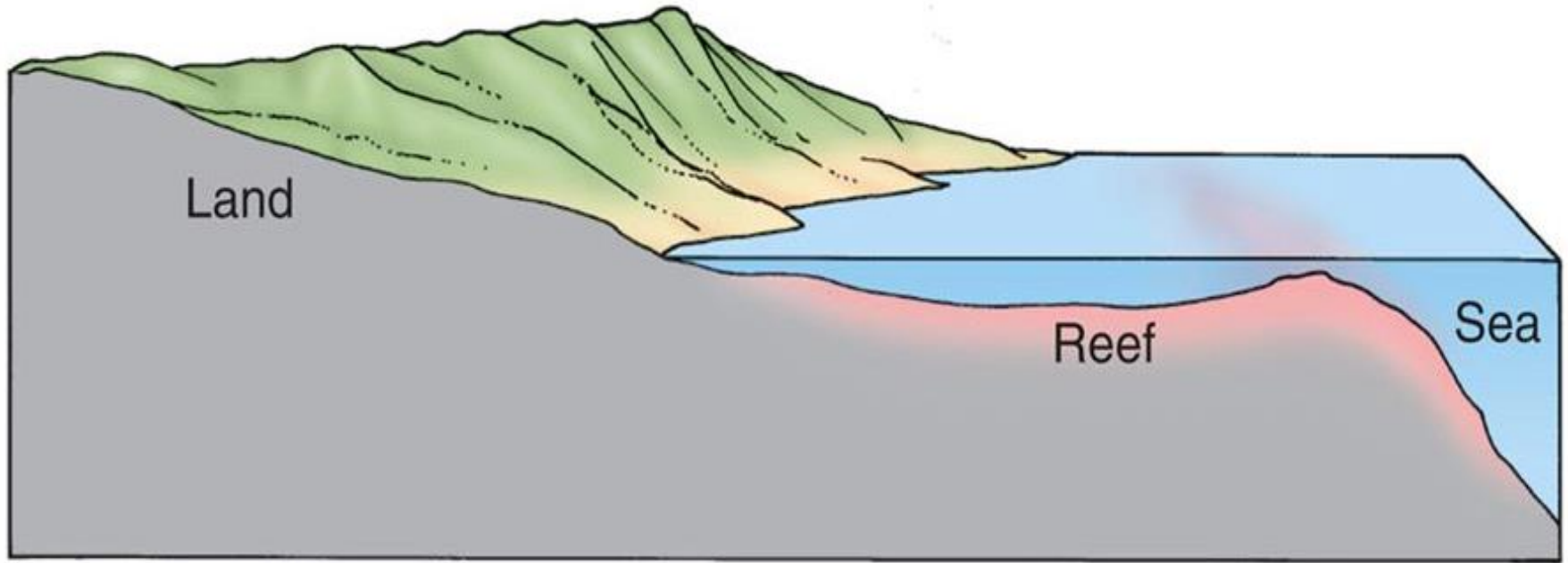


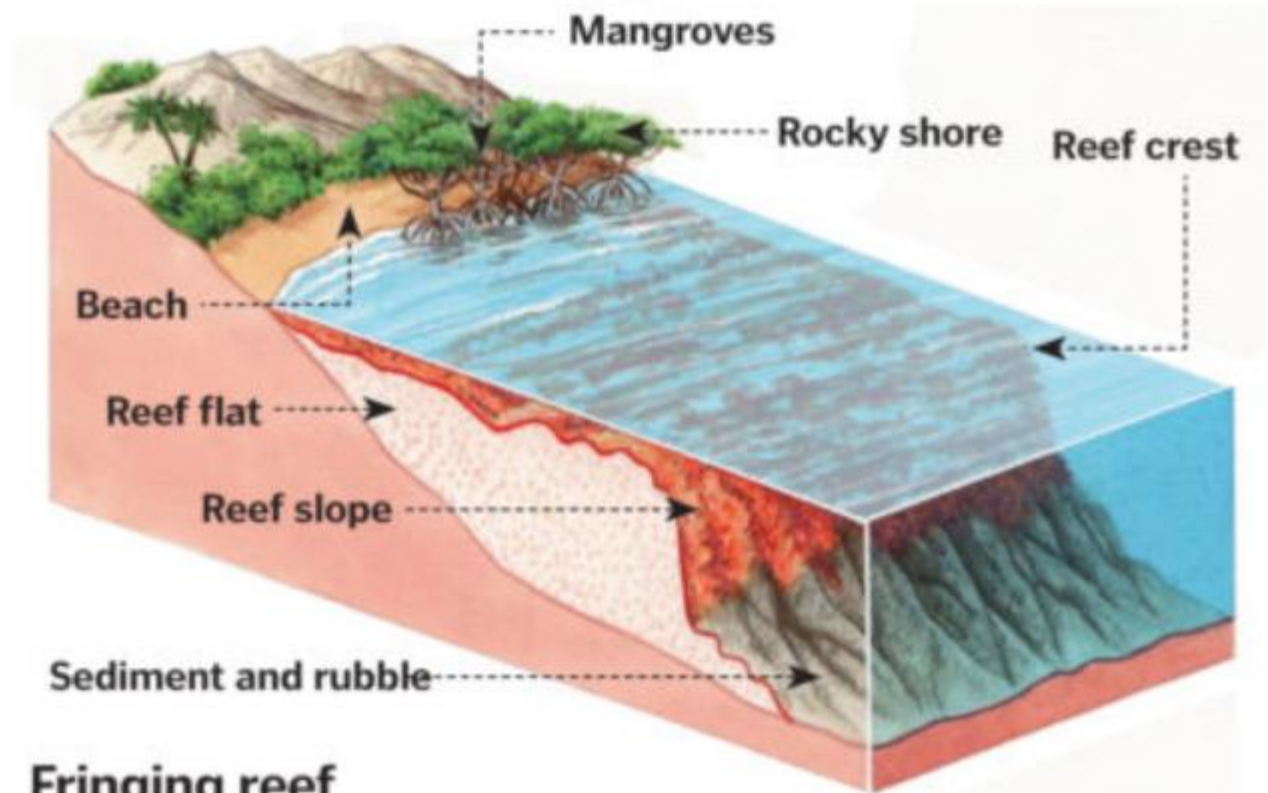
Coral Reefs

- The corals secrete calcium carbonate which acts like a cement.
- These bind together coral, sand and pieces of rubble to form a solid structure known as the reef.
- The major types of coral reefs are:
- **1. Fringing Reefs:** These are coral reefs that grow in shallow waters and in areas of low rainfall runoff, primarily on the leeward side.
- They closely border the coastline or are separated from it by a narrow stretch of water.
- **2. Barrier reefs:** These grow parallel to the coast, but are separated from land by a lagoon.
- Example: Great Barrier reef, Queensland, Australia
- **3. Atolls:** These grow surrounding (or partly surrounding) an island which then sinks relative to sea level. Example: Maldives consists of 26 atolls.

Type of Coral Reefs

(A) Fringing Reef





Fringing reef

The most common type of reef is a fringing reef. They grow directly from land, creating a border along the shoreline.

