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9/17/2024

Ecosystems

Introduction

PART I

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Ecosystems:

Concept,
Structure,
Function of ecosystems
Types-Forests, wetland, deserts….
Biogeochemical Cycles

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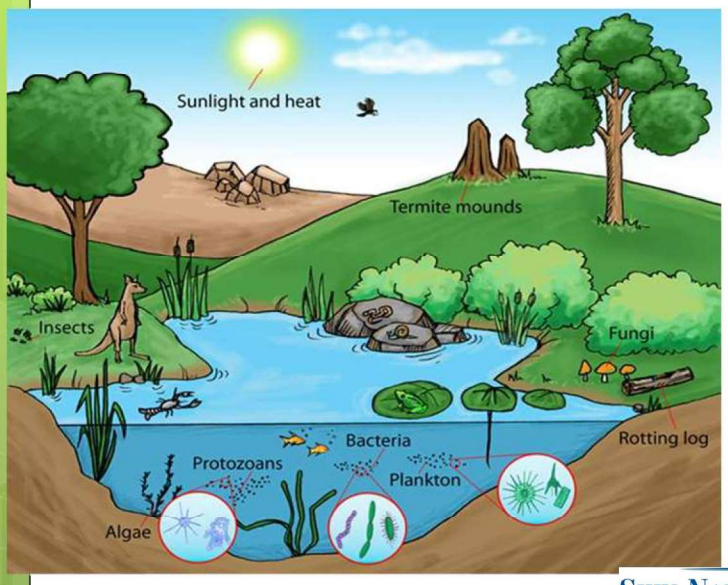
Ecology and Ecosytem

- **Ecology** (from the Greek oikos, meaning "household," "home," or "place to live) is the study of relationship between organisms and its environment.
  - *Coined by the German zoologist **Ernst Haeckel**,* who applied the **term** oekologie to the "*relation of the animal both to its organic as well as its inorganic environment.*"
  - **Ecology** deals with the organism and its environment.
  - Three types of ecology-
    - landscape ecology,
    - **population ecology**, and
    - behavioral ecology
- Ecosystem- is a **place**, such as desert, forest, ocean, grassland, where **interactions** of living and non living occurs.

Ecosystem



An Ecosystem is a community of living organisms (plants, animals and microbes) in conjunction with the non--living components of their environment (things like air, water and mineral soil), interacting as self sustaining a system.

Ecosystems

- The term ecosystem was initially framed in 1930 by Roy Clapham, to denote the physical and biological components of an environment considered in relation to each other as a unit.
- Roy first used the term but it was **AG Tansley**, who coined the term & fully defined the concept of ecosystem
- Arthur George Tansley, coined the term in 1935, Ecosystem (an oxford ecologist and phytologist)
- R D Mishra- Father of Ecology in INDIA.

- An Ecosystem: is a natural unit consisting of all plants, animals and micro-organisms (biotic factors) in an area functioning together with all of the non-living physical (abiotic) factors of the environment.

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Ecosystems

- **British ecologist Arthur G. Tansley later refined the term, describing it as**

"The whole system,…including not only the organism-complex, but also the whole complex of physical factors forming what we call the environment".

- Word ecosystem was first coined by Tansley in 1935 and previously the term '**biocoenosis**' was used.
- '**Biocoenosis**' Coined by Karl Mobius in 1877.

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Ecosystems

Eugene Odum, one of the founders of the science of ecology, stated:

- "Any unit that includes all of the organisms (i.e., the "community") in a given area interacting with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity, and material cycles (i.e., exchange of materials between living and non-living parts) within the system " .
- The **trophic level** of an organism is the **position it occupies** in a food chain/ food web.

Ecosystems

- Classification

Ecosystems have become particularly important politically, since the Convention on Biological Diversity(CBD) - ratified by more than 175 countries – ratified the resolution

"the protection of ecosystems, natural habitats and the maintenance of viable populations of species in natural surroundings"

as one of the binding commitments of the ratifying countries.

An Ecosystem

- This has created the political necessity to spatially identify ecosystems and somehow distinguish among them.
- The CBD defines an *"ecosystem" as a "dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit"*

An Ecosystem

- Smith (1966) has summarized common characteristics of most of the ecosystems as follows:
  - 1. The ecosystem is a major structural and functional unit of ecology.
  - 2. The structure of an ecosystem is related to its species diversity in the sense that complex ecosystem have *high species diversity*.
  - 3. The function of ecosystem is related to energy flow and material cycles within and outside the system.
  - 4. The relative amount of energy needed to maintain an ecosystem depends on its structure. Complex ecosystems needed less energy to maintain themselves. More complex-- More stable. i.e. *Tropical Rainforest*

* more complex interactions, the ability of organisms to deal with disturbances increases.

An Ecosystem

- 5. Young ecosystems develop and change from less complex to more complex ecosystems, through the process called succession.
- 6. Each ecosystem has its own energy budget, which cannot be exceeded.
- 7. Adaptation to local environmental conditions is the important feature of the biotic components of an ecosystem, failing which they might perish.
- 8. The function of every ecosystem involves a series of cycles, e.g., water cycle, nitrogen cycle, oxygen cycle, etc. these cycles are driven by energy. A continuation or existence of ecosystem demands exchange of materials/nutrients to and from the different components.

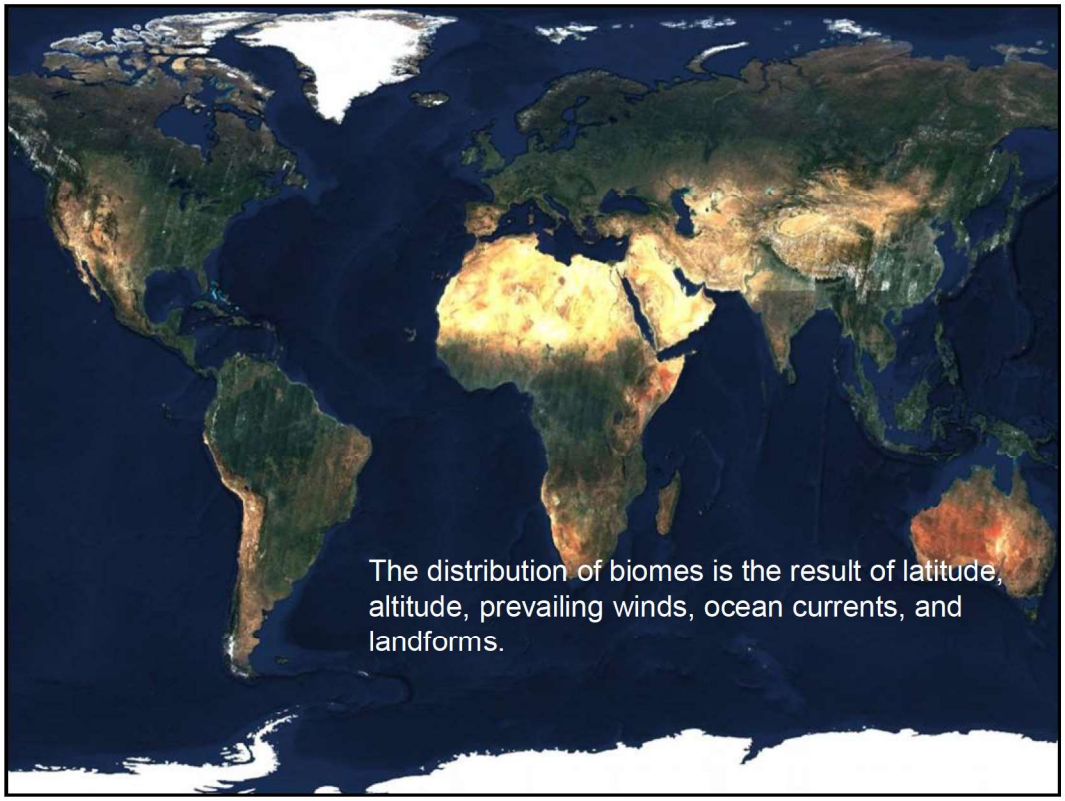
An Ecosystem

Provide Ecosystem services

- Ecosystem services are "*fundamental life-support services upon which human civilization depends,*"

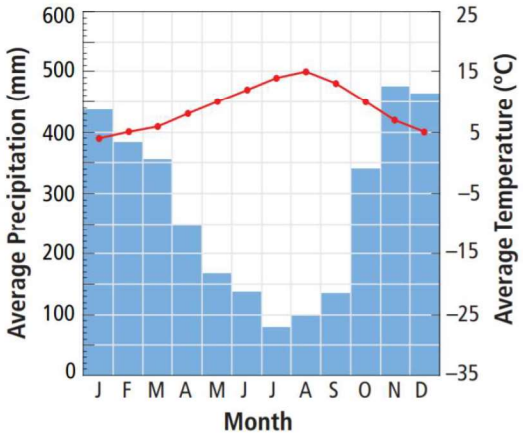
and can be direct or indirect services.

- Example of direct ecosystem services are: pollination, wood, erosion prevention etc.
- Indirect services could be considered climate moderation, nutrient cycles, detoxifying natural substances and many more



Climatographs

- **Climatographs** are combination line/bar graphs that show trends in temperature and precipitation over a typical year in a biome.
  - Average monthly precipitation: Bar graph
  - Average monthly temperature: Line graph



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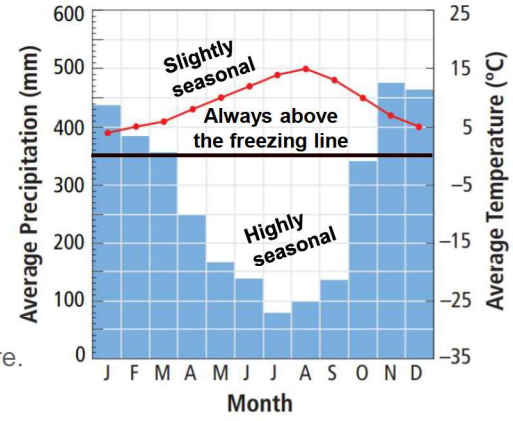
- Climatographs tell you:
  - If temperatures are seasonal or consistent.
  - If precipitation is seasonal or consistent.
  - If the climate is below freezing part of the year.
- You can infer:
  - Latitude and geography of the ecosystem.
  - Northern or southern hemisphere.
  - What type of ecosystem is present.



