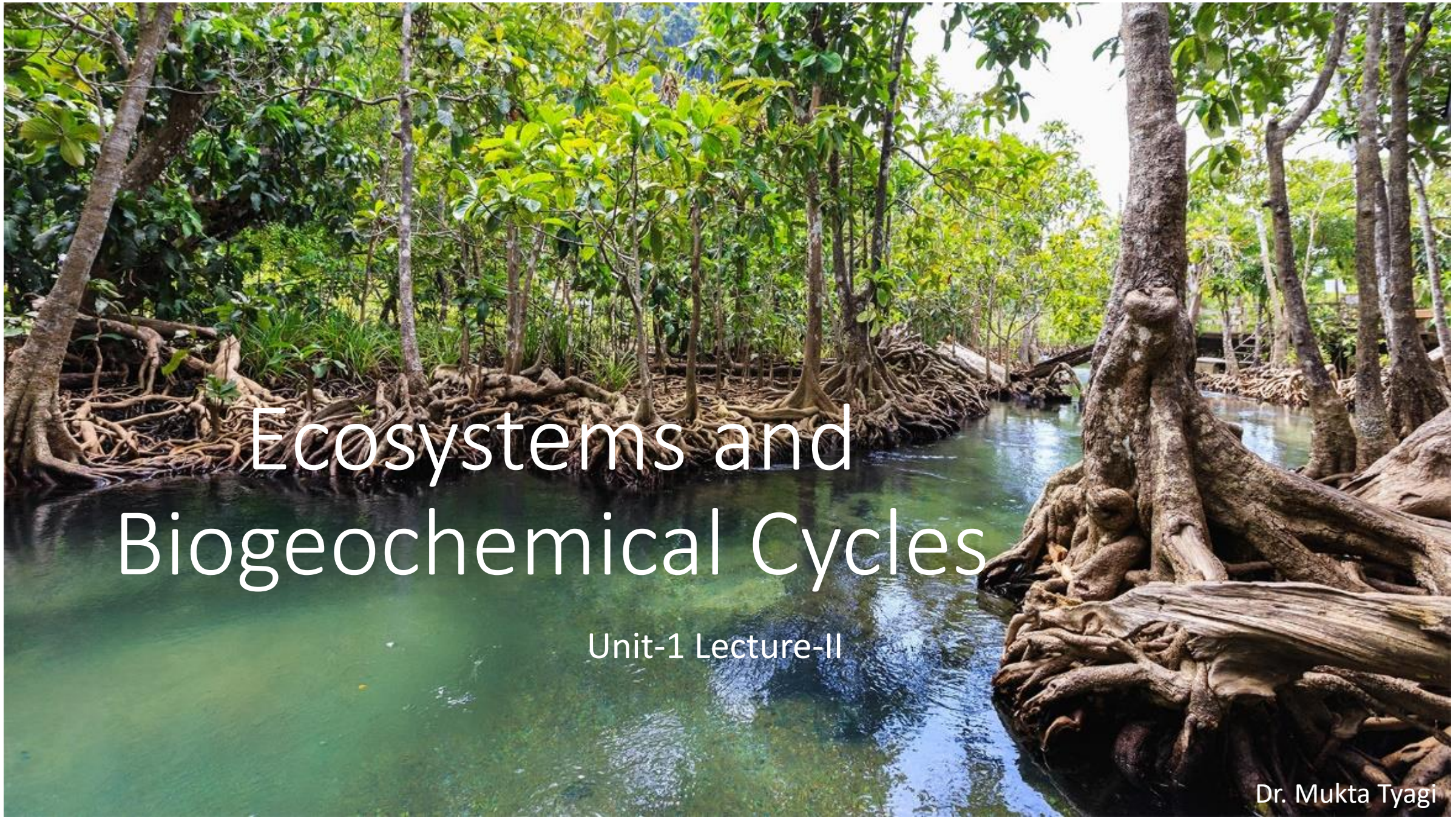


Ecosystems and Biogeochemical Cycles

Unit-1 Lecture-II

Dr. Mukta Tyagi

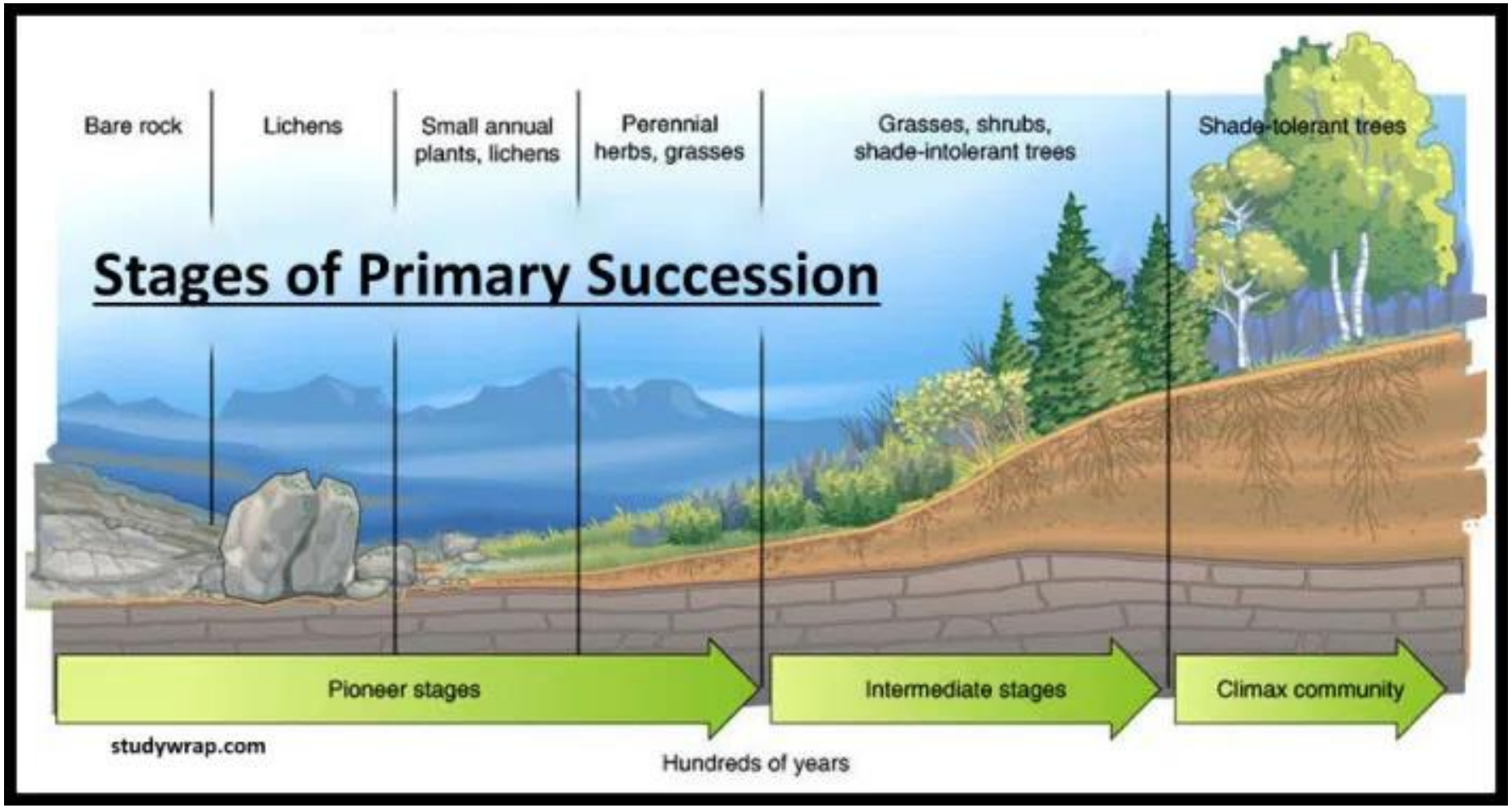
Ecological Succession

- A characteristic feature of biological communities is that their structure and composition changes according to certain changes in environmental conditions
- Some of these changes occur in a more predictable and orderly fashion
- The phenomenon through which these changes occur in ecological communities is Ecological succession
- This is an important aspect of the study of ecology and forms the core of ecological science