▪ 1. Fringing reefs

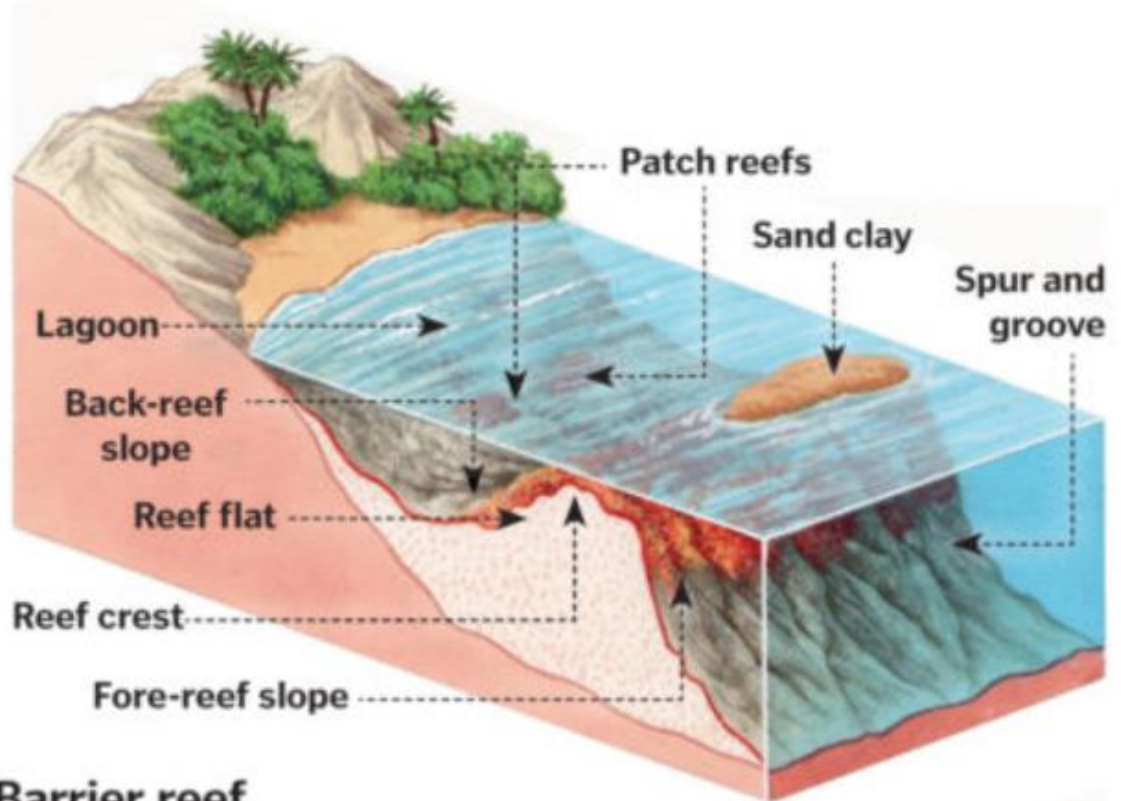
- A fringing reef is a coralline platform lying close to shore extending outwards from the mainland.
- It is sometimes separated from the shore by a shallow lagoon.
- It is widest when fringing a protruding headland but completely absent when facing the mouth of a stream.
- The outer edge grows rapidly because of the splashing waves that continuously renew the supply of fresh food.
- The reefs may be about a mile wide, lying just above the level of low water and sloping steeply downwards on the seaward side to a depth of about 100 feet .

■ 2. Barrier reefs

- A barrier reef is separated from the coast by a much wider and deeper channel or lagoon .
- The reef is partially submerged.
- It lies above the water level and sand can accumulate on it, a little vegetation is possible.
- The barrier reefs have narrow gaps at several places to allow the water from the enclosed lagoon to return to the open ocean.
- Gaps are very useful for shipping and provide the only entrances for ships to enter or leave the lagoon.
- The best known barrier reef is the Great Barrier Reef off the coast of Queensland, Australia.
- It is 1.200 miles long, separated from the coast by a channel 110 miles wide in places and over 200 feet deep.

■ 3. Atolls

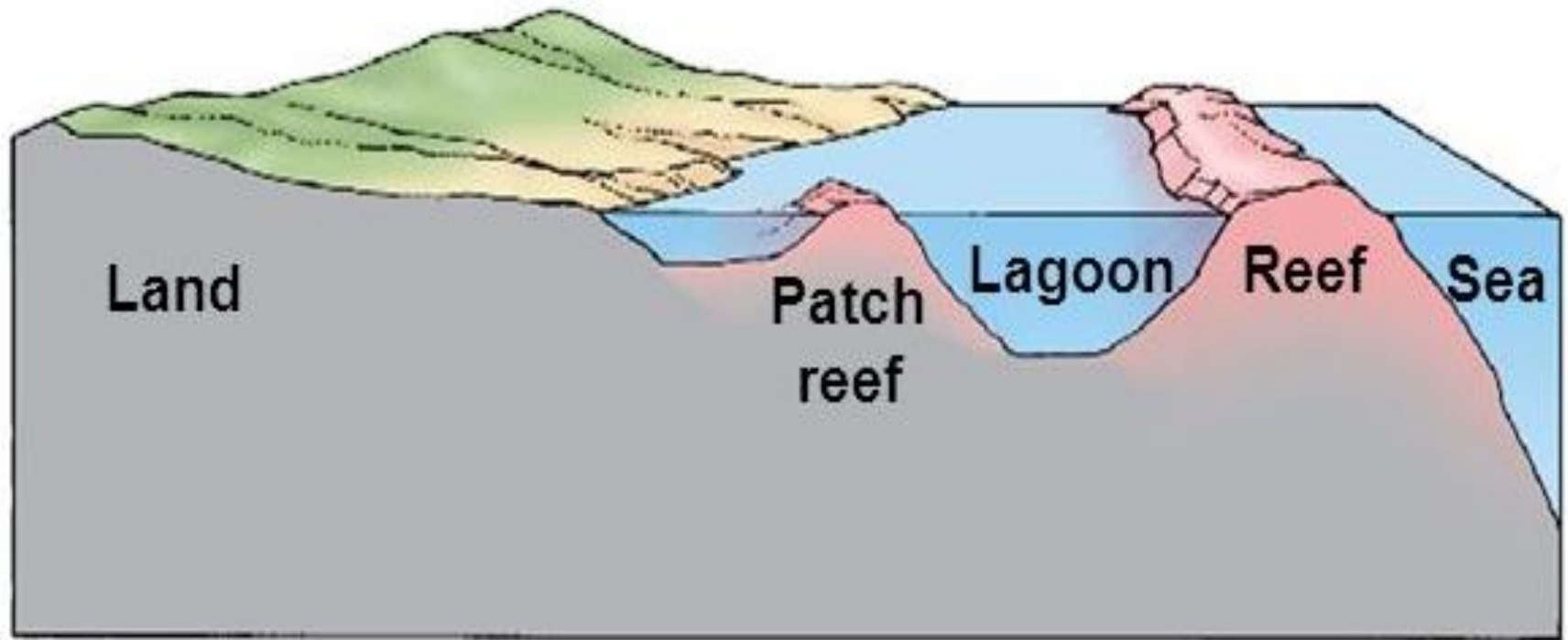
- Atolls are similar to barrier reefs except that they are circular in shape, enclosing a shallow lagoon without any land in the center.
- The encircling ring is usually broken in a few places to allow the free flow of water.
- On the inside of the reefs, sand and limestone debris collect and palm trees like coconuts may grow.
- Such palm trees thrive well in the brackish water of the lagoon.
- The nuts fall into the water and are distributed widely by floating from one coral island to another.
- The calm waters are useful for fishing and canoeing.
- Some of the large atolls, e.g. Suvadiva in the Maldives, west of Ceylon have a lagoon over 40 miles across.
- A number of them provide essential air bases for trans-Pacific aircraft.