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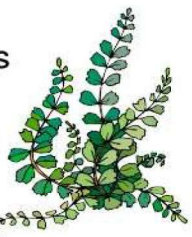
2. Structure of Ecosystem

The Ecosystem

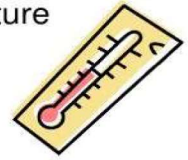
- The co-existence of various species is a highly ordered, dynamic and complex system.
- The interaction between living organisms and their environment is a two-way process- organisms affect their surrounding and the surroundings affect the organisms.
- The ecosystem is initially divided in two components
- Abiotic (non-living)
- Biotic (living)

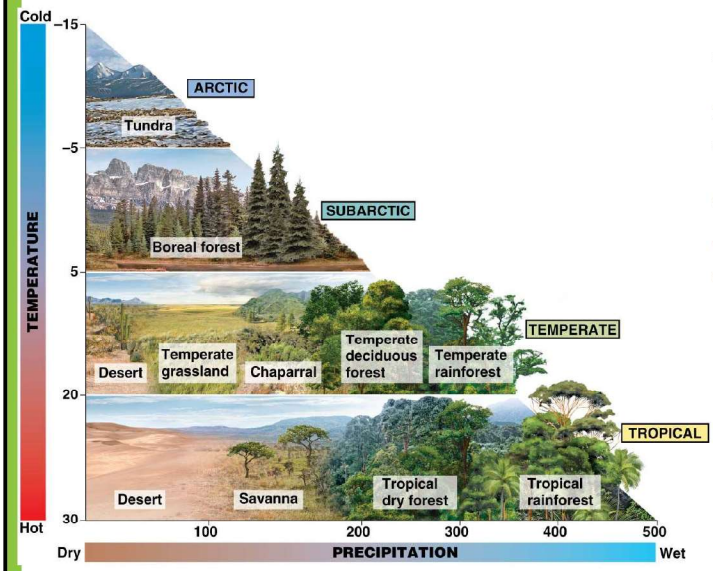
Biotic vs. Abiotic Factors

- Living
- Examples
  - Plants
  - Animals
  - Fungi
  - Bacteria



- Non-Living
- Examples
  - Water
  - Sunlight
  - Soil
  - Air
  - Temperature





The two most significant abiotic factors in biomes are *temperature* and *precipitation*, which are influenced by:

- Latitude
- Altitude
- Prevailing winds
- Nearby mountains

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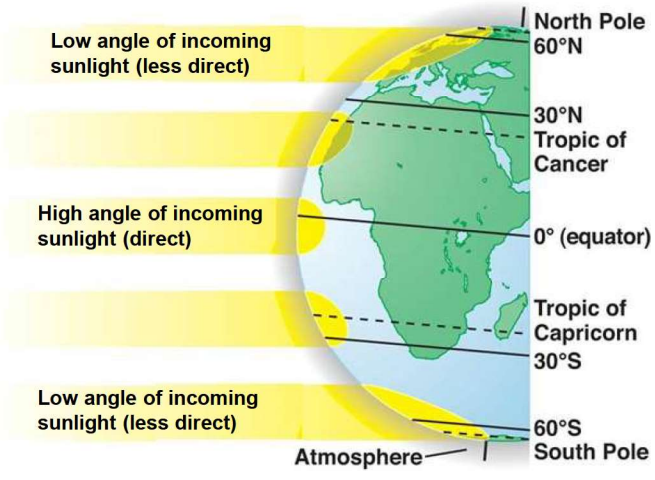

- Latitudes near the equator receive more direct sunlight and a greater amount of warming.

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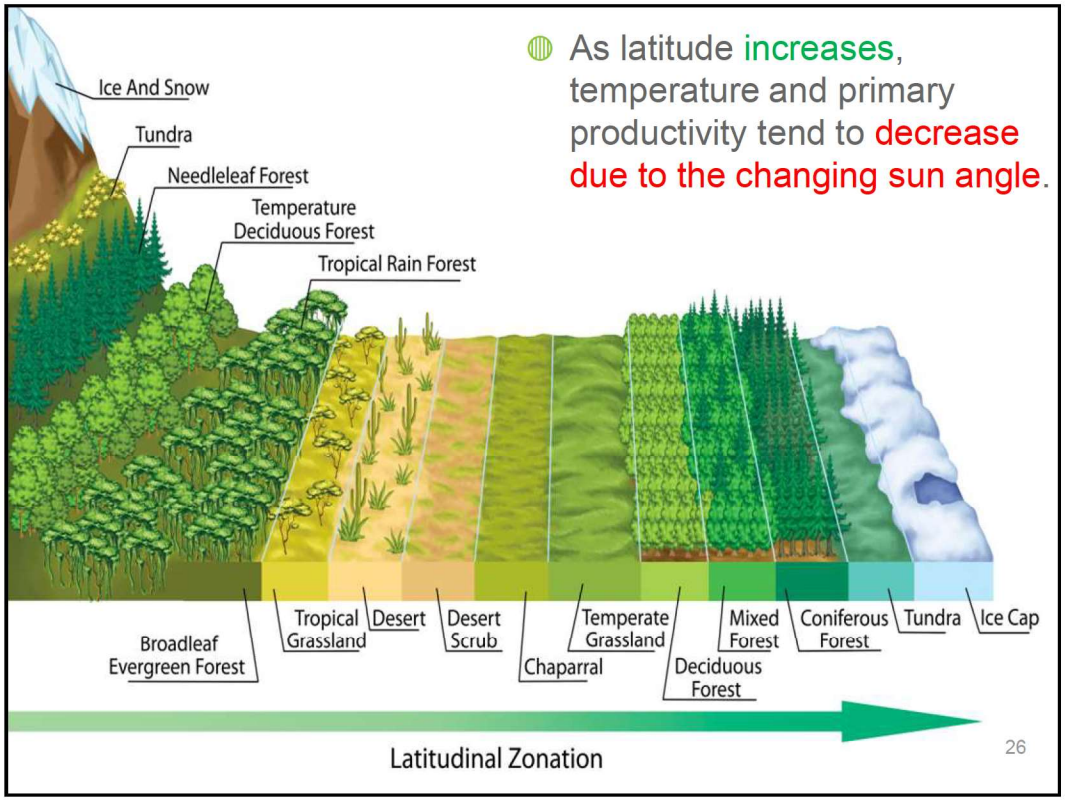
As latitude increases, temperature and primary productivity tend to decrease due to the changing sun angle.
Ice And Snow
Tundra
Needleleaf Forest
Temperature Deciduous Forest
Tropical Rain Forest
Broadleaf Evergreen Forest
Tropical Grassland
Desert
Desert Scrub
Chaparral
Temperate Grassland
Deciduous Forest
Mixed Forest
Coniferous Forest
Tundra
Ice Cap
Latitudinal Zonation
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Altitude is the elevation above sea level.
As altitude increases, average temperature and primary productivity decrease.
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2. Structure of Ecosystem

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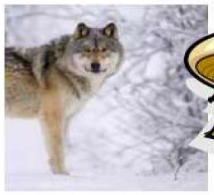
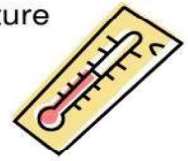


- Non-Living
- Examples
  - Water
  - Sunlight
  - Soil
  - Air
  - Temperature



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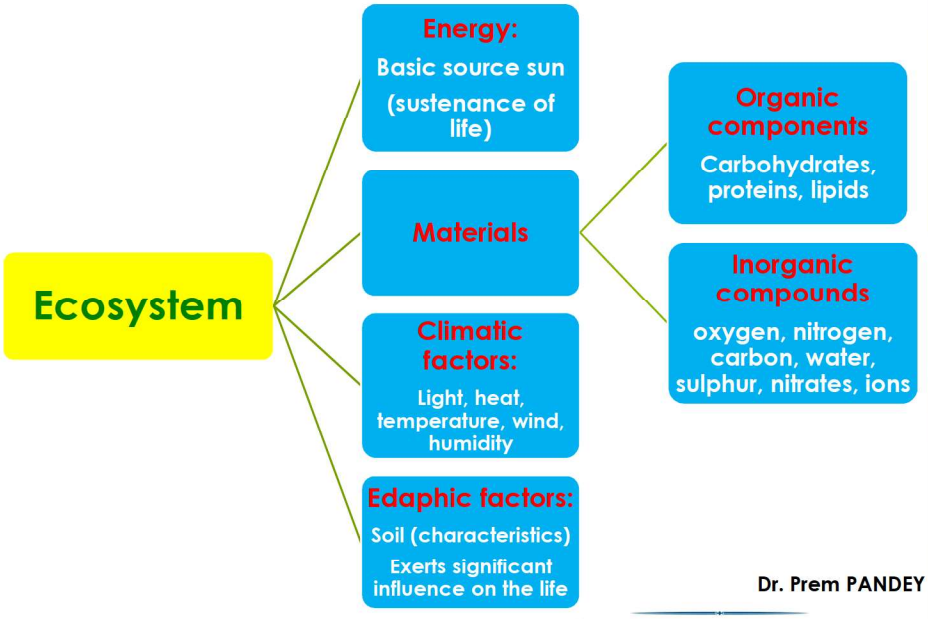
Abiotic components



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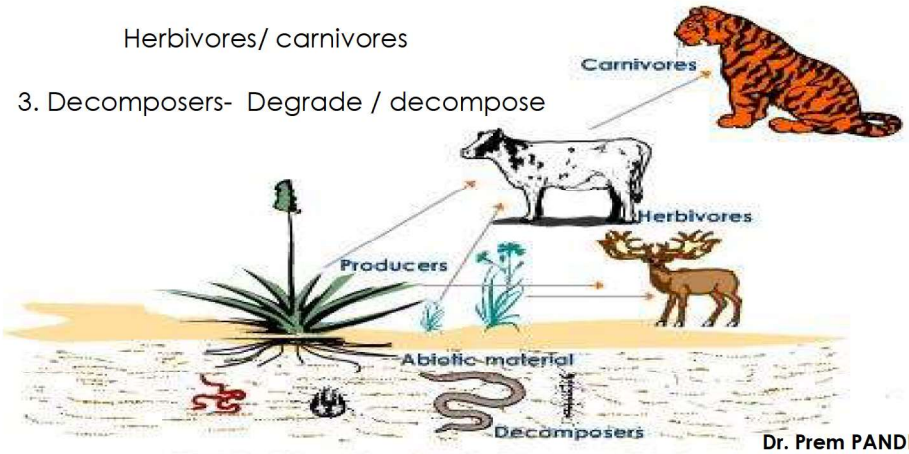
Biotic components

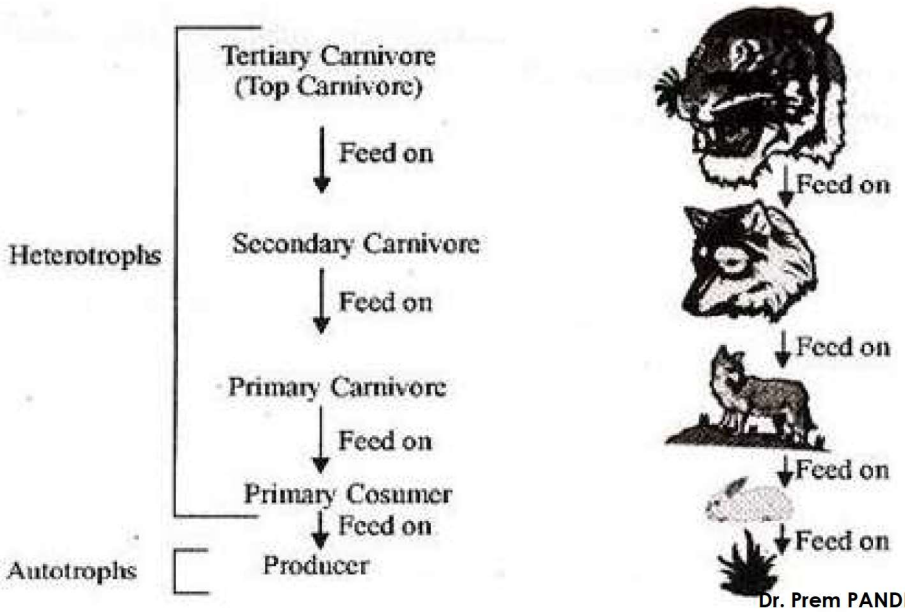
1. Producers → **Autotrophs**
2. Consumers -→ **Heterotrophs**

   Herbivores/ carnivores

3. Decomposers- Degrade / decompose



Grassland Ecosystem Showing Component Parts



Biotic components

- **Producers or autotrophs**

Organisms like plants, certain bacteria, algae that can synthesize their own food in the presence of sunlight (photosynthesis).