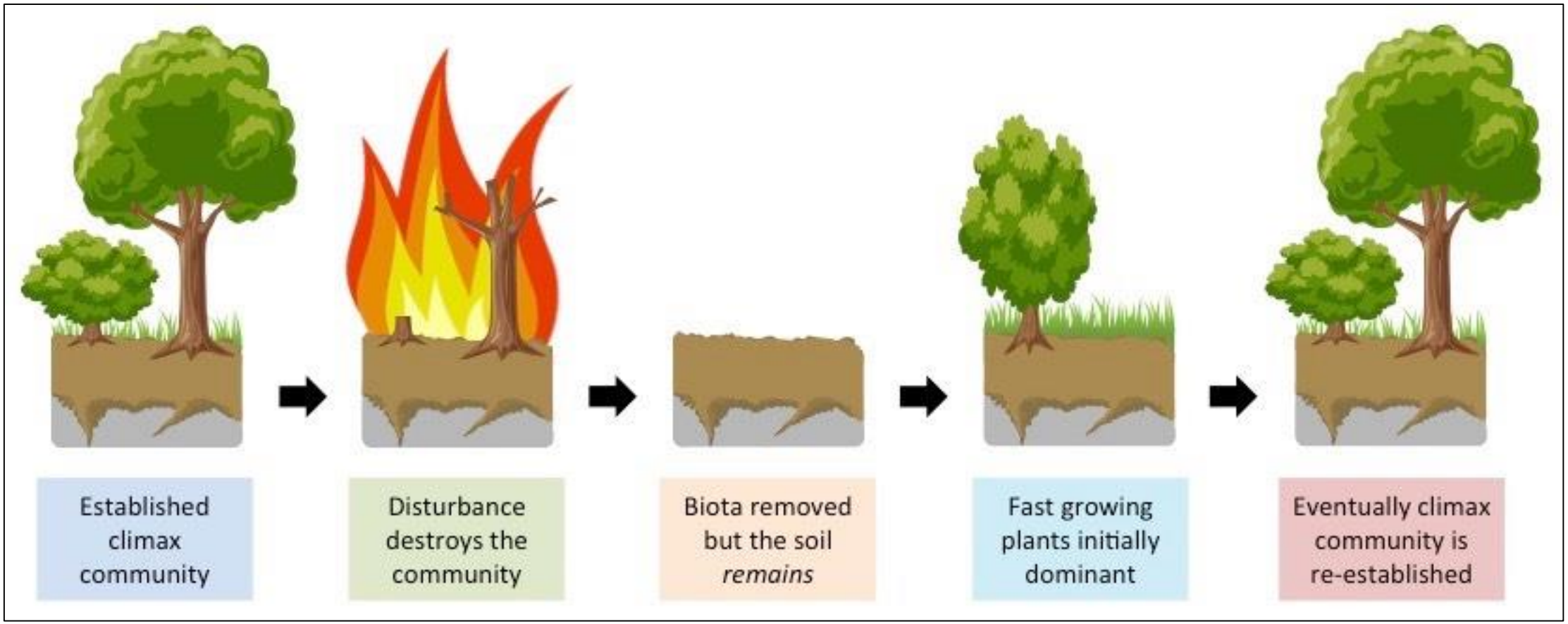
Types of ecological successions

- Ecological succession is mainly of two types-
- **Primary succession:** The primary succession is a slow process that initiates in areas where there are no living organisms
- **Secondary succession**: Secondary succession begins in areas that were once inhabited but destroyed due to environmental disturbances (drought, fire, flooding). This is generally faster, as most of the other factors are already present

Primary Succession



Secondary Succession

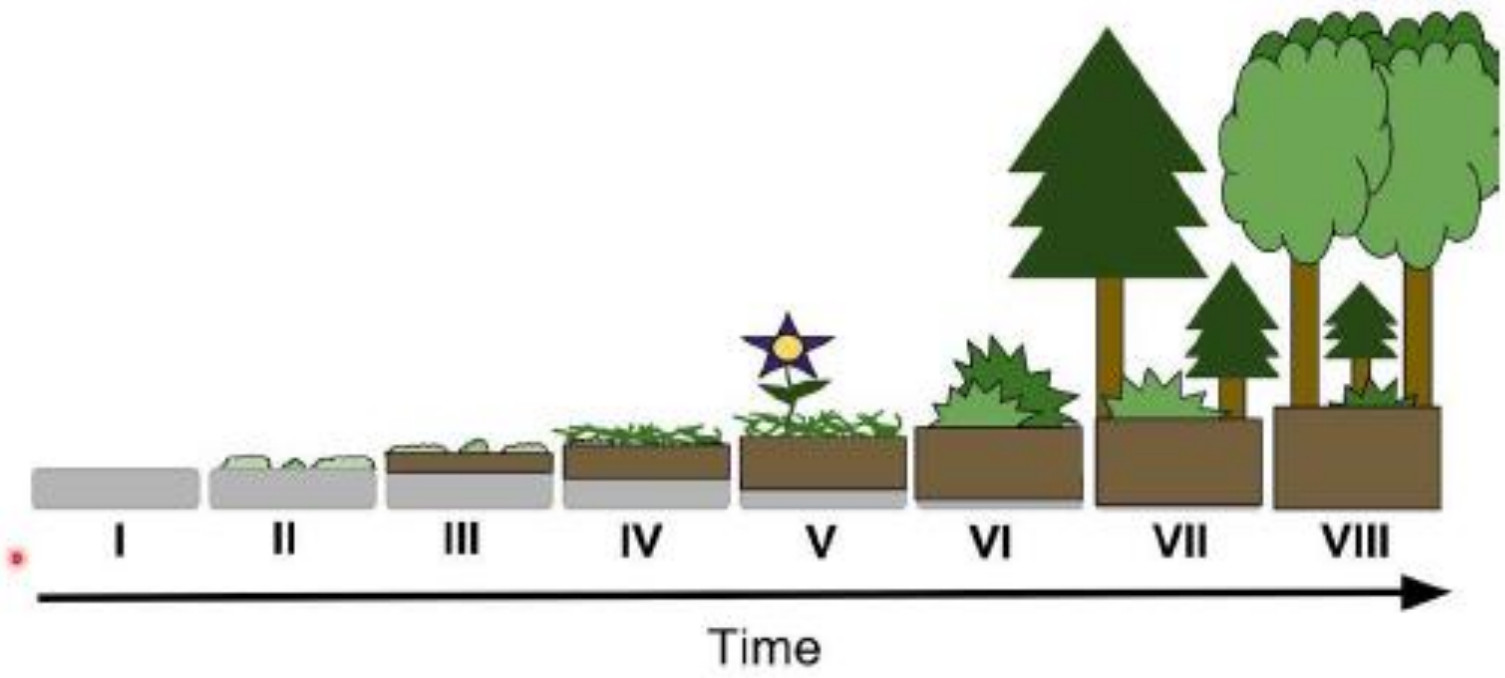


Types of community in a forest

1. Climax Community-When the changes create a community that is almost in equilibrium with the environment, it is what we call a climax community. (the community of species which is in equilibrium with all the biotic and abiotic components around it is called as climax community, it is a stable community when environmental parameters are favourable
2. Sere-In a given ecological area, the communities change successively. This sequence of communities is a sere. The transitional communities are called seral communities (hydrosere, lithosere, xerosere (xero-desert etc.)
3. As the seral communities progress, there is an increase in diversity of organisms, increased number, and an increased biomass