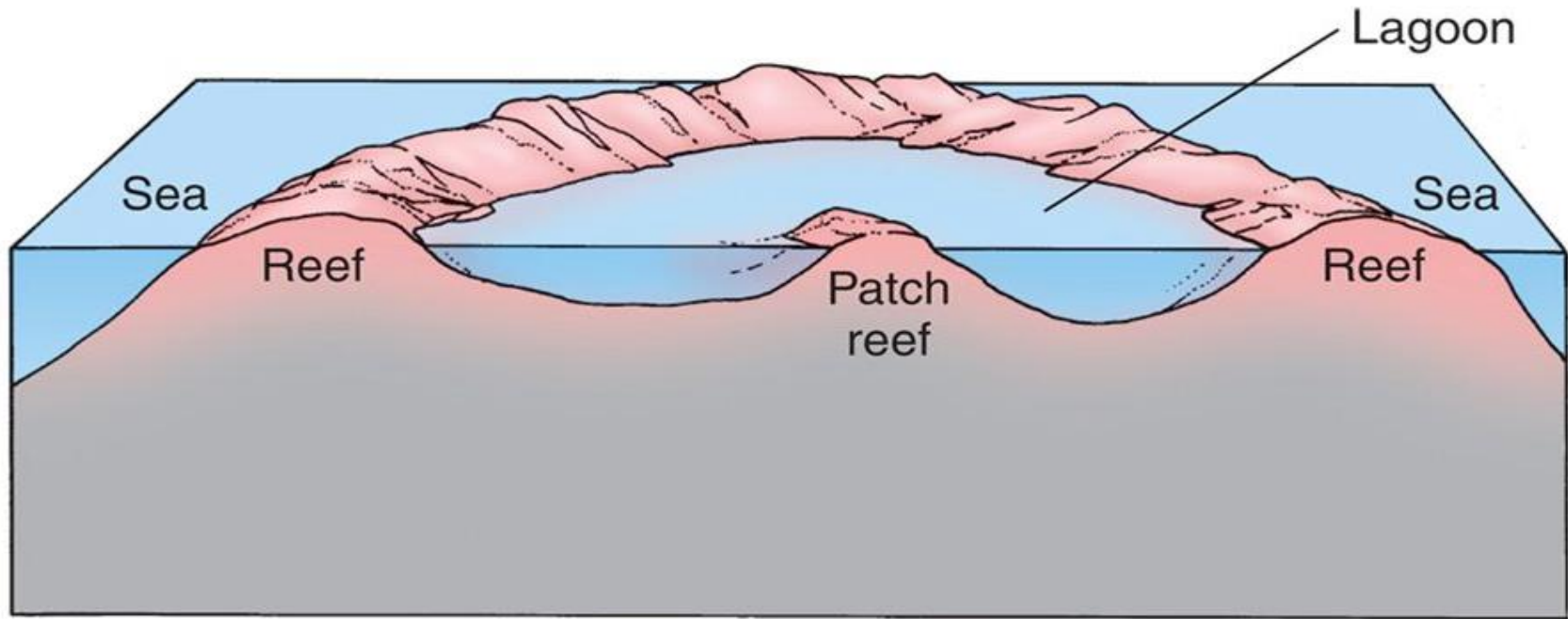
Barrier reef

Although they also form parallel to the land, barrier reefs grow further out to sea and are separated from the shore by a lagoon.

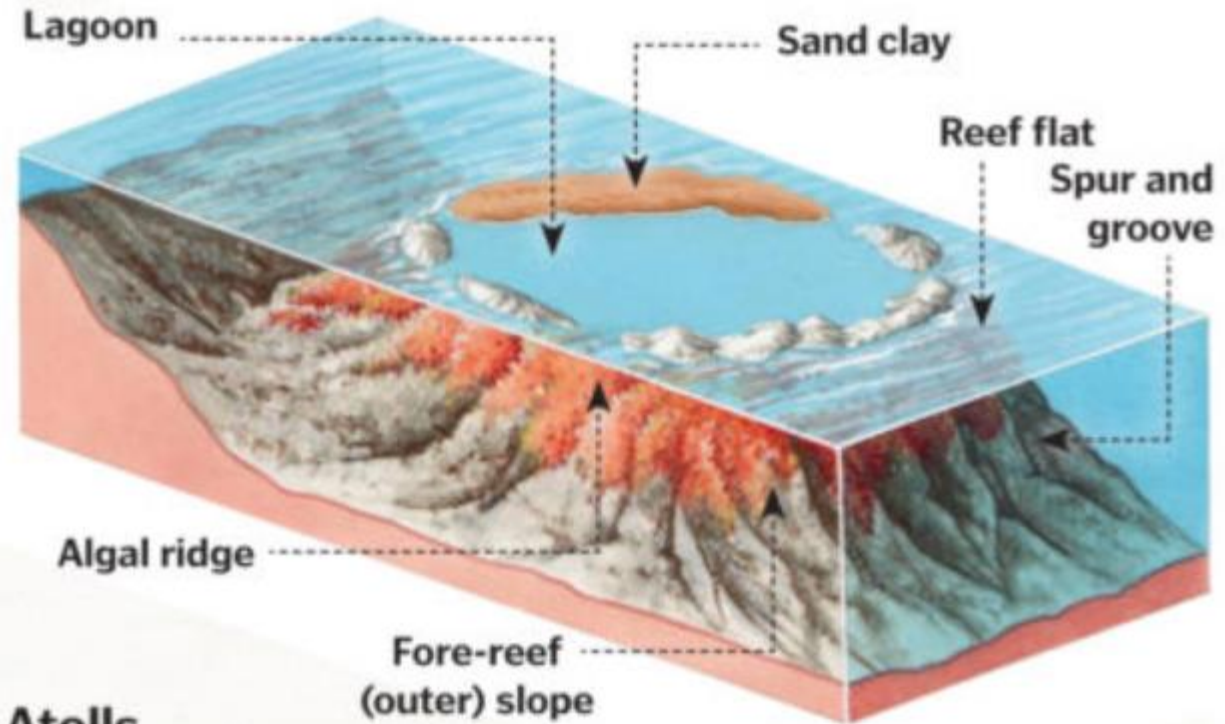
Barrier Reef



Atoll

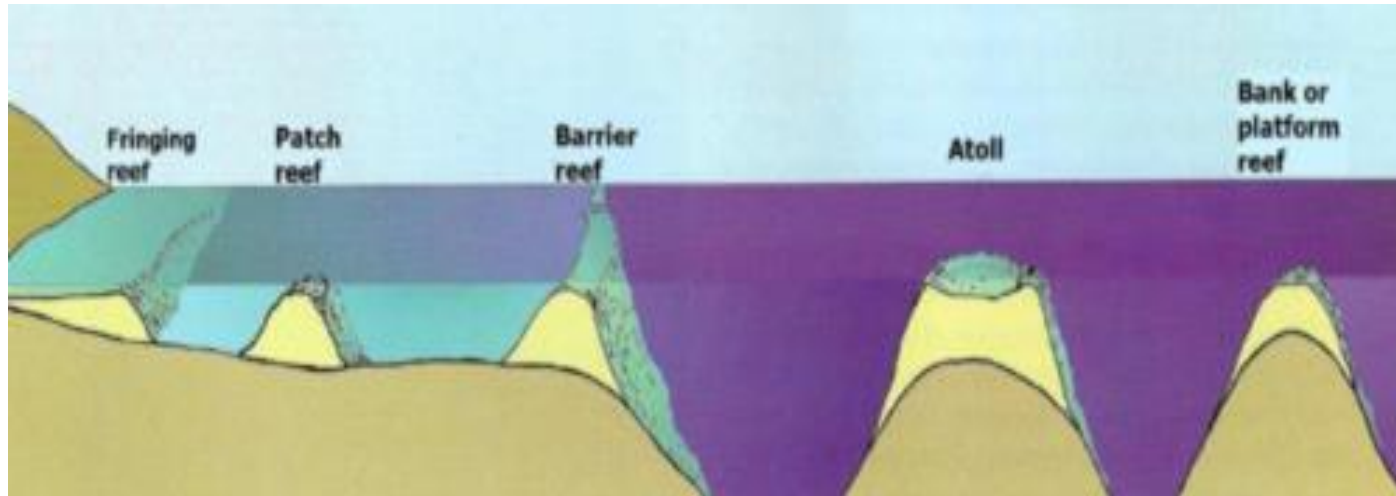


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Atolls

Over time, a volcano or seamount surrounded by a reef erodes or rising sea levels cause it to flood. This forms an atoll with a lagoon in the centre.