Also, chemosynthetic bacteria that are found in deep ocean waters (no sunlight) and derive energy by the process of chemosynthesis from the hydrogen sulphide.

- **Consumers or heterotrophs**

Organisms that cannot make their own food and depend on plants and/or animals. Consumers are of two types:

- Macro-consumers
- Micro-consumers

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Macro-consumers

Macro-consumers are of three types:

a) **Primary consumers:** they feed mainly on plants (herbivores)

b) **Secondary consumers:** carnivores that feed on primary consumers

c) **Tertiary consumers:** carnivores that feed on secondary consumers

Organisms that consume both plants and animals are called omnivores (human beings).

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Micro-consumers

Bacteria or fungi are microorganisms that derive their energy and nutrients by decomposing dead organic substances (detritus) of plants and animals.

Earthworms and some soil organisms (nematodes, arthropods- termites) are also **detritus feeders** and take part in the **decomposition of organic matter**.

The role of decomposers and microorganisms is very important in nutrients cycling. The by-products of their activity are water, CO2, phosphates, and organic compounds that are released in the environment and recycled.

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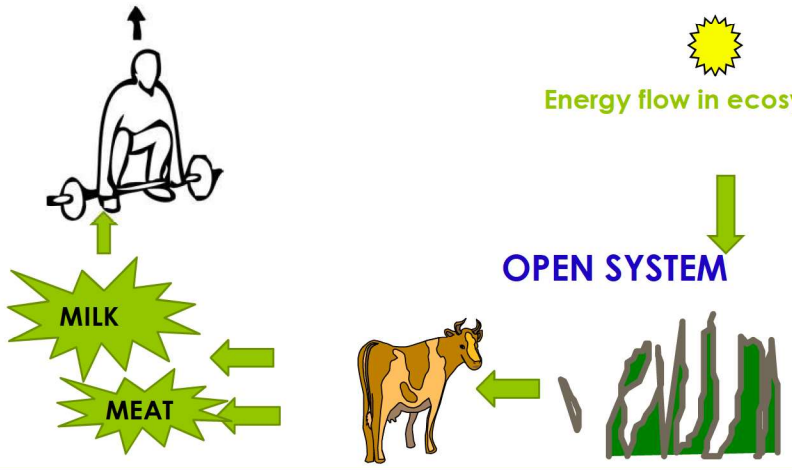
3. Functions of Ecosystem



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Energy flow in the ecosystem

- The two fundamental requirements for <u>any life-supporting system</u> are
  1. Flow of energy
     - Functions of energy
     - Pathways through which it flows
  2. Continual recycling of chemical elements

Energy Flows

Energy moves **continuously** through ecosystems, like a stream.

The flow of energy in ecosystems obeys two **Laws of Thermodynamics**:

1. Energy cannot be created or destroyed, It only changes form.
2. During every transformation, some energy is given off as heat.

This heat is eventually lost to the atmosphere and is no longer available to ecosystems.

Ecosystem processes (function) Energy Flows

By definition, all ecosystems **cycle matter and use energy**, and the processes define the fundamental **ecosystem functions** as well.

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Ecosystem processes (function)

Always the **energy doesn't cycle** and ecosystems need a continuous inflow of high-quality energy in order to maintain their function and structure.

For this reason, ecosystems are **"open systems"** needing a net inflow of energy to continue over time - **without the sun, our biosphere would shortly run out of energy!**

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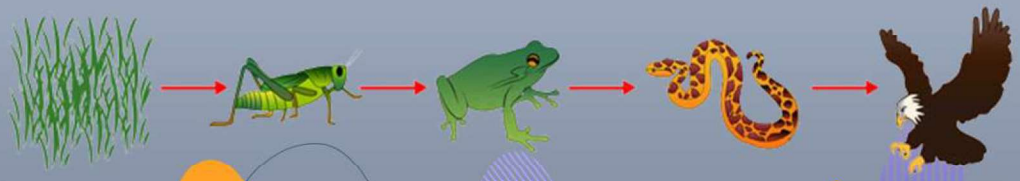
Ecosystem processes (function)

Energy inputs to ecosystems drive the flow of matter --within organisms and their environment in a process called **Bio-geochemical cycle.**

Our biosphere gives a good example of this process, as it exchanges matter with and interacts with the lithosphere, atmosphere and hydrosphere, driving the **Earth's bio-geochemical** cycles of **nitrogen, phosphorus, sulfur, carbon and the other elements.**

Rule #1: Energy transforms

- **Food chains** show the flow of energy through one trophic level of organisms to another.



Producers Absorb energy from the sun

Primary Consumers Herbivores; ingest producers

Secondary Consumers Ingest primary consumers

Tertiary Consumers Ingest secondary consumers

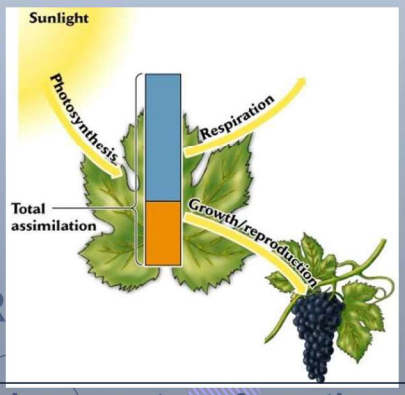
Apex Predator Top of the food chain; are not prey to other organisms

Decomposers consume dead and decaying matter from all trophic levels.

The trophic level of an organism is the **position it occupies** in a food chain/ food web.

Rule #2: Heat loss

The total amount of energy producers capture from the sun is called **Gross Primary Productivity (GPP).**



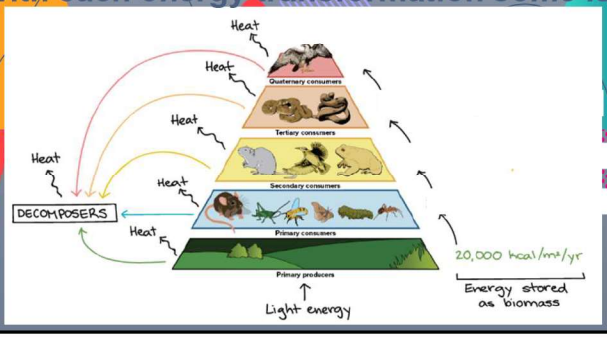
Most of that energy is lost as heat as the plant performs cell **respiration (R)** to maintain itself.

The remaining output of energy stored as leaves, fruit, stems, or roots is **Net Primary Productivity (NPP).**

NPP = GPP - R

Rule #2: With each energy transformation some is lost as heat.

The **10% rule** estimates that only 10% of energy from one trophic level is incorporated into the next.



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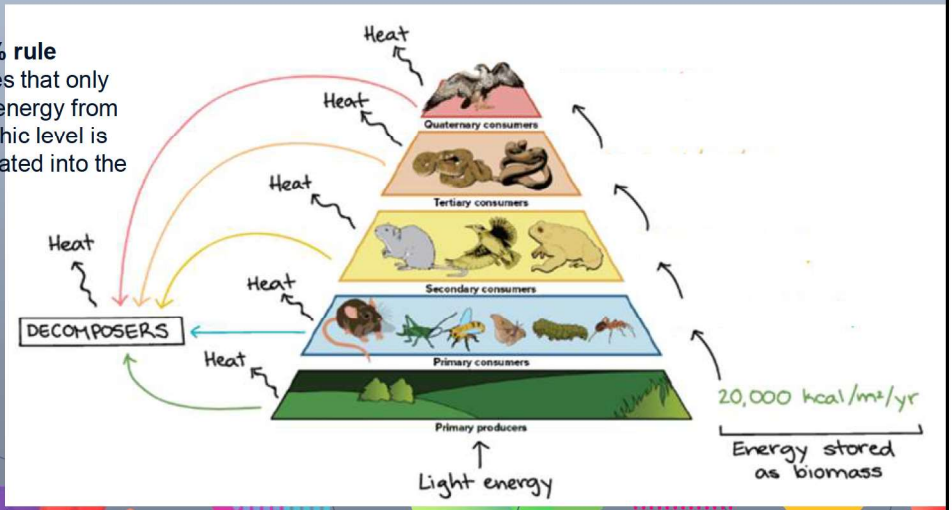
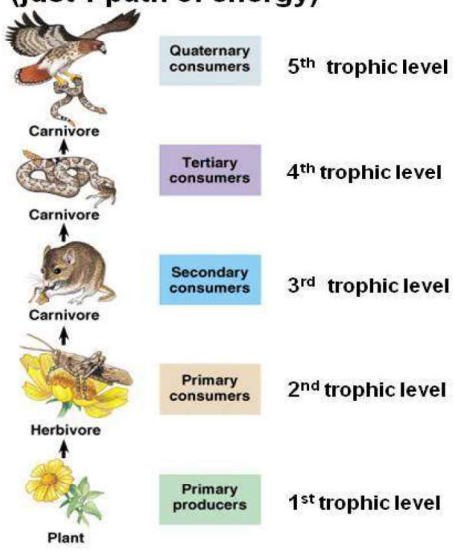


NPP is equal to all of the carbon taken by vegetation through photosynthesis (GPP) minus the carbon lost to respiration (R)
NPP= GPP- R

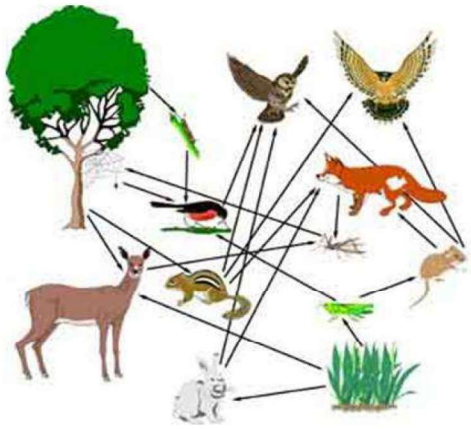
FOOD CHAIN COMPLEX AND ENERGY FLOW

Food Chain
(just 1 path of energy)



Food chain- Path of flow of energy and nutrients in ecosystems

Food Web
(all possible energy paths)