Steps in Ecological Succession

Nudation → invasion or migration → ecesis → aggregation → competition → reaction & stabilization→ climax



Steps in Ecological Succession

1. **Nudation:** Succession begins with the development of a bare site, called Nudation (disturbance), environmental factors are becoming favourable
2. **Migration (Dispersal):** It refers to arrival of **propagules** (buds, spores, seeds), wind acts mode for this stage…
3. **Ecesis (Establishment):** It involves establishment and initial growth of vegetation.
4. **Aggregation:** Increase in numbers of individuals in community
5. **Invasion:** That Migration which ends in establishment (chilli, potato)
6. **Competition:** As vegetation becomes well established, grow, and spread, various species begin to compete for space, light and nutrients (species which are able to survive the competition, are further seen in the community)
7. **Reaction:** During this phase **autogenic (naturally occurring/self-occurring)** changes such as the build up of humus affect the habitat, and one plant community replaces another.
8. **Stabilization:** A supposedly stable climax community forms

Types of Ecosystem

- A **forest ecosystem** is a natural woodland unit consisting of all plants, animals and microorganisms (Biotic components) in that area functioning together with all of the non-living physical (abiotic) factors of the environment
- **Freshwater ecosystems** are found in water containing low concentrations of salts, from ponds to estuaries
- **Marine ecosystems** are found in the saltwater of seas and oceans. Most of us are not far away from an aquatic ecosystem of some kind, whether it be in the ocean or a local pond
- **Desert Ecosystem** Desert are areas of land that are arid, or dry, and get less than 10 inches of rain per year. Deserts can be hot or cold. Plants and animals in the *desert ecosystem* have adaptations that allow them to survive the lack of rainfall and extreme temperatures (thar desert)
- **Grassland ecosystem** is a type of terrestrial **ecosystem** with an open land of grasses. The grassland ecosystem occupies about 25% of the total land area throughout the world. Abiotic components of grassland ecosystem are light, temperature, wind, humidity, atmospheric pressure and some chemicals

Forest Ecosystem

1. Temperate forest Ecosystem- main feature, Areas found, species found
2. Tropical Rain Forest Ecosystem
3. Taiga Forest Ecosystem

Types of Forest Ecosystem

Temperate forest- evergreen, deciduous

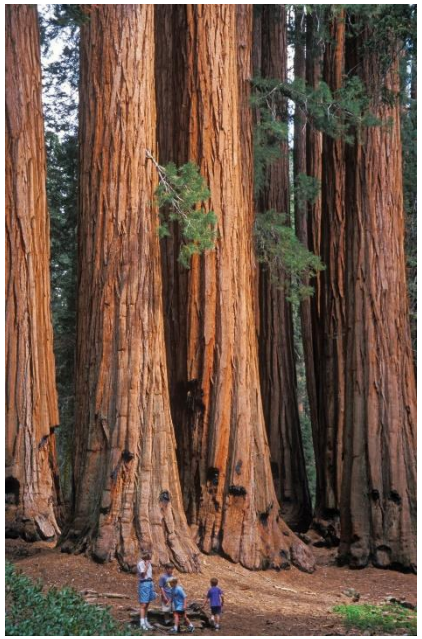
Tropical forest- Amazon

Taiga forest Canada, America

Temperate Forest Ecosystem

- The temperate forest ecosystem is very important on Earth
- Temperate forests are in regions where the climate changes a lot from summer to winter
- Temperate forests are almost always made of two types of trees:
  - deciduous and evergreen Deciduous trees are trees that lose their leaves in the winter
- Evergreens are trees that keep leaves all year long, like pine trees. These are found in California, Oregon and Washington in the United States.
- These forests are made of redwoods and sequoias, the tallest trees in the world
- The amount of rainfall in an area determines if a forest is present. If there is enough rain to support trees, then a forest will usually develop. Otherwise, the region will become grasslands
- Flora- Beech, Oak, Maple and Cherry
- Fauna- Vertebrates and invertebrates
- Mostly productive agricultural areas of the earth, rainfall abundant and moderate average temperature

Temperate Forest Ecosystem



Tropical Rain Forest

- Tropical rain forests are in regions where the climate stays constant all year long
- Temperatures are hot throughout the year – mainly between 26 & 27^{o}C. Rainfall is heavy and mainly convectional – up to 1800 mm a year. It rains everyday in the afternoon and in every month of the year. Its growing season is 365 days a year – in other words no seasons
- These special ecosystems are homes to thousands of species animals and plants
- Rain forests are not only densely packed plants, but are also full of tall trees that form a forest canopy
- This ceiling keeps smaller plants from growing. Areas where sunlight can reach the surface are full of interesting plants. The famous Amazon jungle is located in Brazil

Tropical Rain Forest

Taiga forest Ecosystem

- The forest ecosystem is the contiguous green belt of conifer and deciduous trees that encircles a large portion of the Northern Hemisphere
- In North America, the forest stretches across most of northern Canada and into Alaska
- This forest ecosystem covers roughly 35% of Canada's land mass and is the single largest land based ecosystem in North America
- It also contains a significant proportion of Canada's biodiversity and has long been recognized as an important **global carbon sink (forests)**
- This forest ecosystem houses the largest and smallest mammal species (wood bison & pygmy shrews) of the North American continent

Taiga Forest

Structure of Forest Ecosystem

- ***Producers*** All living organisms intake energy in order to survive. In a forest ecosystem, trees and other plants get their energy from sunlight. Plants produce their own food, in the form of carbohydrates. Photosynthesis is the chemical reaction that allows plants to produce their own food
- ***Consumers*** Animals cannot produce their own food therefore animals particularly primary consumers (herbivores) take food from producers of plants
- ***Decomposers*** Leaves, needles, and old branches fall to the forest floor as trees grow. Decomposers break these items down into their smallest primary elements to be used again. Decomposers are important in that they sustain the nutrient cycle of ecosystems

Humans as a part of ecosystem

- Humans are consumers. We get food and materials from forests. Because of this, we are a part of the forest ecosystem.
- Human consumption alters forest ecosystems. Human intervention may be necessary to sustain forest communities under the increased pressure of human use

Aquatic Ecosystem

- An **aquatic ecosystem** is an ecosystem in a body of water. Communities of organisms that are dependent on each other and on their environment live in aquatic ecosystems
- Fresh Water Ecosystem
  - Lentic Ecosystem (standing water): Ponds, lakes
  - Lotic Ecosystem (Running Water): River, streams
- Marine Ecosystem _oceans (salt water ecosystem)
- Transition/Brackish Water Ecosystem- Kerala Back waters, Sundarbans
  - Estuaries
  - Wetlands/Swamps