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Stages of coral reef development

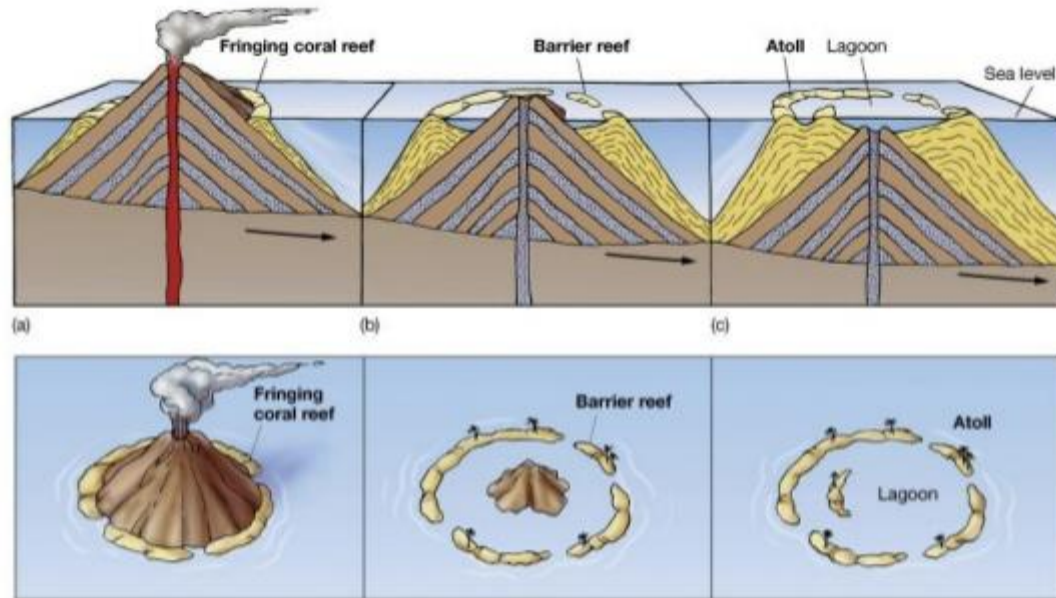
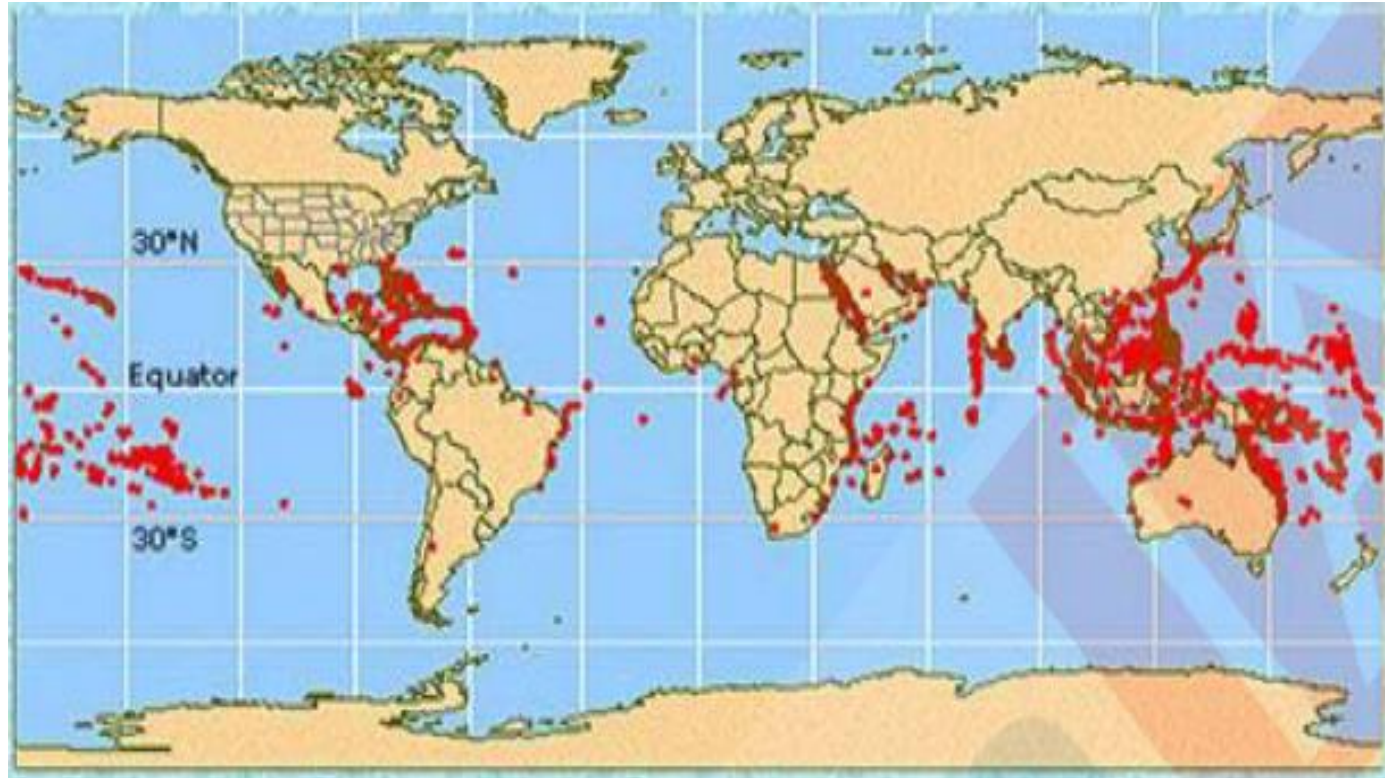