Food web- Complex food chain are known as Food web

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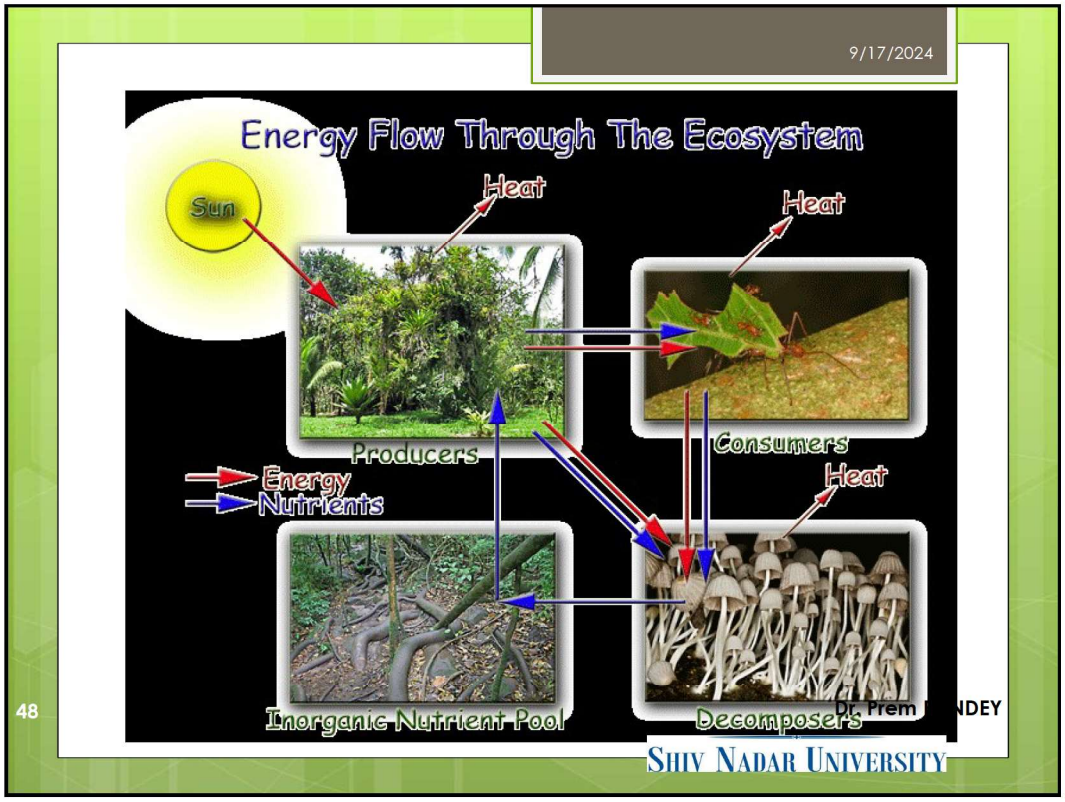

Energy flow in the ecosystem

- SUN → PRODUCERS → CONSUMERS → DECOMPOSERS → NUTRIENT POOL IN SOIL → PRODUCERS
- The basic function of energy is to make the production of organic matter possible
- The total amount of organic matter in any particular ecosystem is the biomass
- Biomass increases as a result of biological production, the transformation of energy into matter by biological processes

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Energy flow in the ecosystem

Plants convert solar energy into chemical via photosynthesis. This is the reaction of CO2 and H2O with the presence of chlorophyll.

Mg (magnesium) is essential element for photosynthesis, it is part of Chloroplast which prepare food for plant.

Green plants are grazed by animals. The chemical energy is transferred to herbivores (carbohydrates, fats, proteins).

The same energy transfer process- continues to carnivores.

The initial solar energy trapped by the plants and stored as chemical energy incurs loss along the whole chain.

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ENERGY FLOW IN ECOSYSTEMS

- All organisms require energy, for growth, maintenance, reproduction, locomotion, etc.
- Hence, for all organisms there must be:
  - A source of energy
  - A loss of usable energy

Types of Energy:

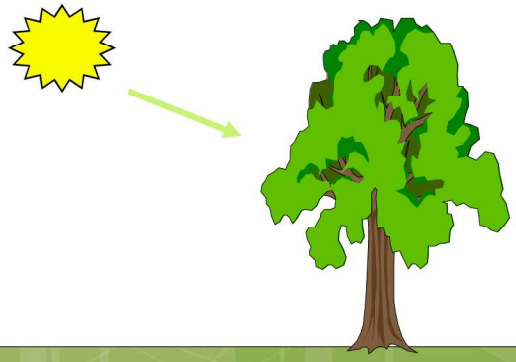
- Heat energy
- Mechanical energy (+gravitational energy, etc.)
- Chemical energy = energy stored in molecular bonds

Transformations of energy

- Solar energy is converted to chemical energy by primary producers.
- The transformations of energy from solar radiation to chemical energy and mechanical energy and finally back to heat are a traditional topic of Ecosystem Ecology.

Primary productivity

- Primary productivity is the rate of energy capture by producers.
- = the amount of new biomass of producers, per unit time and space



Energy flow in the ecosystem

- Primary producers convert energy and inorganic compounds into biomass
  - 1st: autotrophic organism produces organic matter in its body
  - 2nd: uses this organic matter as fuel in metabolism and respiration, releasing heat
  - 3rd: stores some of the organic matter for future use

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Types of Ecosystems

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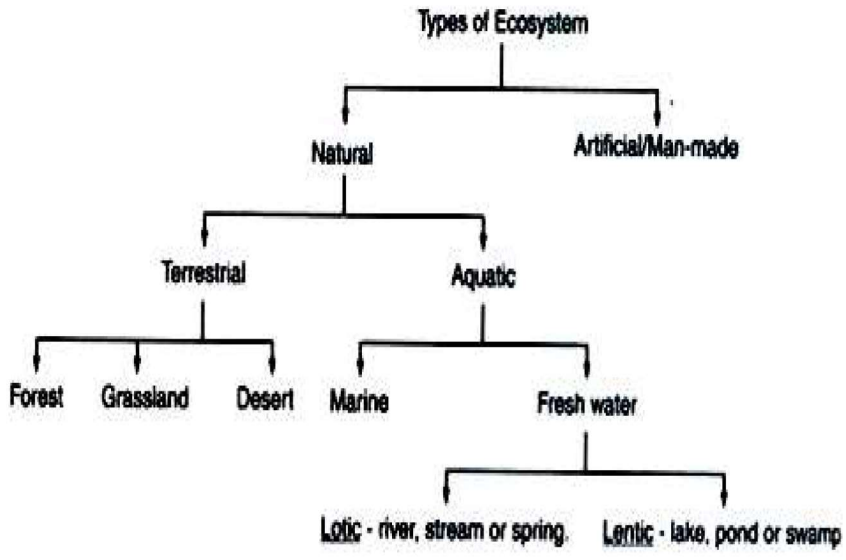

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Types of Ecosystems

- There are many types of ecosystems on earth.
- Major classes of relatively contained ecosystems are called Biomes.
- There are 3 Major classes of ecosystems

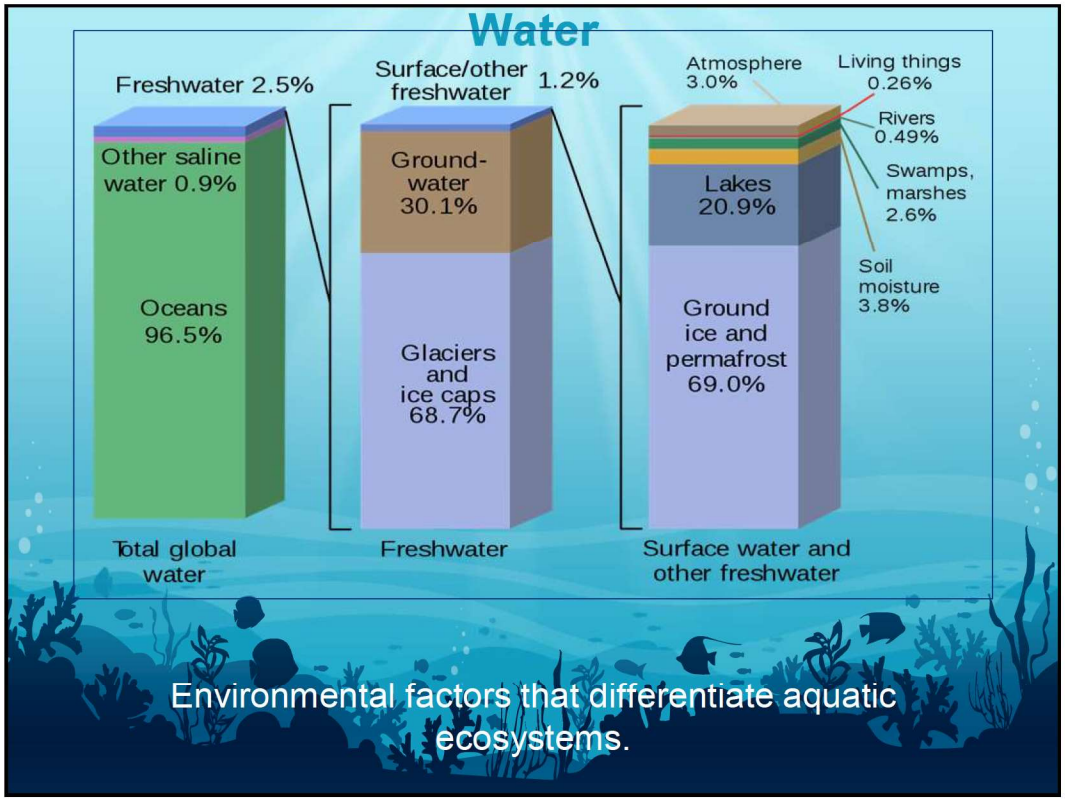
1. Terrestrial Ecosystems
2. Ocean Ecosystems
3. Freshwater Ecosystems

Freshwater ecosystems:

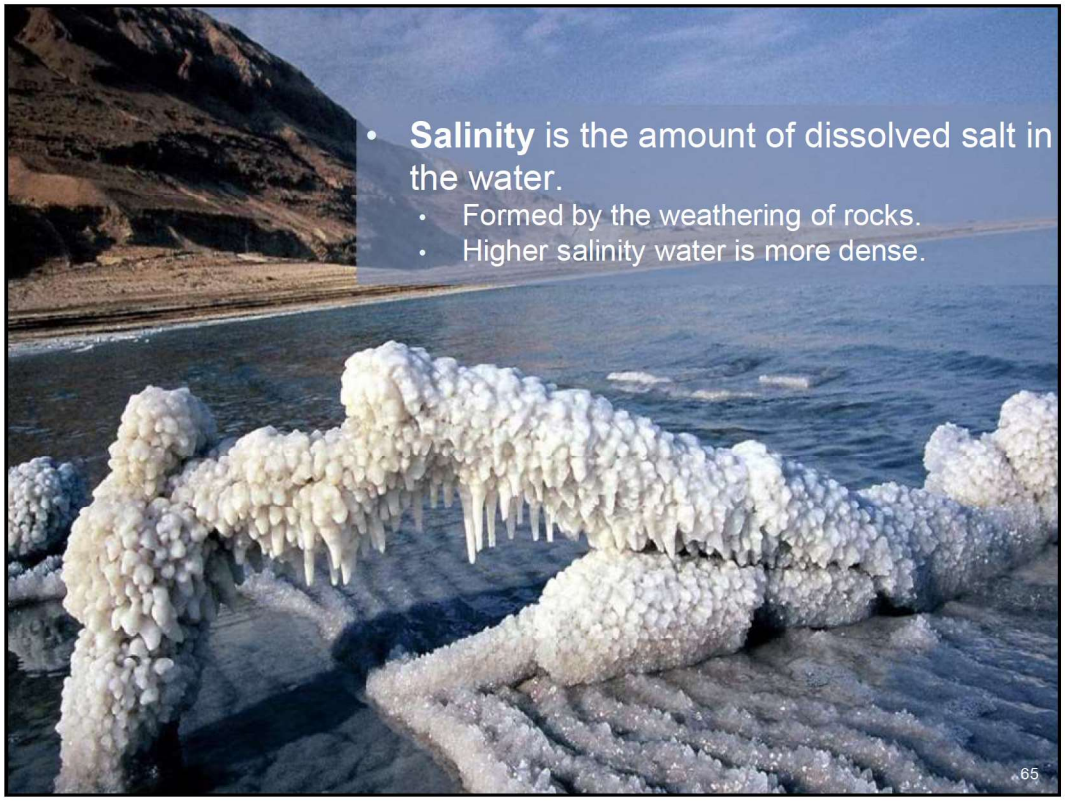
- Relatively small in area ~ 1.8% of earth's surface
- Support many species of life including fish, amphibians, insects and plants.
- Base of food-web is found in freshwater Plankton (small microscopic organisms)