Factors affecting a Fresh Water Ecosystem

1. Temperature- it fluctuates as the area changes (rivers). The variation is small, decreasing gradually from the surface to the bottom of the water body

- It is a limiting factor as the aquatic animals have a narrow range of tolerance for temperature change
- Waterbodies like rivers also play role in controlling the climate of the land and its surroundings

Factors affecting Fresh Water Ecosystem

2. Transparency- it is limiting factor as it affects the amount of light penetrating the water body

- Large shallow lakes with large area tend to be more productive than those with deep water because more light reaches the lake bed
- Proper light maintains the ecological balance between the trophic levels…producers, consumers etc.
- In river systems, heavily shaded streams rely on the degraded organic matter and leaves from the surrounding catchment to fuel the ecosystem
- Transparency of water is measured using Secchi disk
- Secchi disk transparency of clear lake is about 40 meters whereas for a heavily turbid waterbody it is as low as a few centimeters

Secchi disk

Factors Affecting Fresh Water Ecosystem

3.Current- Current plays important role in estimating the distribution of salts, vital gases and small organisms. It serves as an important limiting factor for the lotic systems especially for streams

- Oxygen and the carbon dioxide concentration are often limiting in freshwater environment.
- Dissolved oxygen content (DO) and Biological oxygen demand (BOD) are important factors for measuring the biological and physical health of a waterbody.
- Bod tells you, the amount of oxygen consumed by micro-organisms to convert organic matter present in water into simpler compounds

Lotic Ecosystem (Running)- Rivers & Streams

- Lotic aquatic systems are the fresh water bodies with flowing waters
- Rivers and streams are the most common examples of such systems
- The basic function of lotic water bodies is assumed to carry the excess of rain water back to the sea
- The flow of water in continuous and unidirectional in a lotic system
- The volume of water changes rapidly which results in change in the velocity of water currents
- Water in these systems act as effective agent of transportation, transfer, and dilution
- They continuously erode materials along their channels and deposit them to other places
- Watershed- area drained/watered by a stream or river and its tributaries

Lentic Ecosystem (Still Waters)- Ponds, Lakes, Wetlands, Swamp

- This type of ecosystem includes the lakes, ponds, wetlands, small reservoirs of water storage
- The major source of water for this type of ecosystem is seasonal rainfall
- Any adverse situation like sparse rainfall or drought situations leads to drying up of this type of ecosystem
- Rice culture is one of the most common forms of artificial wetlands created
- Swamps or flood plains are another kind of naturally occurring wetlands
- Swamps and flood plains are found in the low-lying areas where there is depression in soil topology

Types of Lentic Ecosystem

- Lakes - is a body of relatively still fresh water of considerable size, localized in a basin, that is surrounded by land
- Ponds- body of standing water, either natural or man-made, that is usually smaller than a lake
- Swamp - is a wetland that is forested
- Bog - is a wetland that accumulates peat, a deposit of dead plant material—often mosses, and in a majority of cases eg. Sphagnum moss

Lentic Ecosystem

Pond

Lake

Swamp

Bog

Importance of Fresh Water Ecosystem

1. These ecosystem provide water for terrestrial as well as domestic use
2. There is only 1 % of total water present on earth which supports a population of more than 7 billion humans on this earth
3. It is important to keep the fresh water ecosystem safe in order to survive on this plant

Eutrophication

Definition- It is the process in which a water body becomes overly enriched with nutrients, leading to plentiful growth of simple plant life. The excessive growth (or bloom) of algae and plankton in a water body are indicators of this process

- **Natural Eutrophication-** it is caused by normal process and can take several years ,
- **Cultural Eutrophication-** caused by human activities
- **Causes-**
  - Natural run off from soil, inorganic fertilizers
  - Erosion
  - Animal waste and sediments entering into water
  - Discharge of partially untreated sewage into water
  - Domestic and Industrial Wastes

Eutrophication

Marine Ecosystem

- A marine ecosystem is the one that occurs in or near salt water like sea or ocean
- The ocean covers 71% of the planet, so marine ecosystem make up the most of the earth
- Types of Marine ecosystems
  - Sandy Beaches
  - Salt Marshes
  - Coral Reefs
  - Mangrooves

Rocky Shore

Mangroves

Ecological uses	Economical uses	Social uses
Erosion control	Fishing	Education
Protection from damage	Shrimp and crab industries	Ecotourism
Indicator of climate change	Charcoal production	Food
Habitat provision	Timber production	Local employment
Water quality management	Firewood	Agriculture
Carbon Sequestration		Traditional medicine

Desert Ecosystem

- Desert- Desert are areas of land that are arid, or dry, and get less than 10 inches of rain per year
- Deserts can be hot or cold
- Plants and animals in the desert ecosystem have adaptations that allow them to survive the lack of rainfall and extreme temperatures
- There is one desert in every continent except Europe and Antarctica
- The desert sand started out as rock, but years of weathering by wind and water has created dunes in the deserts
- These sands are mostly minerals, and sometimes oil can be found hidden deep within the rocks

Types of Deserts

Hot Desert- Sahara

Cold Desert

Types of Deserts

- Hot Desert- Generally remains above 40 degree Celsius, rainfall- less than 250 mm a year
- eg. Sahara desert, Thar desert
- Cold desert – Cold deserts have hot summers but extremely cold winters. These are found in high flat areas like plateaus or mountain areas
- Eg. Gobi Desert in Central Asia , sees a temperature drop of -40 degree Celsius during winters
- Ladakh region and Spiti Valley in India are also examples of cold desert

Species in Deserts

- Plants- Mainly Shrubs and Cactus
- The saguaro cactus is the tall, pole shaped cactus. The saguaro can grow up to 40 feet tall. It can hold several tons of water inside its soft tissue
- These plants are called as succulents as they store a lot of water in their tissues and have a waxy coating over their leaves to preserve water from evaporation
- Animals-Reptiles are some of the most interesting creatures of the desert
- Reptiles can withstand the extreme temperatures as they can control their body temperatures very easily
- Desert reptiles into one of two categories: snakes and lizards
- Camels are the most common animals used for transport in desert areas

Saguaro Cactus

Grassland Ecosystem

- Grassland ecosystem is a type of terrestrial ecosystem with an open land of grasses
- The grassland ecosystem occupies about 25% of the total land area throughout the world
- Abiotic components of grassland ecosystem are light, temperature, wind, humidity, atmospheric pressure and some chemicals
- Biotic Componets
  - Grass Species- Brachiaria sp., Cynodon sp.
  - Animals- Herbivores, Carnivores
- Eg. Prairies in USA, Pampas in Argentina, Alpine Meadows of Himalayas, Banni Grassland Reserve in Gujarat