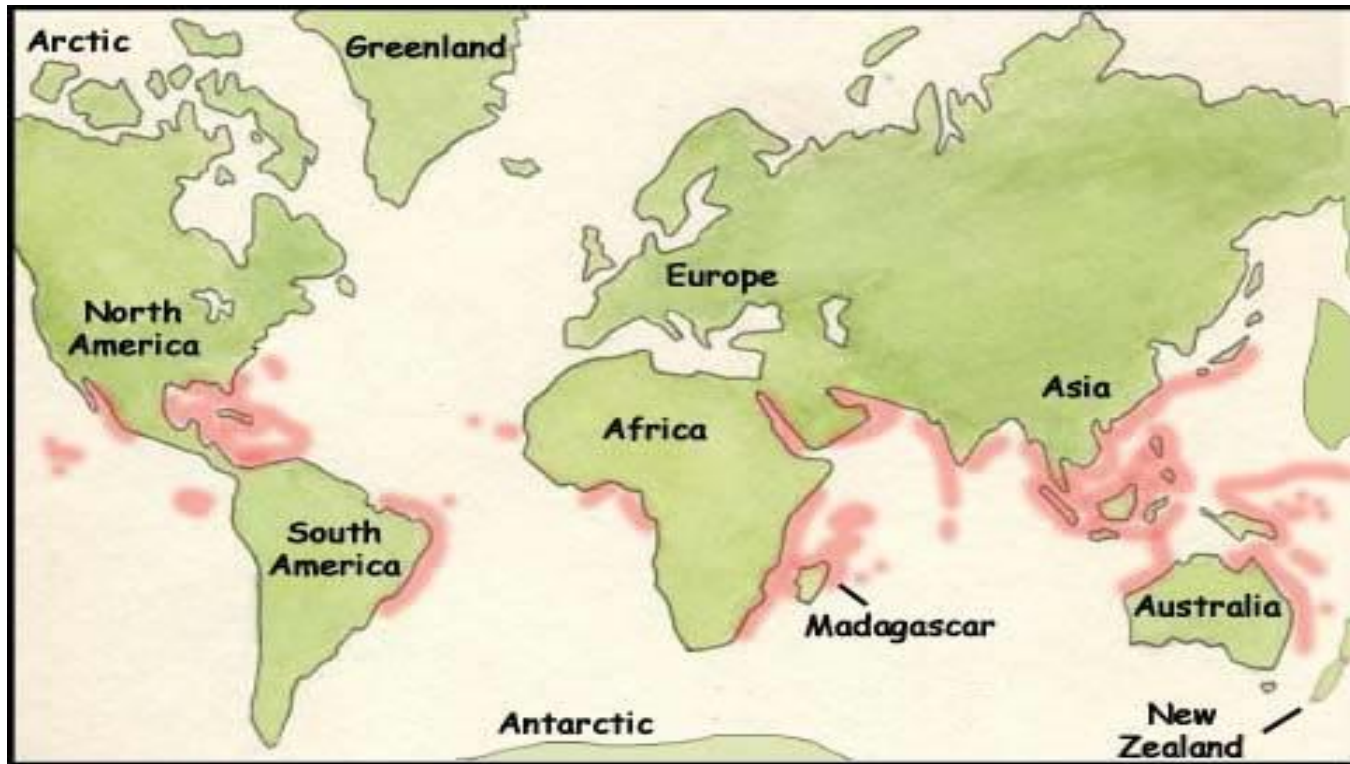
Figure 2-30

Location of coral reefs

- Coral reefs are mainly found in tropical seas (30°N to 30°S) where the sea is shallow (less than 100m); and warm (usually between 25° and 29°C).

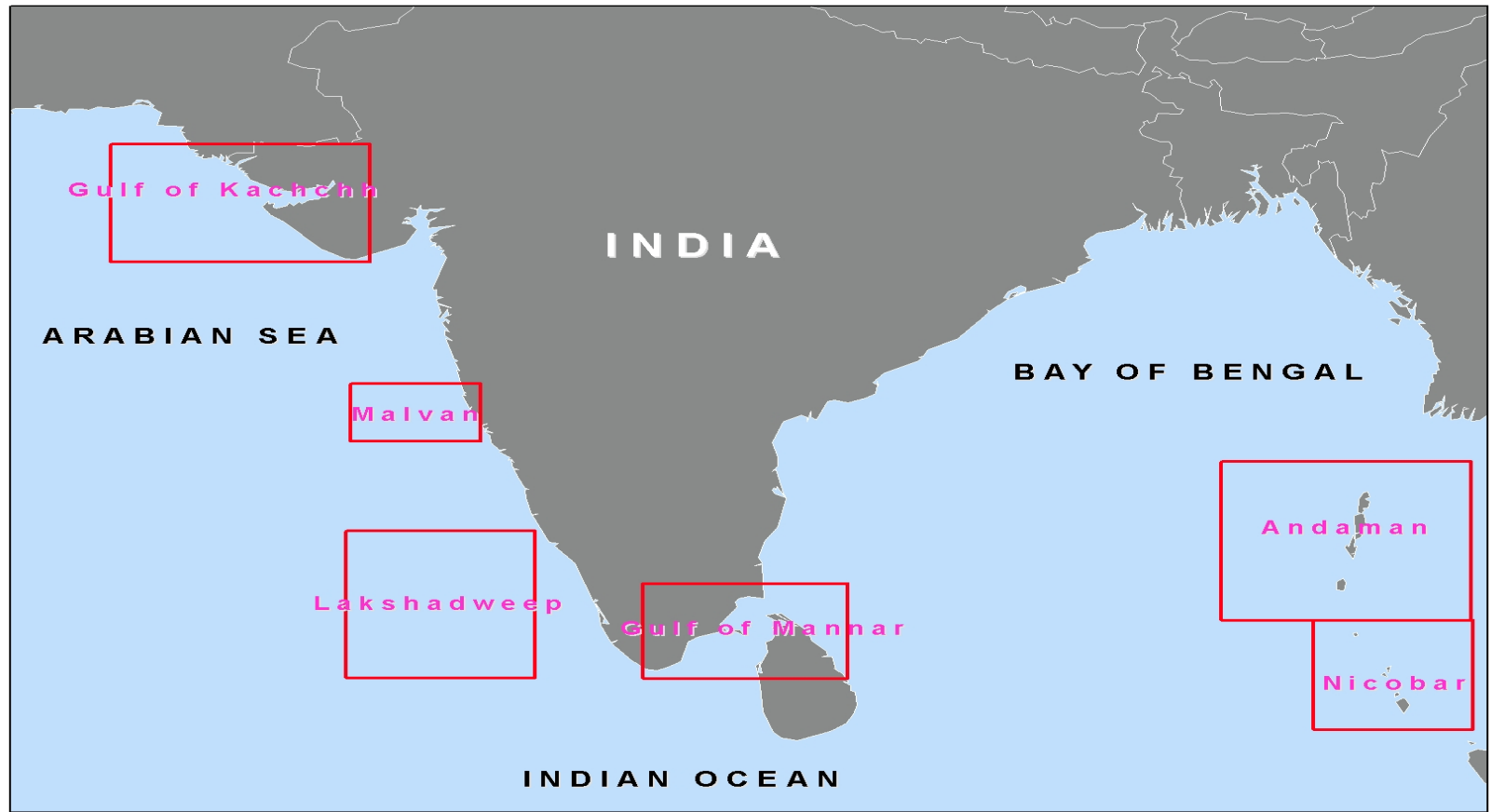


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- **In India, coral reefs are located in 7 regions:**
- Goa coast
- Kerala coast
- Palk Bay,
- Gulf of Kucch
- Gulf of Mannar
- Lakshadweep islands
- Andaman and Nicobar islands



Importance of coral reefs

- **Biodiversity:**
- Coral reefs are extremely productive ecosystems and are called 'the rainforests of the sea.'
- Despite covering less than 0.1% of the ocean floor, reefs host more than 25% of all marine fish species and other marine animals.
- **Regulating services:**
- Coral reefs protect the shoreline and reduce flooding.
- Coral reefs contribute to land accretion (opposite of land erosion)

- **Economic value:**
- Coral reefs support human life and livelihoods and are therefore important economically.
- For example: According to WWF, 1 sq.km of well-managed coral reef can yield an average of 15 tonnes of fish and other seafood annually.
- Further, coral reefs support tourism industry in countries like Seychelles and Maldives.
- **Cultural values:**
- Coral reefs have aesthetic and recreational values

Threats to Coral Reefs

1. Climate Change and its impact on Coral reefs:

With rising global temperatures, mass coral bleaching events and infectious disease outbreaks have become more frequent.

Bleaching is when corals lose the highly pigmented zooxanthellae from their tissues due to stress from high sea temperatures and solar irradiation exposing the white calcium carbonate skeletons of the coral colony.