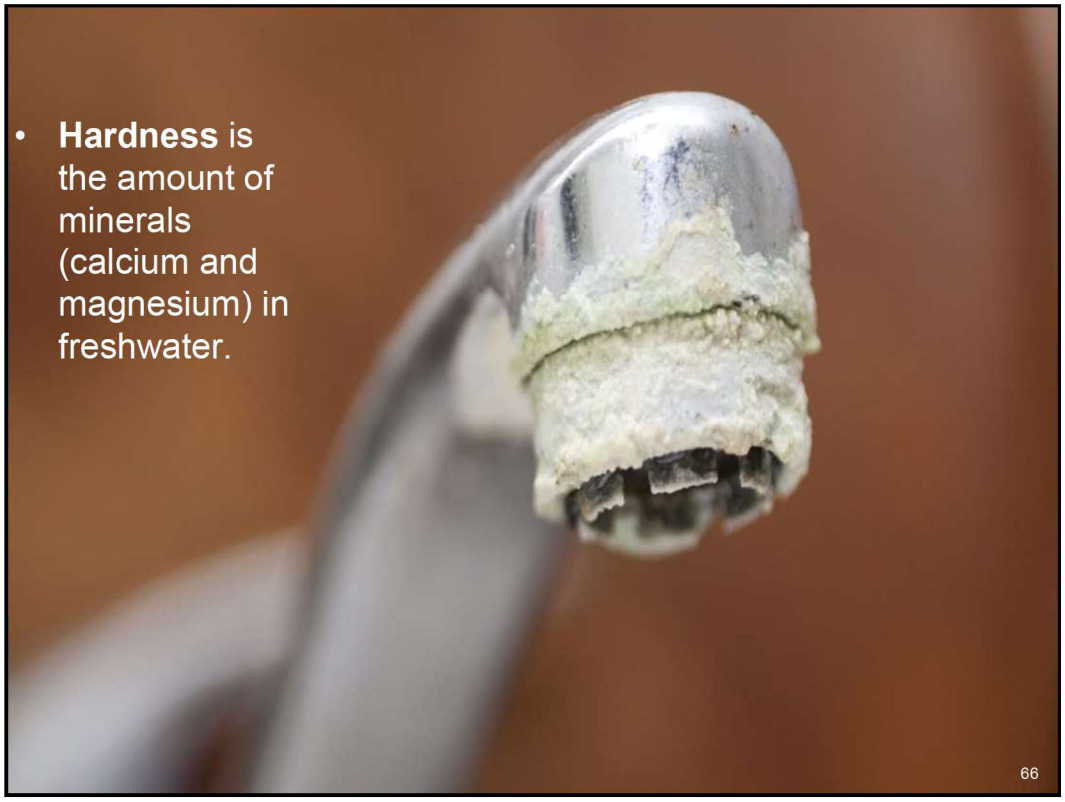
1.
Abiotic and Biotic Factors

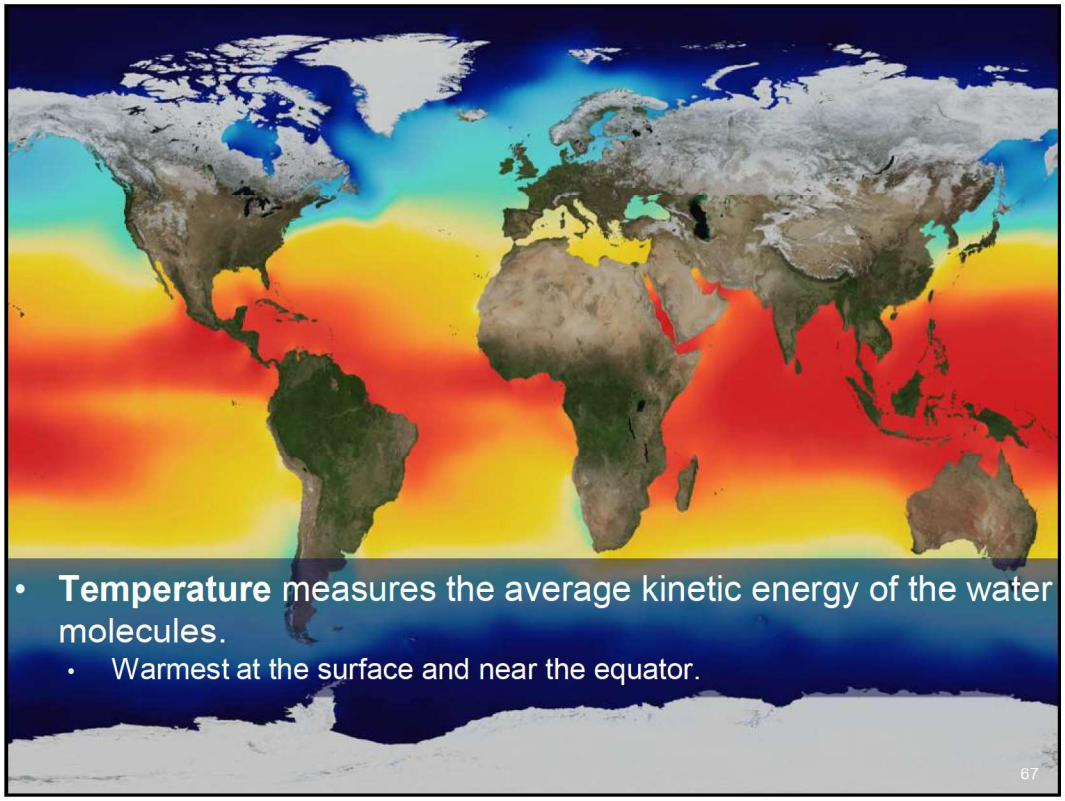
Environmental factors that differentiate aquatic ecosystems.

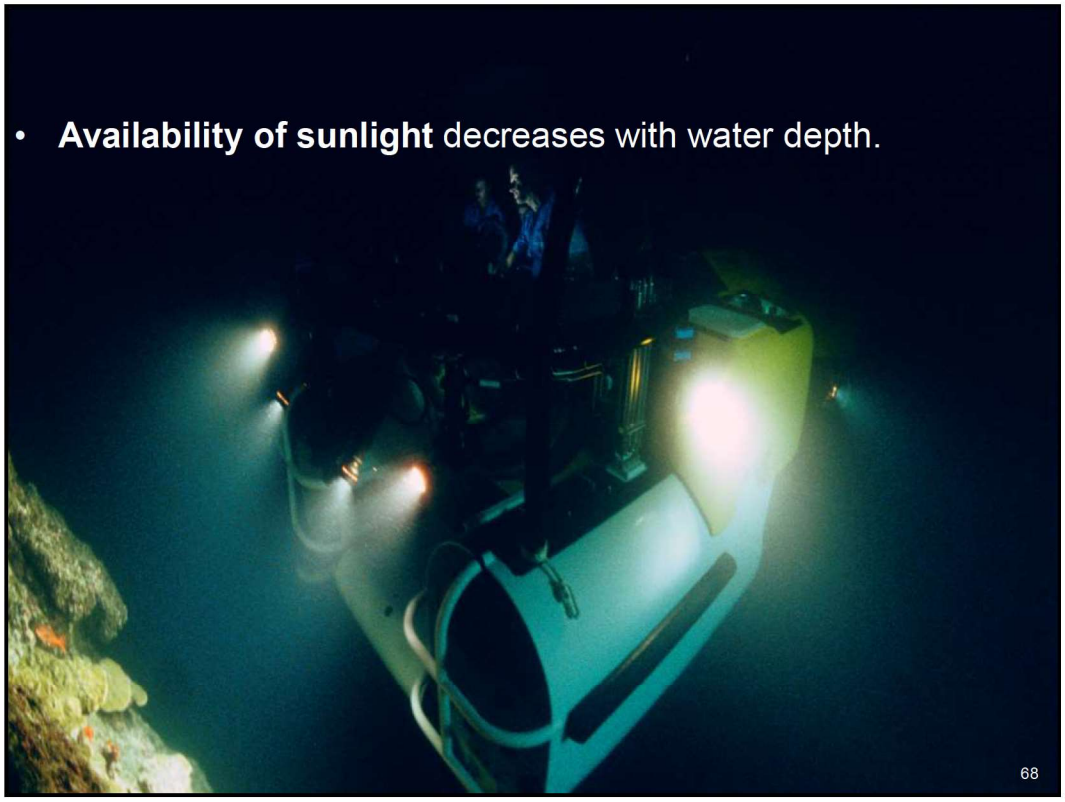


Environmental factors that differentiate aquatic ecosystems.


• **Salinity** is the amount of dissolved salt in the water.
• Formed by the weathering of rocks.
• Higher salinity water is more dense.
65


• **Hardness** is the amount of minerals (calcium and magnesium) in freshwater.
66


• **Temperature** measures the average kinetic energy of the water molecules.
• Warmest at the surface and near the equator.
67


• **Availability of sunlight** decreases with water depth.
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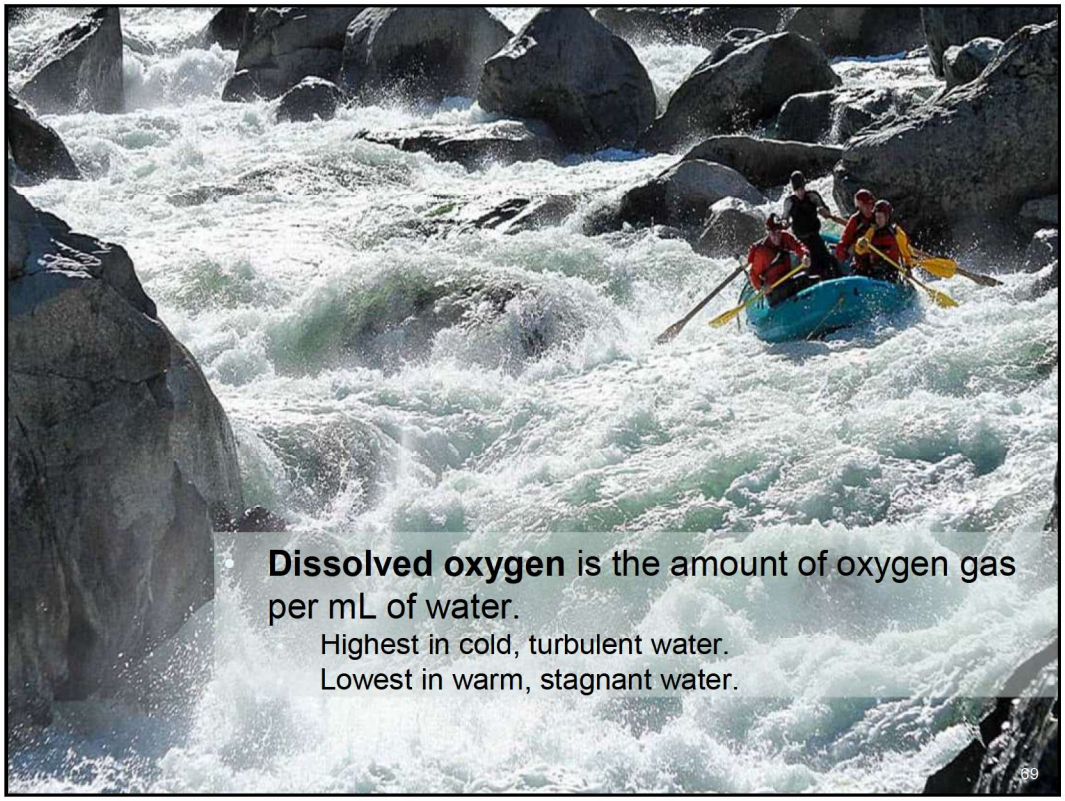

- **pH** is a measurement of the acidity or alkalinity of water.