Types of Grasses

Brachiaria sp- Browntop Millet

Cynodon Sp.-Scutch grass

Grasslands

Prairies -USA

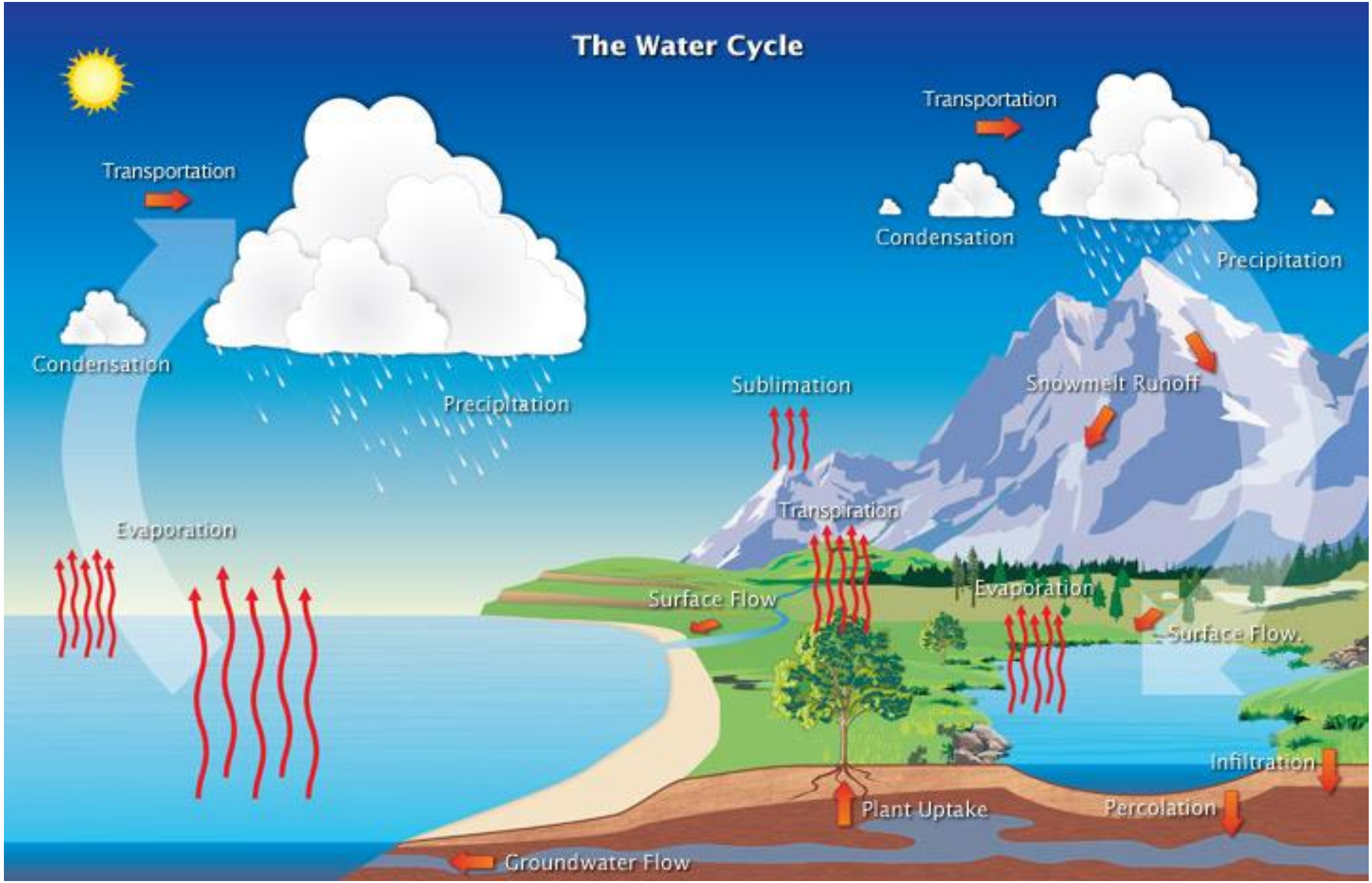
Alpine Meadows in Himalayas

Biogeochemical Cycles in Environment

- **Definition**-Biogeochemical cycles mainly refer to the movement of nutrients and other elements between biotic (flora/fauna) and abiotic factors (water, Soil or air)
- Types of cycles involved in a environment
  - Carbon Cycle
  - Nitrogen Cycle
  - Phosphorus Cycle
  - Oxygen Cycle
  - Sulphur Cycle
- Depending upon the source of elements the cycles are divided into two types
  - Gaseous Cycles- Carbon, Oxygen, Nitrogen and Water Cycle
  - Sedimentary Cycles- Sulphur Cycle, Phosphorus cycle

Water Cycle (Hydrologic Cycle)

- Water is an important ecological factor that determines the structure and function of the ecosystem
- Cycling all the nutrients depends on water as it provides mode of transport
- It acts a solvent medium for the uptake nutrients in organisms
- Hydrologic cycle is the continuous circulation of water in Earth- Atmosphere system
- This cycle is driven by solar energy
- Water on Planet Earth is stored in major reservoirs like atmosphere, oceans, lakes, rivers, soils, glaciers, snow fields and ground water
- Process Involved - Evaporation, transpiration (is the mode water intake by plants through roots), condensation or precipitation , deposition, run off, Infiltration and ground water flow


The Water Cycle
Transportation
Condensation
Precipitation
Evaporation
Transportation
Condensation
Precipitation
Sublimation
Snowmelt Runoff
Transpiration
Surface Flow
Evaporation
Surface Flow
Infiltration
Plant Uptake
Percolation
Groundwater Flow

Carbon Cycle

- Carbon is the minor constituent of the atmosphere as compared to oxygen and nitrogen
- Although, life is will not exist without carbon because it is the vital constituent of carbohydrates which are produced by plants during photosynthesis
- It is the element which anchors all organic substances from coal to DNA
- Carbon is present in the atmosphere mainly in the form of CO_2
- Carbon cycle involve exchange of carbon between atmosphere and organisms