Ocean acidification:

Carbon dioxide absorbed into the ocean from the atmosphere has been reducing calcification rates in reef-building and reef-associated organisms by changing chemical properties of seawater. This can ultimately lead to dissolving coral reefs.



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- **Increased frequency and intensity of tropical storms:** Violent storms will lead to coral breakage, dislocation and degradation from wind and waves
- **Changes in precipitation:** increased precipitation will lead to more freshwater runoff.
- Freshwater run-off reduces salinity levels, may cause bleaching, and brings increased nutrients and sediments, which can lead to disease outbreak.
- Altered ocean circulation patterns may lead to lack of food due to dispersal of larvae

Coral bleaching was first recorded in 1911 in the Florida Keys.

The first report on The "Status of Coral Reefs of Worldwide" (also known as Wilkson Report) was published in 1988 by the Global Coral Reef Monitoring Network and has been updated since then.

The initial report focussed on overfishing, pollution and other anthropogenic stresses on reefs.

Later, the impact of rising global temperatures on reefs has been focussed upon.

2. ENSO:

Sudden exposure of reef flat corals to the atmosphere during events such as, ENSO-related sea level drops or tectonic uplift can potentially induce bleaching.

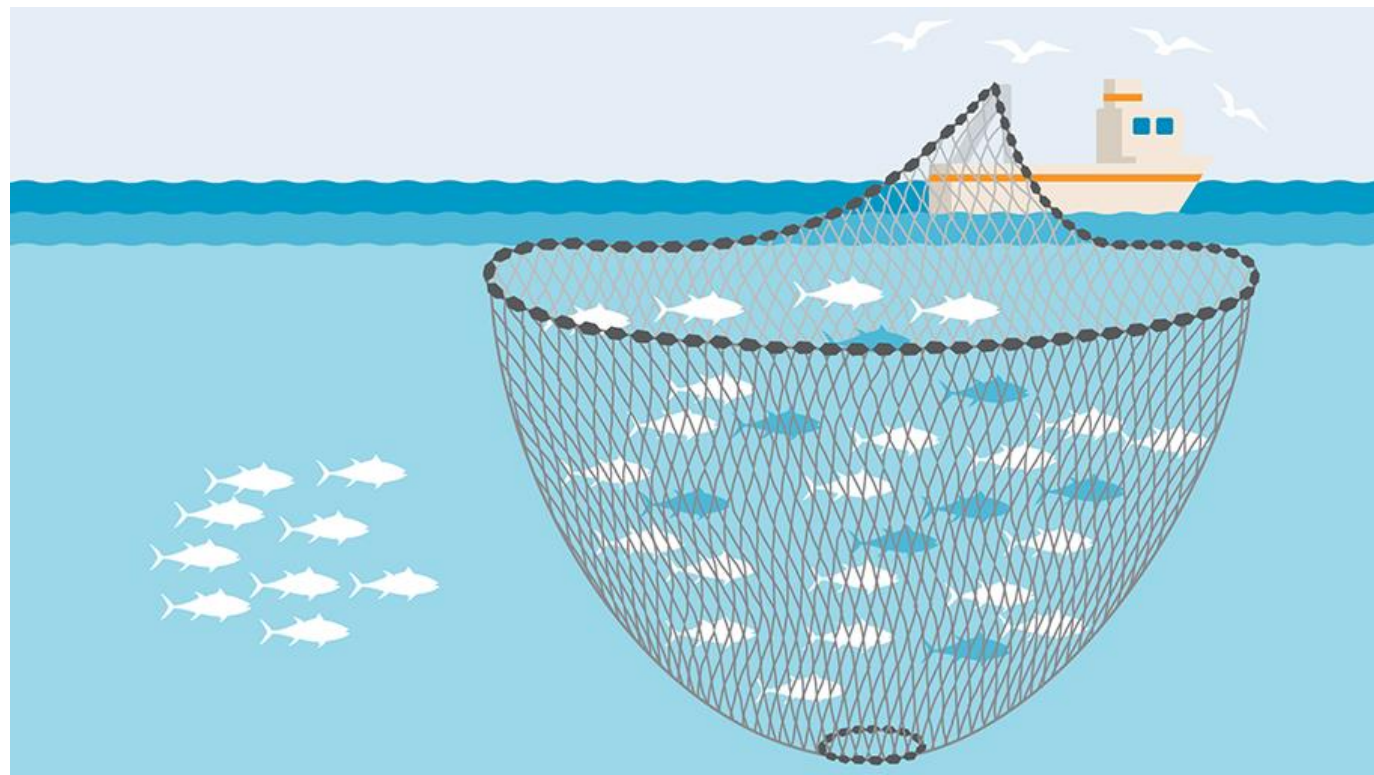
The consequent exposure to high or low temperatures, increased solar radiation and sea water dilution by heavy rains could lead to zooxanthellae loss and also cause coral death.

3. Marine Pollution:

Zooxanthellae loss occurs during exposure of coral to increased concentrations of various chemical contaminants and oil.

Plastic and garbage at the seaside often ends up in the sea and disrupts the coral reefs' delicate environment.

- **4. Overfishing and destructive fishing practices** – such as purse seining, fine-mesh fishing, 'moxy' nets, cyanide fishing and blast fishing result in unsustainable damage to coral reefs.
- **5. Coral mining** (for example in south and south-east Asia) which involves blasting of reefs and coral being removed, cause immediate destruction but also result in indirect detrimental effects such as sand erosion and sedimentation
- **6. Sedimentation:** Erosion caused by construction, mining, logging, and farming has lead to increased sediment in rivers.
- The sediment drastically reduces the amount of light reaching coral reefs and destroys them.
- Further, destruction of mangroves, which check sediments have aggravated the problem.



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- **7. Poorly managed tourism** has both direct and indirect negative effects on coral reefs.
- Snorkelling, diving and boating can cause direct physical damage to reefs.
- Overexploitation of reef species as food, for aquaria and as curios for tourist markets can threaten the survival of species.
- 8. Indiscriminate Exploitation of coral reefs for **wildlife trade** has also emerged as a major threat to coral ecosystems.
- 9. Massive outbreaks of predatory starfish, **invasive species** also pose threat to survival of corals



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Extent of Coral Bleaching

- According to a study published in the journal *Science*, the global proportion of coral being hit by bleaching per year has increased from 8% in the 1980s to 31% in 2016.
- From 1980 to 2016, the number of bleaching events was highest in the western Atlantic, including Central America and the Caribbean, which experienced 3 times more events than other regions such as Australasia, the Indian Ocean and the Pacific Ocean.
- Since 1980, 58% of severe bleaching events have been recorded during strong periods of El Nino.
- The last coral bleaching event took place from 2014 to 2017.
- It had destroyed nearly 12000km of reefs. Global coral bleaching was also recorded in 1998 and 2010.
- In 2016-17, the Great Barrier Reef of Australia suffered extreme coral bleaching which killed around 50% of its corals.

Extent and cause of coral bleaching in India

- **1. The corals of Andaman and Nicobar Islands:**
 - These were severely affected by the 2004 Tsunami and have not yet fully recovered.
 - Other reasons for coral bleaching in these islands include unregulated tourism, fishing and marine pollution
- **2. Coral in the Gulf of Kachchh region:**
 - Siltation and Eutrophication due to developmental activities have been the major cause of bleaching of corals.
- **3. Corals of Lakshadweep islands:**
 - Periodic dredging for boat passage in the lagoons, amongst others, affects the health of corals in these coral islands.

4. Gulf of Mannar reefs

They are affected due to intense local activities like intensive fishing, illegal harvesting of protected species which affects the ecological balance, pollution from boats, construction along the shores etc.