Acids
pH below 7
Rainwater: 5.6 due to mixing with CO_2.
Acid rain: <4.5 due to mixing with sulfur.

Neutral
pH is exactly 7
Pure water.

Bases
pH above 7
Ocean Water: 8.1 due to carbonate (CO_3^{2-}) ions.

- How would you describe the characteristics of the environment in this clip?
  - Salinity
  - Light levels
  - Temperature
  - Dissolved oxygen

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Ecosystems

The global Ocean-Marine

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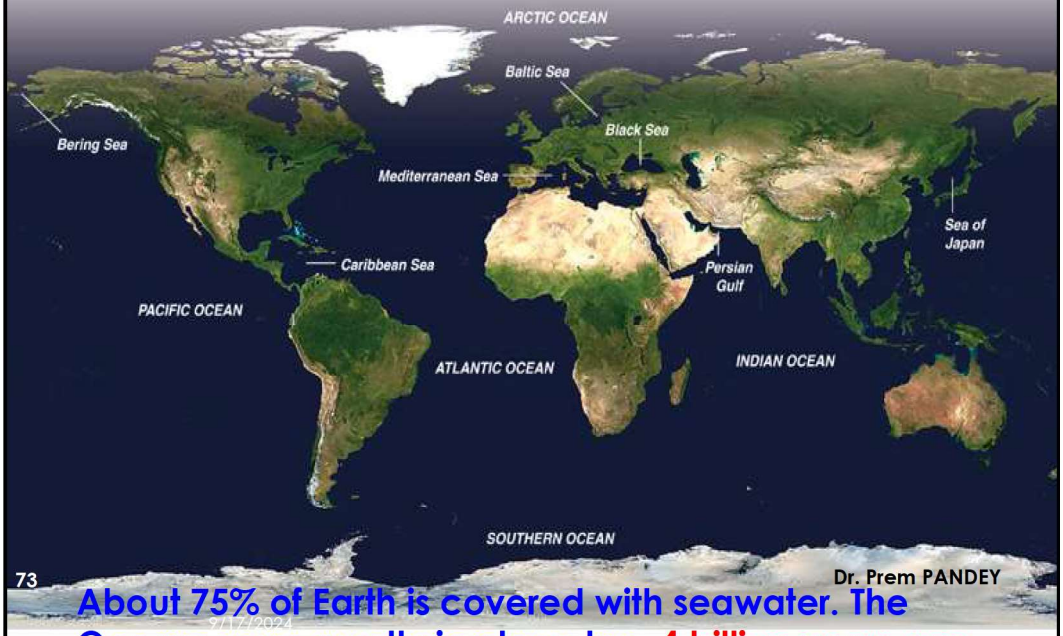
Global Oceans



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About 75% of Earth is covered with seawater. The Oceans were mostly in place by ~4 billion years ago.

Formation of Oceans

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- The **ocean formed** billions of years ago. Over vast periods of time, our primitive **oceans formed**.
- Water remained a gas until the **Earth** cooled below 212 degrees Fahrenheit **(ca 100 degree centigrade).**
- At this time, about **3.8 billion years ago,** the water condensed into rain which filled the basins that are now our **oceans**.

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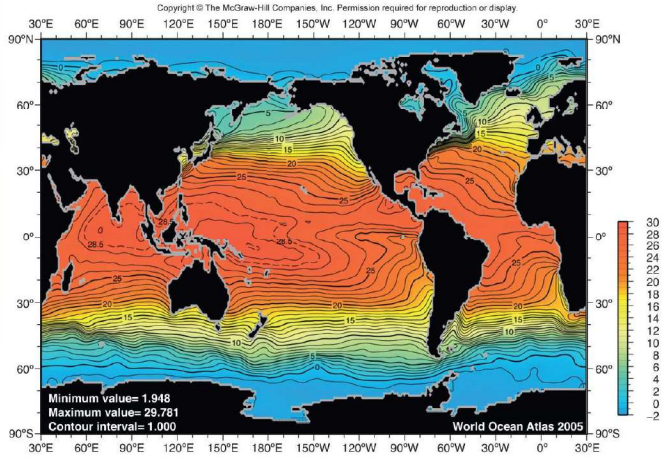
Summery -Features of marine - ocean ecosystem

1. Salinity: It is fairly constant (3.5% on average). The main salt is NaCl (27%), and the rest are Ca, K, Mg salts.
2. Light: It penetrates to a certain extent and is responsible for production of organics (photosynthesis)
3. Temperature: Remains fairly constant, ranging from about -2C to 2C in polar seas to 32 C in tropics.
4. Nutrients: Nutrients concentration is low; major limiting factor in determining the size of marine population.
5. Dissolved gases: Oceans are great reservoirs of O2 and CO2
6. Alkalinity: Sea water is alkaline with pH of about 8.2
7. Pressure: Pressure changes from 1 atm (at surface) to 1000 atm at the greatest depth. Effect on the distribution of life
8. Currents: Sea water is always moving. The currents are driven either by wind (surface currents) or by variation in temperature and salinity (deeper currents).
9. Waves and tides: Several types produced by the gravitational pull of moon and sun.

Ocean Waters: Temperatures

Temperature varies according to latitude and depth

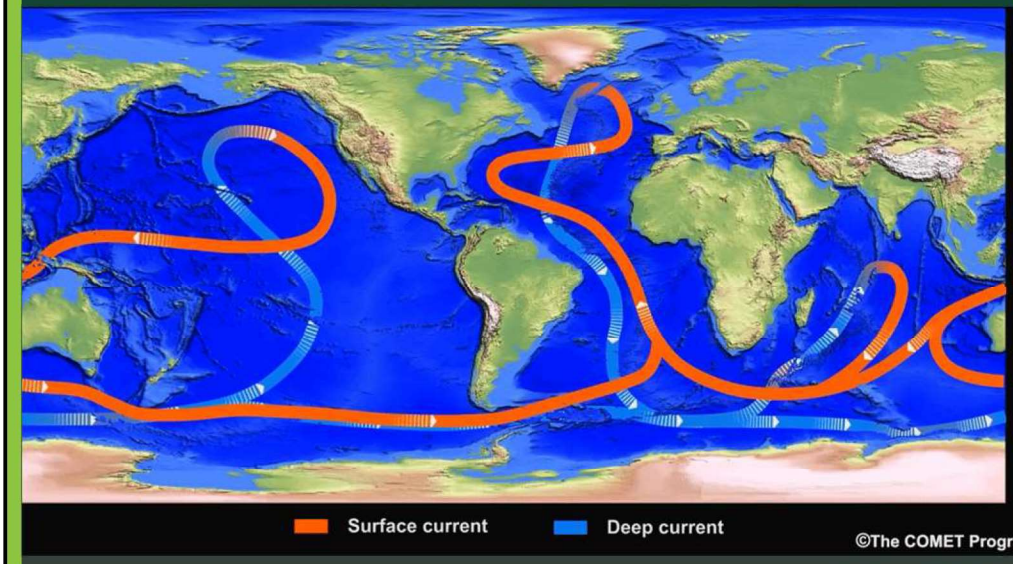


Ocean temperatures are affected by:

- ***Solar insolation*** (power per unit area received from the Sun in the form of electromagnetic radiation
- ***Ocean currents***

Temperatures are highest where solar energy is highest.

The **ocean conveyor** is a moving system of deep ocean currents that circulate warmth across the globe.