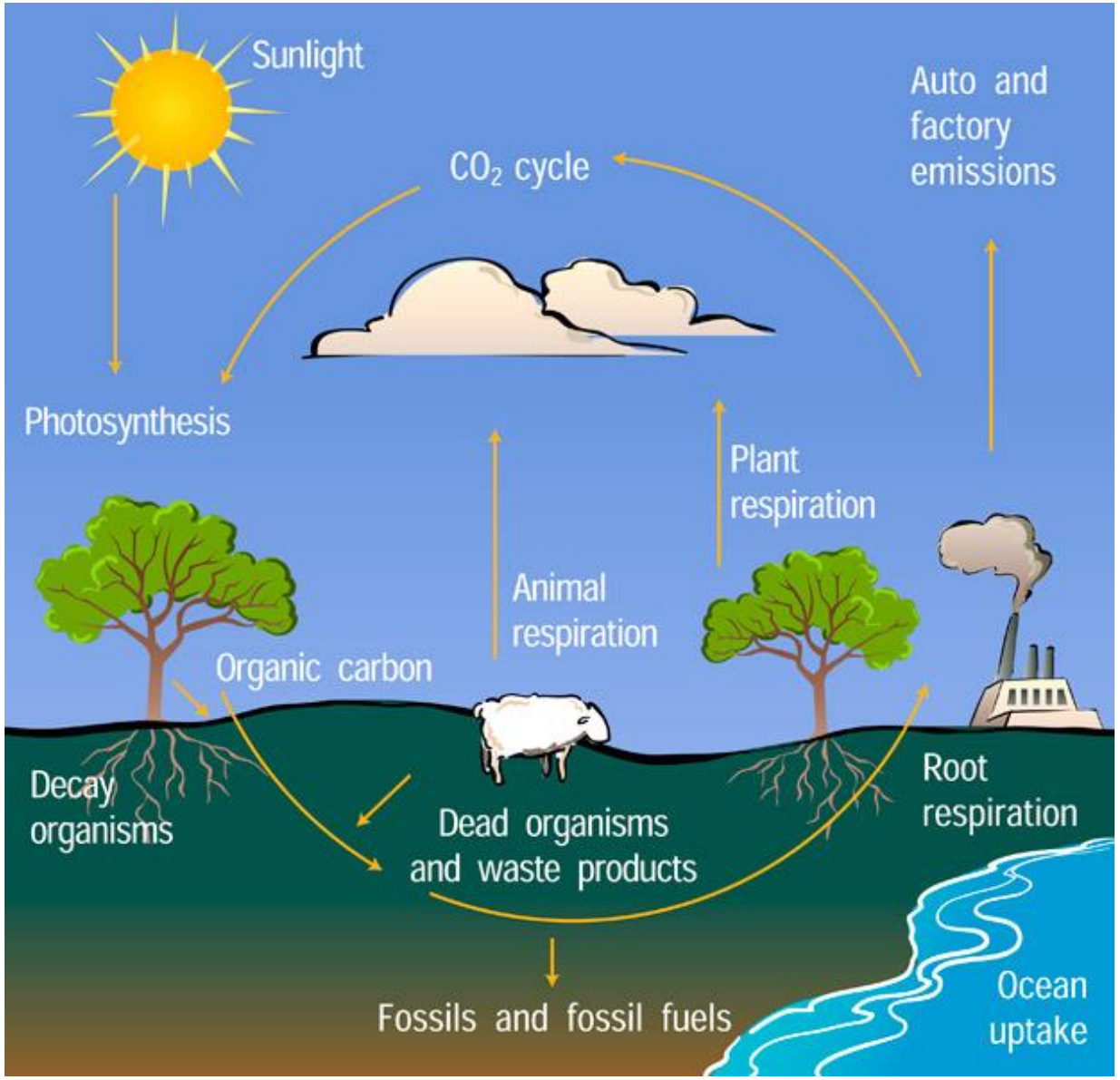
Carbon Cycle

There are two types of carbon cycle

Short Term cycle- Carbon from atmosphere moves into plants and animals

- This form of carbon is taken up by animals and then converted to CO_2 (during respiration) and dead and decaying organic matter and returned to atmosphere and soil
- Long Term Cycle- Carbon converts into coal from undecomposed peaty layers in marshes and swamps
- The carbon can be stored as carbonates and bicarbonates of various elements and stay unchanged for several years before returning back to atmosphere
- Oceans are the biggest reservoirs of carbon dioxide

Carbon Cycle

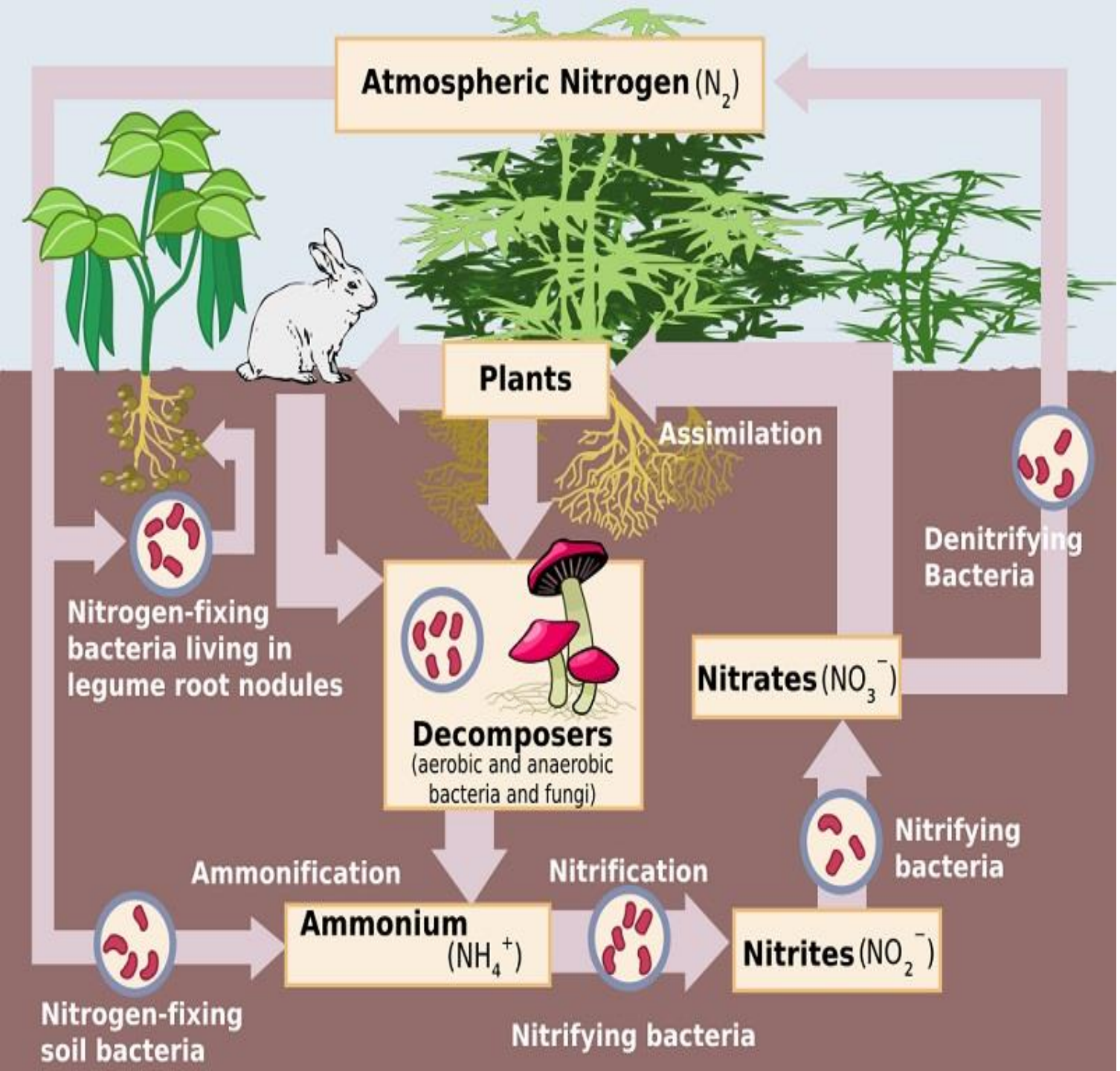


Nitrogen Cycle

- Nitrogen is an essential Constituent of all proteins and is basic building block of all living tissues
- It constitutes nearly 16% by weight of all the proteins
- There is inexhaustible source of nitrogen in the atmosphere but its elemental form cannot be used directly by most organisms
- Nitrogen needs to be 'fixed' i.e. it needs to be converted to ammonia, nitrites or nitrates before it can be taken up by plants
- Nitrogen fixation on earth is done by two process
  - By micro-organisms(bacteria and algae)
  - By man using industrial processes(fertilizers)
  - Thurderstorm/lighting

Nitrogen Cycle

- The amount of nitrogen fixated by humans is more than natural process
- Such production of fertilizers is acting as a pollutant and disrupting the environmental balance
- Acid Rain, Eutrophication and harmful algal blooms are few such examples
- Various bacteria are capable of converting atmospheric nitrogen into ammonium ions
- Ammonium Ions are directly taken by the plants or oxidized into nitrites or nitrates by specialized bacteria
- Nitrates are taken up by plants and converted into amino acids which are the building blocks of proteins
- Proteins are taken up by consumers in higher trophic levels and returned to soil once dead