Impact of Coral Bleaching

Ecological Impacts of bleaching:

- Decline in marine species diversity
- Land masses will be directly exposed to waves leading to a risk of erosion.
- Changes in coral communities affect the species that depend on them

Socioeconomic impacts of bleaching

- Degraded coral reefs are not able to provide the ecosystem services on which local human communities depend.
- Reefs damaged by coral bleaching can quickly lose many of the features that is important for the aesthetic(branch of philosophy that explores the nature of art) appeal that is fundamental to reef tourism.
- Thus there is loss of revenue from tourism.

- It can drive large shifts in fish communities.
 - This results into reduce catches for fishers targeting reef fish species, which in turn impacts food supply and associated economic activities.
- Coral reefs are a valuable source of pharmaceutical compounds.
- Degraded and dead reefs are less likely to serve as a source for important medicinal resources.

Global Initiatives

1. International Coral Reefs Initiative (ICRI)

The International Coral Reef Initiative (ICRI) is an informal partnership between Nations and organizations which aims to preserve coral reefs and related ecosystems around the world.

The Initiative was founded in 1994 by eight countries:

Australia, France, Japan, Jamaica, the Philippines, Sweden, the United Kingdom, and the United States of America.

India is a member of ICRI Main objectives are:

Encourage the adoption of best practice in sustainable management of coral reefs and associated ecosystems

Capacity Building

Raise awareness at all levels on the plight of coral reefs around the world.

- The ICRI declared 2018 as the third International Year of the Reef(IYOR).

2. Global Coral Reef monitoring network

- It is a network under ICRI which works to provide scientific information and communication on the status of coral reef ecosystems to increase conservation and management for coral reefs

3. International Coral Reef Action Network (ICRAN)

ICRAN is a strategic alliance of private and public organizations that acts worldwide to address the management of coral reef ecosystems and the needs of the communities that depend upon them.

It operates by sharing and promoting traditional knowledge, current research, and best practices in order to strengthen reef management.

4. **United Nations Environment Programme (UNEP)** has included coral reef conservation and restoration as an **ecosystem-based adaptation measure (EBA)** for coastal protection.

5. **Coral Triangle Initiative:** The six governments of the Coral Triangle - Indonesia, Malaysia, Papua New Guinea, the Philippines, Solomon Islands, and Timor Leste have established partnership to conserve coral reefs and the multitude of species and fisheries they support.

Recent Step taken in Australia to protect Great Barrier Reef:

In 2018, the Australian government has announced it's largest-ever investment in the coral reef:

over half a billion Australian dollars (\$378 million).

The money will be used to counter water pollution, combat coral-eating starfish, increase public awareness, boost reef monitoring, and improve the environmental impact of surrounding businesses.

Conservation of Coral Reefs in India

1. The protection of coral reef has been stressed under **Wildlife Protection Act, 1972** and **Environmental Protection Act, 1986** and **Coastal Regulation Zone (CRZ)**.

Corals are included in Schedule I of the Wild Life Protection Act, 1972.

Integrated Coastal and Marine Area Management (ICMAM) also takes up the issue of coral reef habitat destruction

2. On the recommendations of the **National Committee on Mangroves and Coral Reefs** following coral reef areas in the country have been identified for intensive conservation and management since 1987:

Andaman & Nicobar Islands

Lakshdeep Islands

Gulf of Kutch (Gujarat)

Gulf of Mannar (Tamil Nadu)

- 3. The **coral bleaching Alert System (CBAS)** has been initiated by INCOIS since 2011.
- This model uses the satellite derived Sea Surface Temperature (SST) in order to assess the thermal stress accumulated in the coral environs.
- This information yields in drawing the early signs of the intensity and spatial extents of coral bleaching
- **4. Recommendations of Task Force on Islands, Coral Reefs, Mangroves and Wetlands (11th Five Year Plan 2007-2012)**
- Initiatives on conservation, development and poverty reduction in coastal areas need to be more effectively integrated
- Development of sustainable alternative livelihoods and viable options for coastal populations to reduce the pressure on reef resources.
- Indian National Centre for Ocean Information Services

- Management of coral reef areas should be improved by increasing the efficiency in use of funding.
- Increase enforcement of existing laws such as those relating to coral mining, while ensuring that populations are not deprived of livelihood options
- Research into current conservation status of food fishes, lobsters, sea cucumbers, ornamental fishes and other reef-associated biota
- Appropriate regulation mechanisms to ensure that fisheries are sustainable, possibly through introduction of licenses and certification schemes.
- Develop mechanisms for managing coral reef information, including monitoring data, and ensure that these are available to coral reef managers and decision makers.
- Coral reef management should be seen much more 'as a way of life' rather than a series of short-term projects.

- Based on the recommendations of National Committees on Wetlands, Mangroves and Coral Reefs, 24 wetland, 33 mangrove and four coral reef areas in the country have been identified by the Ministry for conservation and management
- **5. National Coral Reef Research Centre** has been established at Port Blair. Database Network and Website on Coral Reefs has also been established.

Steps to be taken

- **1.** It is important to undertake immediate actions to address climate change under the Paris Agreement's goal of limiting global average temperature increase to 1.5°C above preindustrial temperatures.
- **2. Measures to combat local stressors causing coral bleaching:**
 - Regulate tourism
 - Check water pollution by treating industrial effluents before discharging them into the sea, reduction in use of chemical fertilizers in farms
 - Ban fishing and harvesting of protected species.
 - Regularly service and maintain fishing vessels so that they cause minimum pollution
 - Regulate construction along the coast
 - Banning of the quarrying of massive corals.

3. Coral restoration programs can play an important role in conserving coral reefs.

For example, the innovative Force Blue project is training retired Special Forces soldiers to transplant endangered coral species

4. A recent paper published in Nature argues that there should be focus on strengthening the reefs, to make them immune to pollution (for example through genetic engineering and of restoring reefs by targeting more resilient corals)

5. Improved scientific knowledge is required to inform an effective response to threats to coral Reefs.

6. Community awareness and education programmes are required to educate and inform the public, policymakers and other stakeholders of the ecological and socio-economic values of coral reef ecosystems