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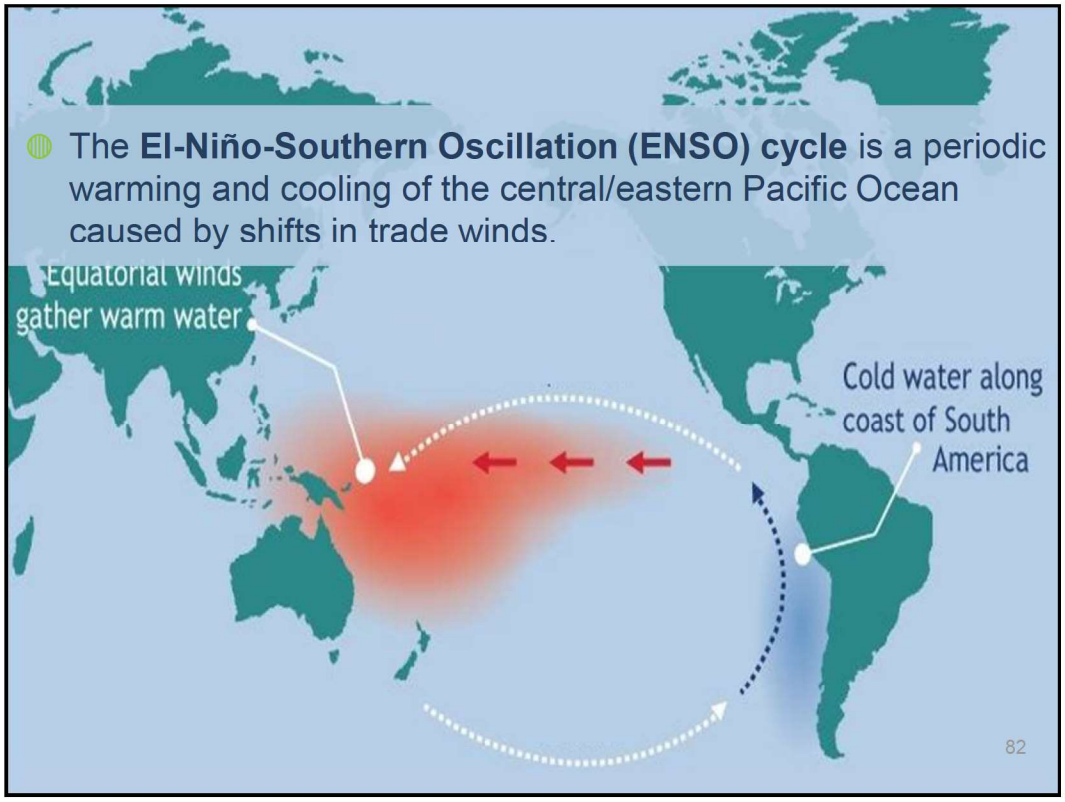
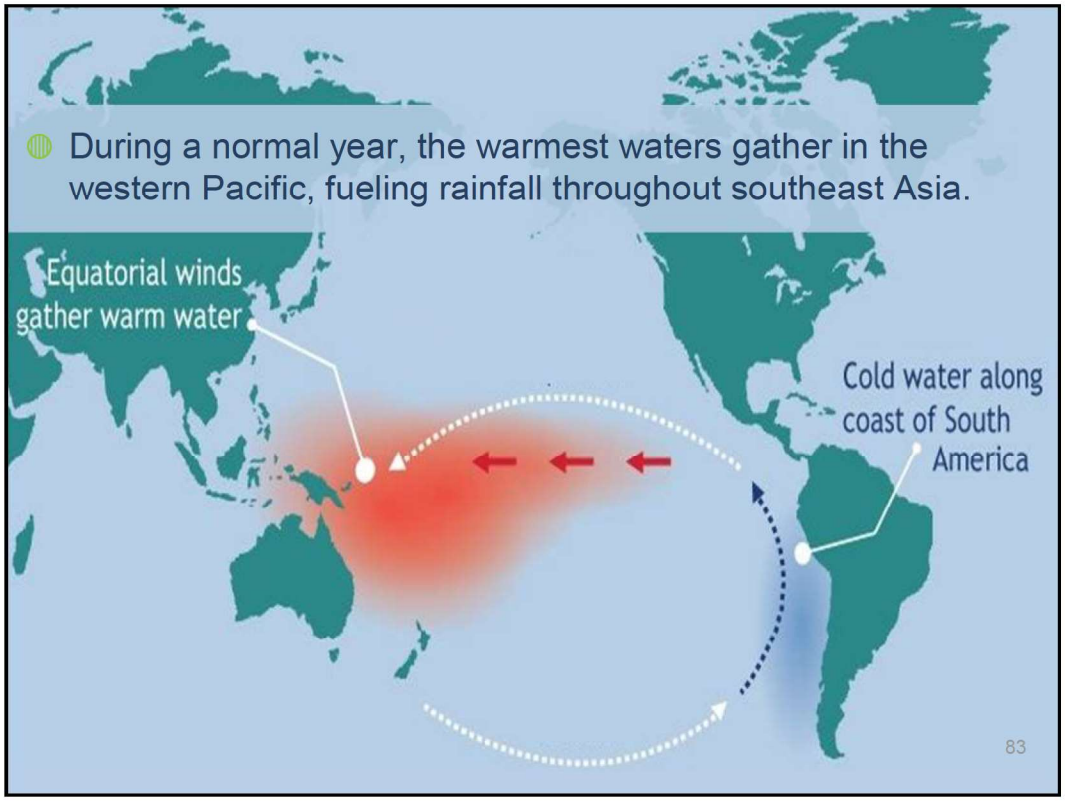
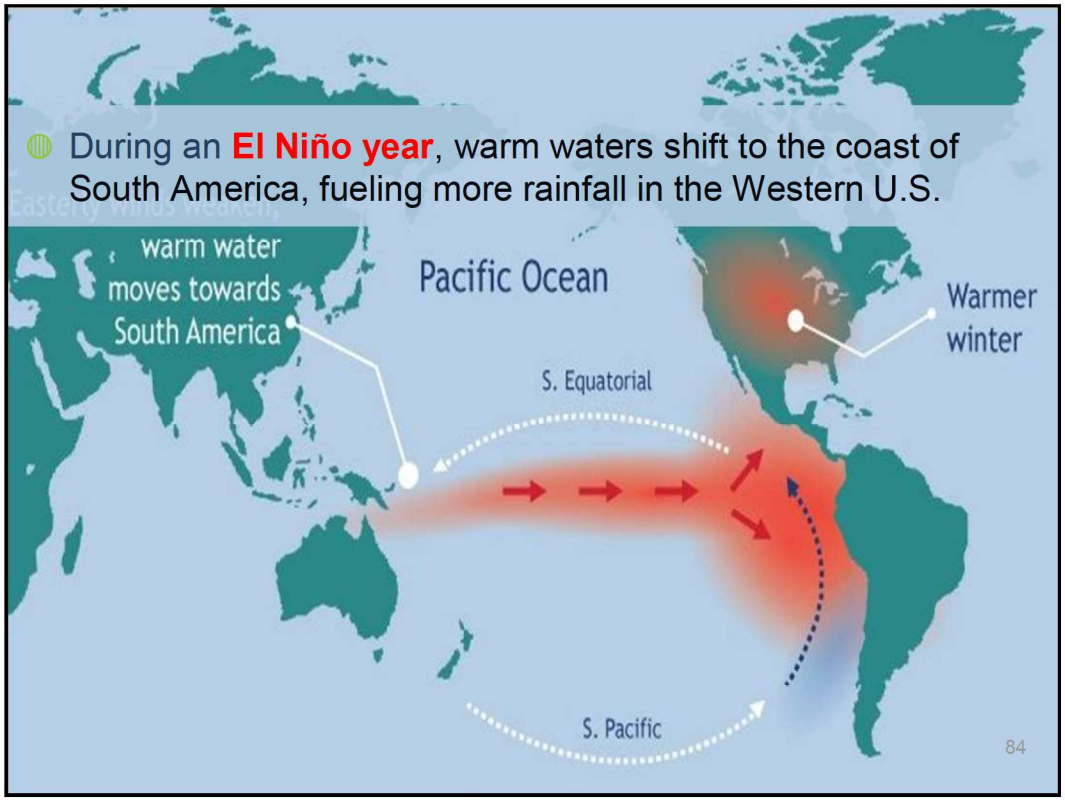
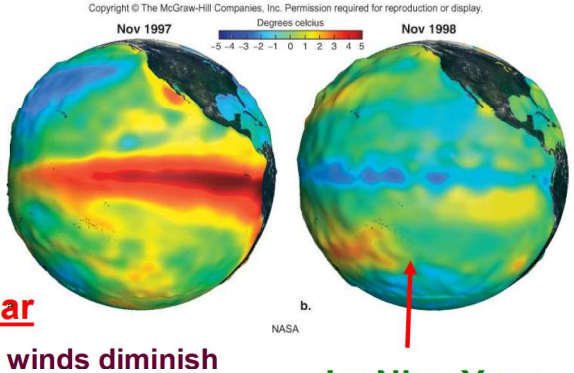



During a normal year, the warmest waters gather in the western Pacific, fueling rainfall throughout southeast Asia.
Equatorial winds gather warm water
Cold water along coast of South America
83


During an El Niño year, warm waters shift to the coast of South America, fueling more rainfall in the Western U.S.
warm water moves towards South America
Pacific Ocean
Warmer winter
S. Equatorial
S. Pacific
84

El Niño and La Nina: The Earth system in action



El Niño Year

- Westerly winds diminish
- Warm water remains in Pacific
- Heavy rains occur in SA
- Surface salinity decreases, reducing upwelling
- Droughts in western Pacific, Asia, India

La Nina Year

- Cold conditions dominate
- Droughts in SA, western US
- Severe weather in western Pacific,
- Good rains in India

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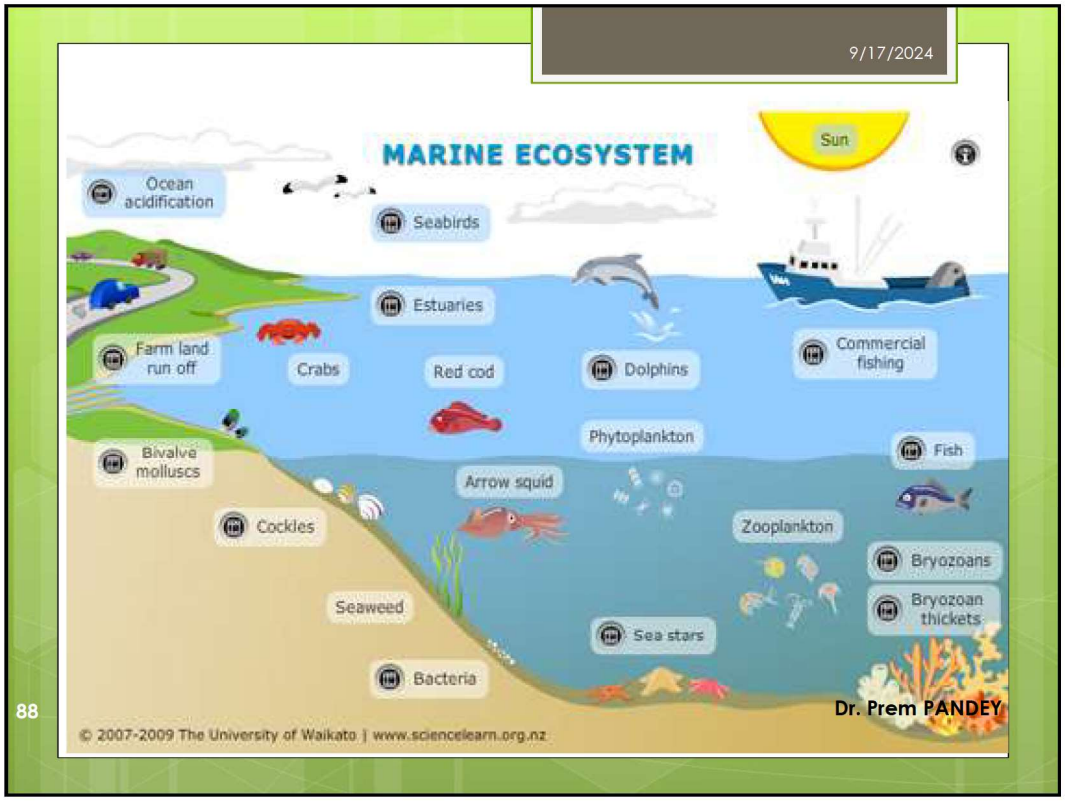
4. Marine / Ocean ecosystems

Shallow seas, open ocean, and the sea floor.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MARINE ECOSYSTEM
Sun
Ocean acidification
Seabirds
Estuaries
Farm land run off
Crabs
Red cod
Dolphins
Commercial fishing
Phytoplankton
Fish
Bivalve molluscs
Arrow squid
Cockles
Zooplankton
Bryozoans
Bryozoan thickets
Seaweed
Sea stars
Bacteria
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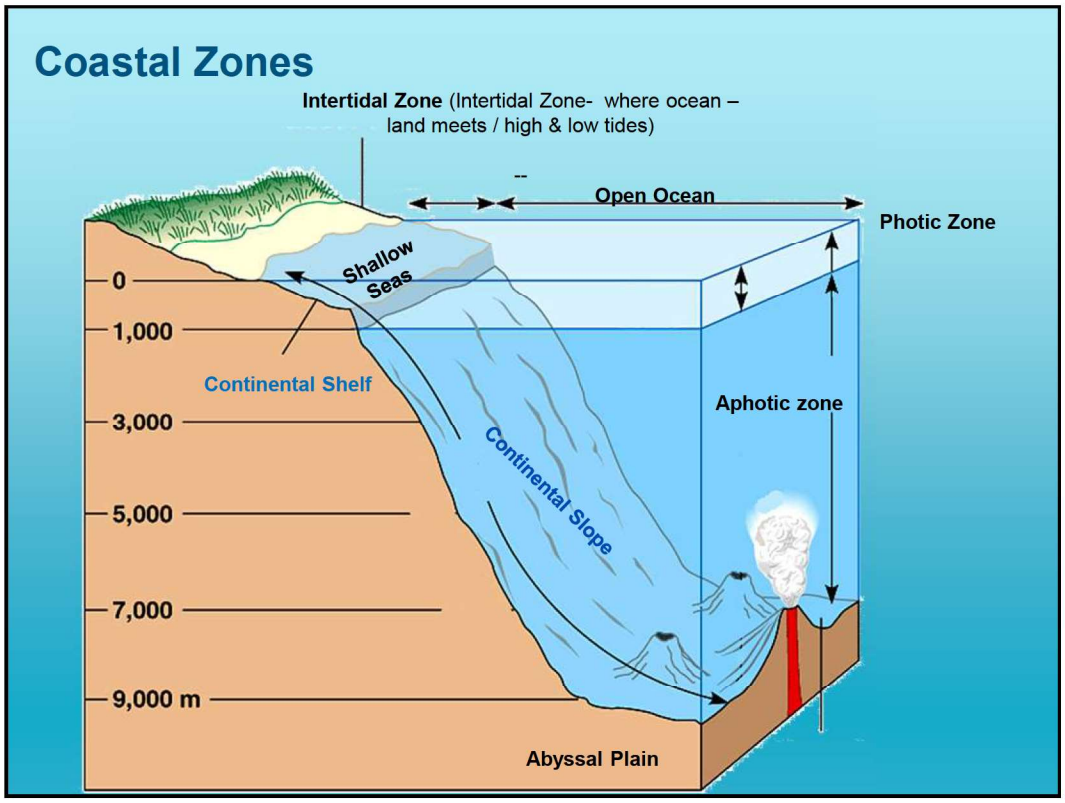
Coastal Zones
Intertidal Zone (Intertidal Zone- where ocean – land meets / high & low tides)
--
Open Ocean
Photic Zone
Shallow Seas
0
1,000
Continental Shelf
3,000
Aphotic zone
Continental Slope
5,000
7,000
9,000 m
Abyssal Plain