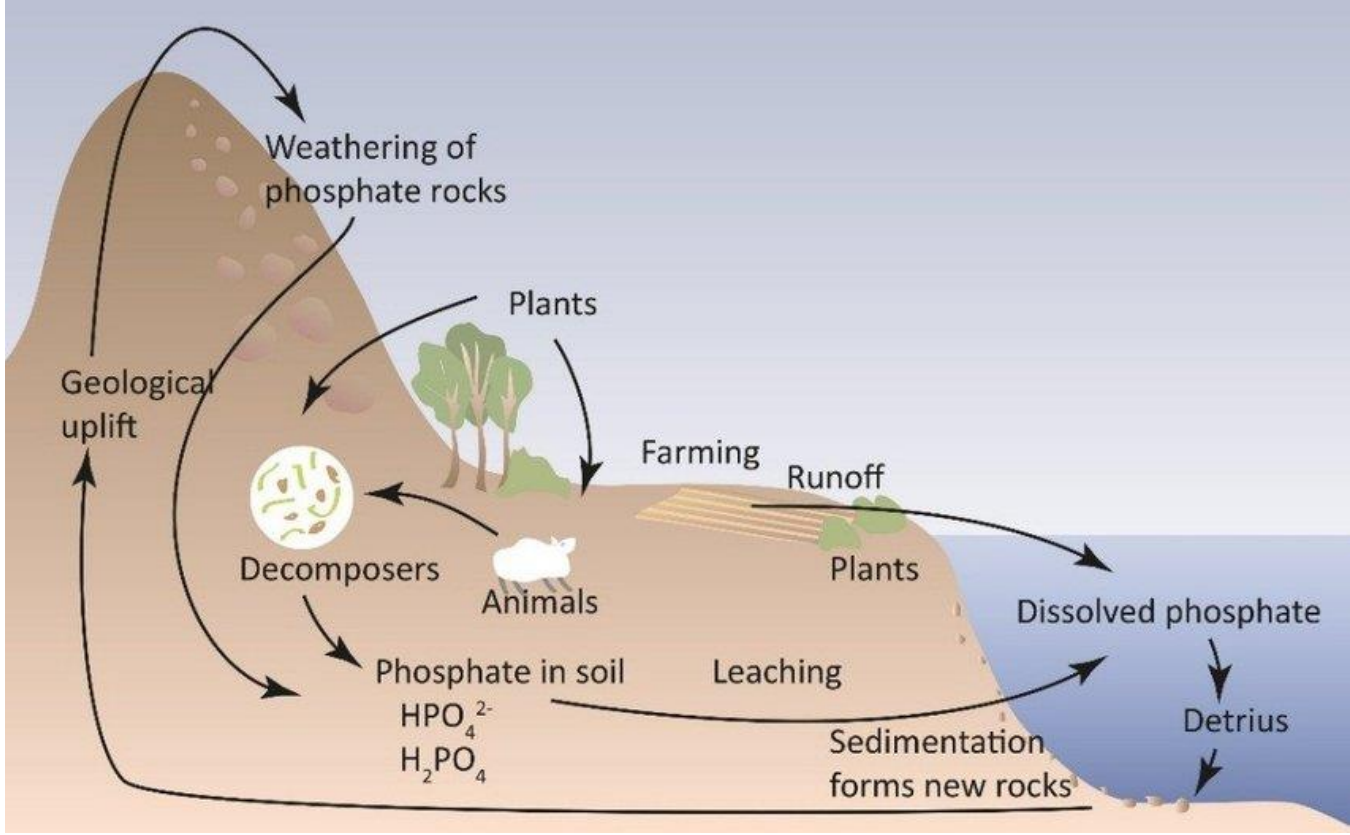


- Free living microorganisms which can convert atmospheric nitrogen to ammonium ions- Anerobic azotobacter and Clostridium; Bacteria living in the leguminous plant roots- Rhizobium, Spirulina
- Ammonium ions to nitrite- nitrosomonas bacteria
- Nitrite to Nitrate- Nitrobacter bacteria
- Denitrifying bacteria- Pseudomonas bacteria (Nitrates to atmospheric nitrogen)

Phosphorus Cycle

- Phosphorus plays a central role in aquatic ecosystems and water quality
- Phosphorus occurs in large amounts as mineral in phosphate rocks and enters the cycle through erosion and mining activities
- It is the main element which leads to excessive growth of rooted and free – floating microscopic plants in lakes
- Phosphorus on earth's crust is stores as phosphate and by process of weathering and erosion phosphates enter rivers and streams
- In oceans, Phosphorus is stored in continental shelves and is exposed only when these plates rise to the surface in millions of years

Phosphorus Cycle

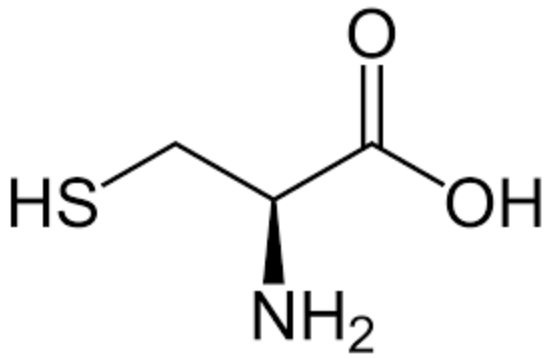


Sulphur Cycle

- Sulphur reservoir is in the soil as:
  - Organic- Coal, peat, oil
  - Inorganic deposits- pyrite rock and Sulphur rock as sulphates, sulphides and organic Sulphur
- It is released by weathering of rocks, erosion and decomposition of organic matter and is taken up by terrestrial and aquatic ecosystem in salt solution
- H_2S and SO_2 are two gaseous components of Sulphur cycle
- It enters into atmosphere by volcanic eruptions, fossil fuel combustion, from surface of ocean and gases released by decomposition
- Atmospheric hydrogen sulphide is oxidized to Sulphur dioxide which reaches earth surface through rain (acid rain)