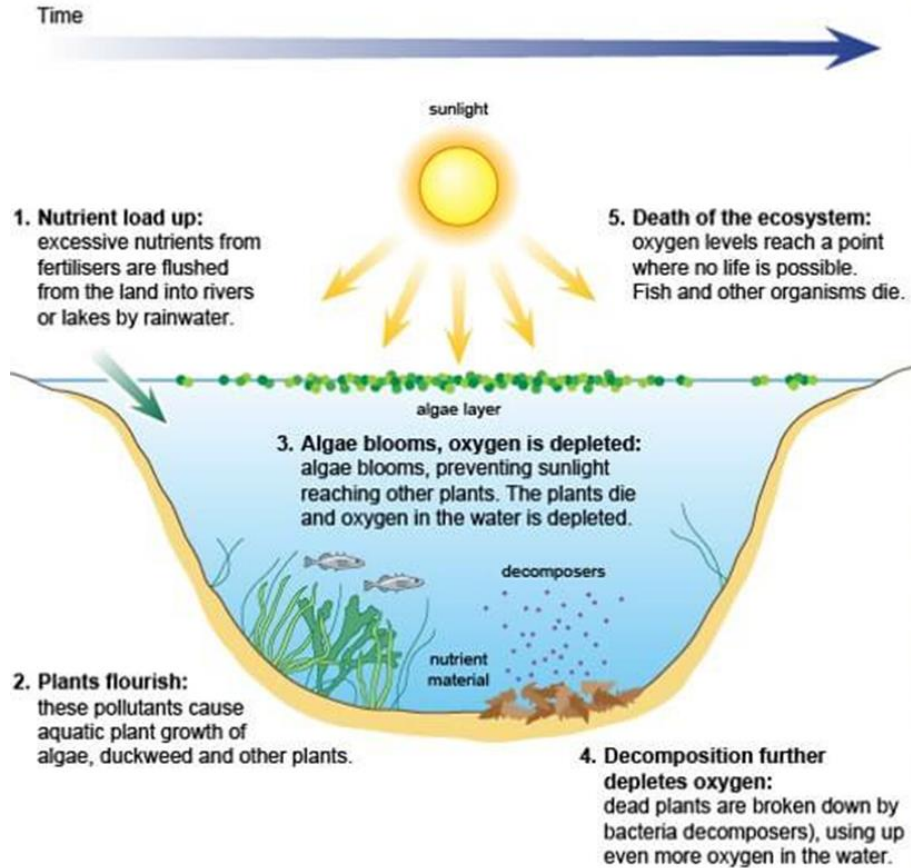
- **Eutrophication – Ageing of Lakes**

- Lakes receive their water from surface runoff and along with its various chemical substances and minerals.
- Over periods spanning millennia, ageing occurs as the lakes accumulate mineral and organic matter and gradually, get filled up.
- The nutrient-enrichment of the lakes promotes the growth of algae, aquatic plants and various fauna. This process is known as natural **eutrophication**.
- Similar nutrient enrichment of lakes at an accelerated rate is caused by human activities and the consequent ageing phenomenon is known as **cultural eutrophication**.
- On the basis of their nutrient content, lakes are categorized as **Oligotrophic (very low nutrients)**, **Mesotrophic (moderate nutrients)** and **Eutrophic (highly nutrient rich)**.

A vast majority of lakes in India are either **eutrophic or mesotrophic** because of the nutrients derived from their surroundings or organic wastes entering them

- **Eutrophication and Algal Bloom**

- Eutrophic water body: it is a body of water rich in nutrients and so supporting a dense plant population, the decomposition of which kills animal life by **depriving it of oxygen**.
- Eutrophication is the response to the addition of nutrients such as **nitrates** and **phosphates** naturally or artificially, fertilising the aquatic ecosystem.
- Phytoplankton (algae and blue-green bacteria) thrive on the excess nutrients and their population explosion covers almost entire surface layer. This condition is known as **algal bloom**.



- **Mitigation of Eutrophication**

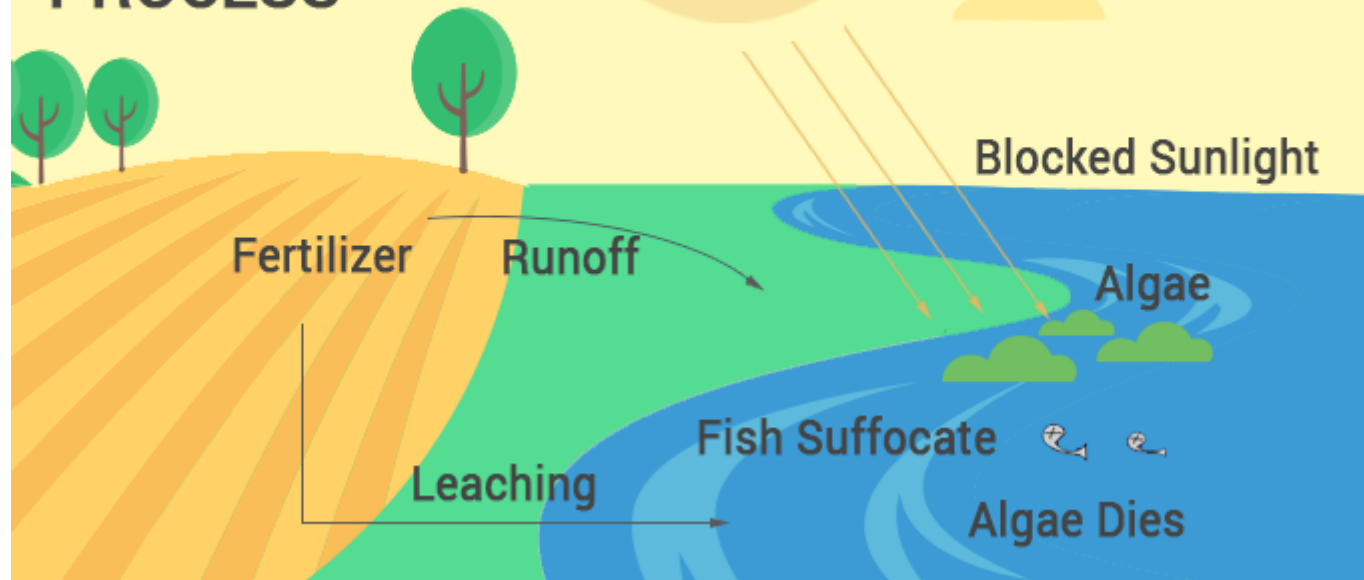
- Treating Industrial effluents domestic sewage to remove nutrient-rich sludge through wastewater processing.
- **Riparian buffer:** Interfaces between a flowing body of water and land created near the waterways, farms, roads, etc. in an attempt to filter pollution.
- Sediments and nutrients are deposited in the buffer zones instead of deposition in water (**Wetlands, estuaries are natural riparian buffers**).
- Increase in efficiency of nitrogen & phosphorous fertilisers and using them inadequate levels.
- Nitrogen testing & modelling: N-Testing is a technique to find the optimum amount of fertiliser required for crop plants. It will reduce the amount of nitrogen lost to the surrounding area.
- Encouraging organic farming.
- Reduction in nitrogen emission from vehicles and power plants.







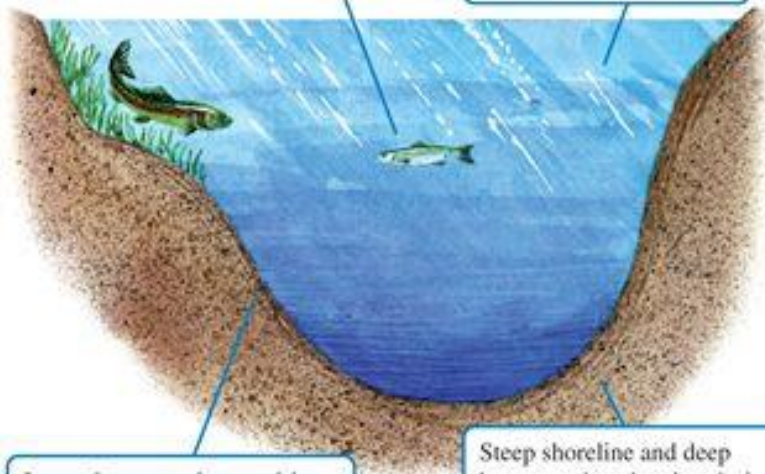
EUTROPHICATION PROCESS



Oligotrophic lake

Cool temperatures and high oxygen concentrations provide a suitable environment for fish such as trout and whitefish.

Low availability of nutrients, especially phosphorus and nitrogen, support low densities of phytoplankton and vascular aquatic plants.



Invertebrate species requiring high oxygen concentrations are dominant in the benthic fauna.

Steep shoreline and deep bottom reduce heating during summer and help maintain lower water temperatures.

Eutrophic lake

Warm temperatures and low oxygen availability provide environments favouring tolerant fish such as catfish and bowfins.

High availability of nutrients, especially phosphorus and nitrogen, support high densities of phytoplankton and vascular aquatic plants.



Benthic invertebrate biomass is high and dominated by species tolerant of warm temperatures and low oxygen.

Shallow bottom reduces total water volume and increases heating in summer.