Sulphur Cycle

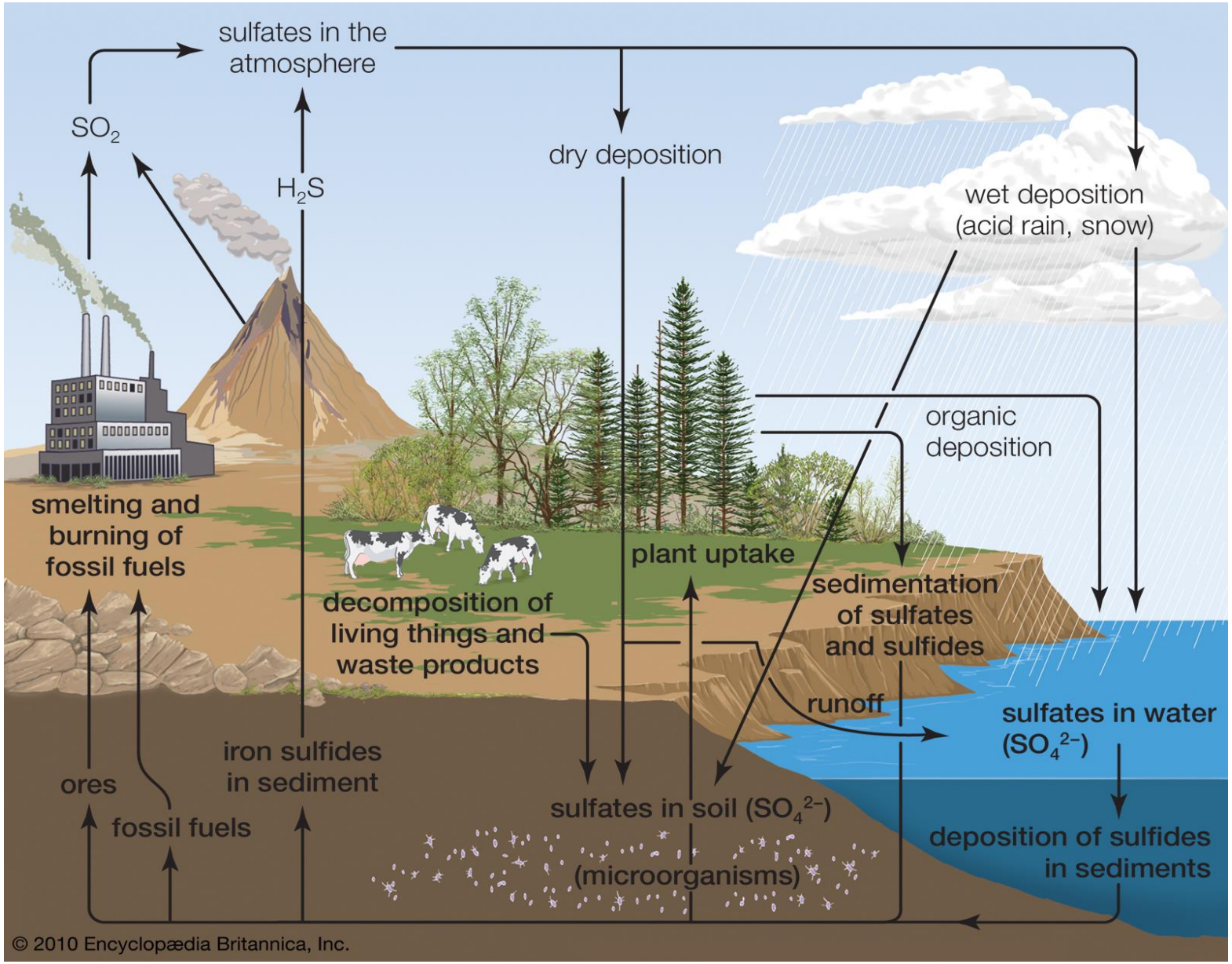
- In plants, Sulphur in the form of sulphates is taken up by plants and through various metabolic process it changed into Sulphur containing amino acids eg. Methionine, cysteine, homocysteine, and taurine



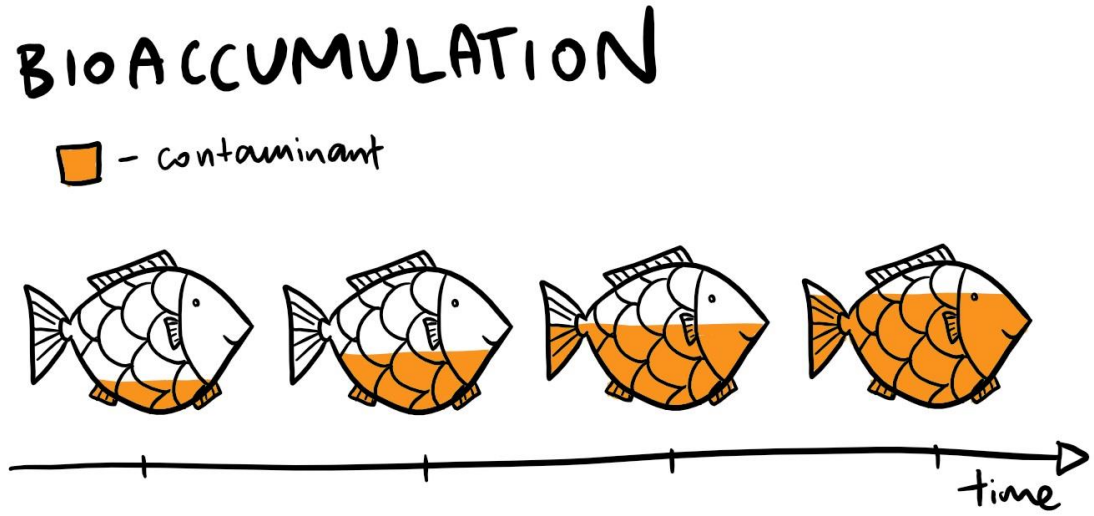
Cysteine

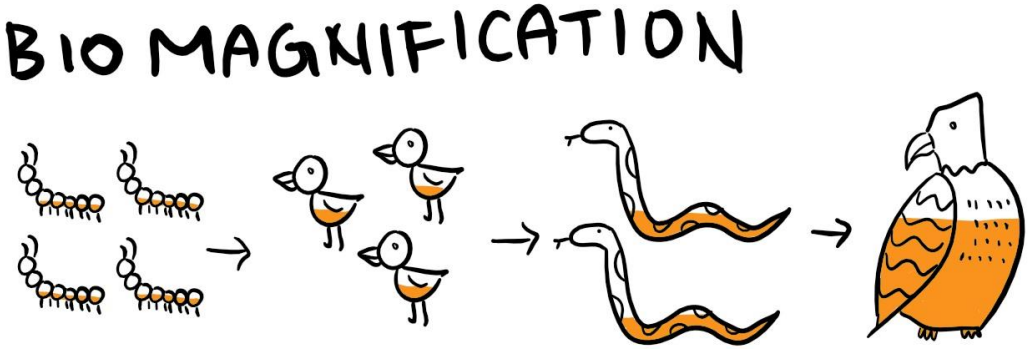
- Cysteine helps with chronic respiratory conditions, brain health, fat reduction etc.

Sulphur Cycle



Bioaccumulation	Bio magnification
Gradual accumulation of substances such as pesticides or other chemicals in living beings	The concentration of toxic chemicals in organism while going along a food chain from one trophic level to other trophic levels
It occurs in a organism	It occurs between different trophic levels





Ecological Values, Services and Carrying capacity

- Humans are consuming much more resources than what Earth can regenerate in a year
- It shows humans may be going beyond the carrying capacity of Earth as an ecosystem
- Carrying capacity is the maximum population size that an ecosystem can sustainably (using resources in such way that they are available for upcoming generations too) support without degrading the ecosystem
- Eg. Over grazing
- Deaths and long term damage to an ecosystem occurs when a population exceeds the carrying capacity of its ecosystem
- Disease, competition, predator-prey interaction, resource use and the number of populations in an ecosystem all affect carrying capacity

Ecological Values, Services and Carrying capacity

- Therefore, there is need of sustainable development that meets the needs of the present without compromising the ability of future generations to meet their own needs
- Various factors affecting Sustainable living
  - Economic Planning- it should be done in order to provide resources at the place of need
  - Population Control- to stop over exhaustion of fossil fuel, potable water, food resources
  - Biodiversity Conservation- all the species present on this planet are the part of food web. Sancturies, natural parks and should be protected
  - Agriculture Management- reflect the need of population, requirement of crops according to the water available in the region
  - Urban Planning- reduce pollution, waste management, sewage treatment
  - Food security