Intertidal Zone Ecosystems

Rocky Shores

Substrate is hard and stable

Erosion is slow

Sandy Shores

Substrate is shifting and unstable

Erosion is rapid

Color depends on source

91

Common Types of Sand

Black	Brown	White
Volcanic rock	Quartz	Coral
		

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Marine Ecosystem

- Marine ecosystems are among the largest of Earth's aquatic ecosystems. They include oceans, salt marsh and intertidal zones, estuaries and lagoons, mangroves and coral reefs, the deep sea and the sea floor.
- Marine waters cover two-thirds of the surface of the Earth. Such places are considered ecosystems because the plant life supports the animal life and vice-versa.
- They can be contrasted with freshwater ecosystems, which have a lower salt content.

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Marine Ecosystem

Marine ecosystems are very important for the overall health of both marine and terrestrial environments.

Marine ecosystems usually have a large biodiversity.

According to the World Resource Center, coastal habitats alone account for approximately 1/3 of all marine biological productivity, and estuarine ecosystems (i.e., salt marshes, sea grasses, mangrove forests) are among the most productive regions on the planet.

In addition, other marine ecosystems such as coral reefs, provide food and shelter to the highest levels of marine diversity in the world.

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Coral reefs are ecosystems built on the exoskeletons of coral polyps.

- Found mostly in warm, shallow, sunlit waters.

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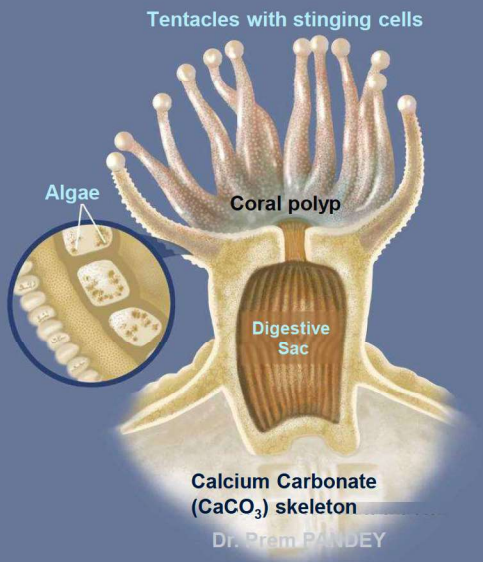
- Coral is a symbiotic relationship between two organisms:
  - Polyps, which build the calcium carbonate exoskeleton.
  - Algae, which photosynthesize most of the coral's food.
- Calcium carbonate is an important sink in the carbon cycle and helps to maintain ocean pH.



96

Coral reef- Great Barrier Reef, Australia (Low tide)

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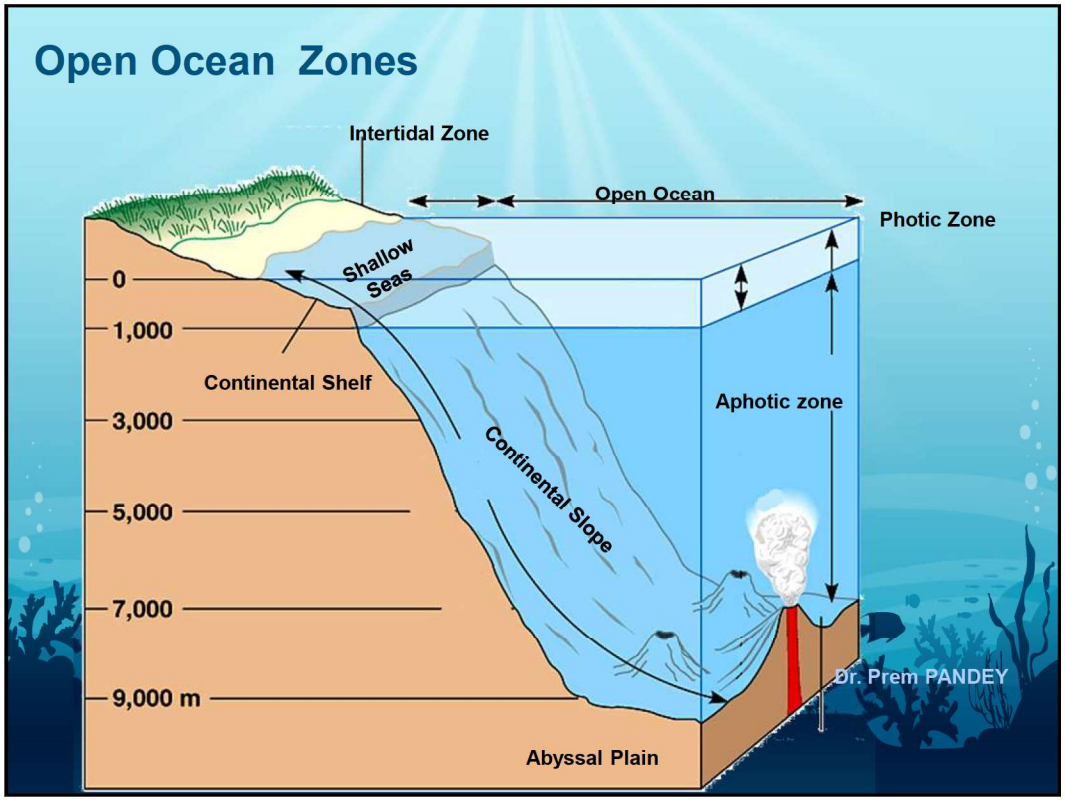
Coral reef- Great Barrier Reef, Australia (High tide)

Bleaching of Corals due to Global warming


Open Ocean Zones
Intertidal Zone
Open Ocean
Photic Zone
Shallow Seas
0
1,000
Continental Shelf
3,000
Aphotic zone
Continental Slope
5,000
7,000
9,000 m
Abyssal Plain
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The **open ocean** includes all areas beyond the continental shelf.
Low nutrient availability limits plankton.
"Marine Desert"
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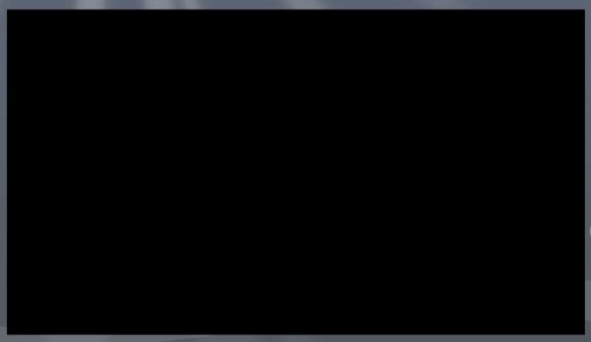
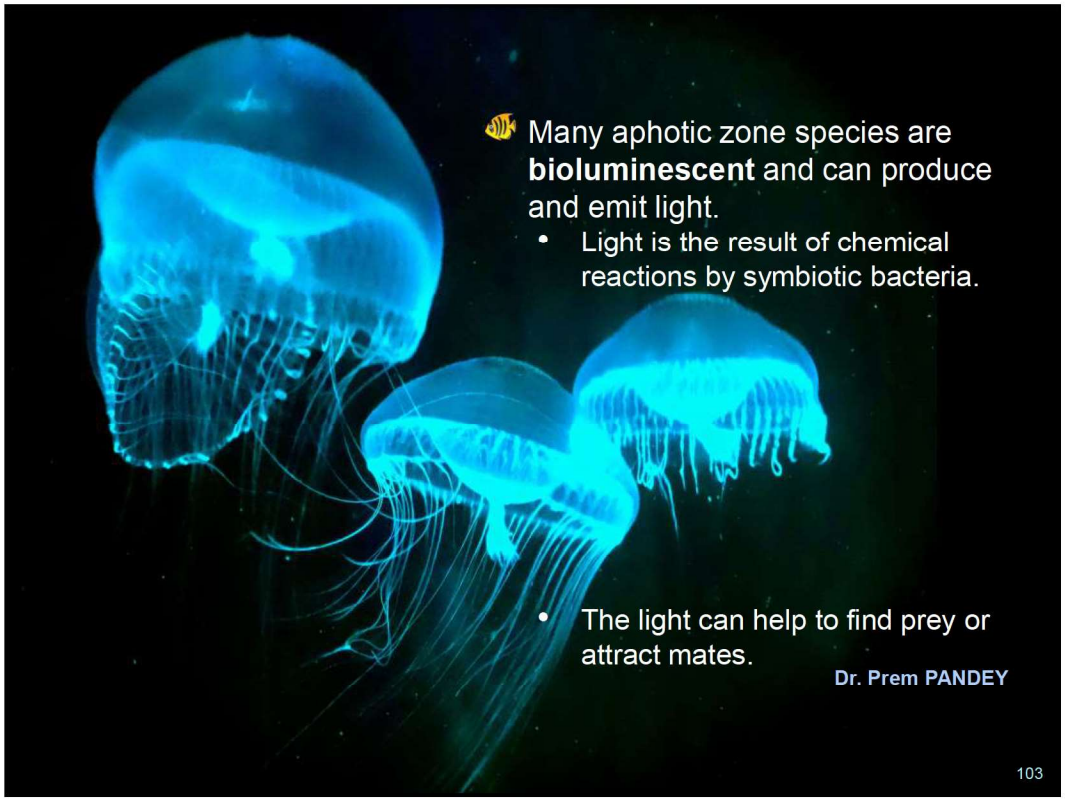
Ocean Light Zones

- The **photic zone** contains sunlight; enough to perform photosynthesis in the topmost layer.
- The **aphotic zone** has no sunlight at all.



102



- Many aphotic zone species are **bioluminescent** and can produce and emit light.
  - Light is the result of chemical reactions by symbiotic bacteria.
  - The light can help to find prey or attract mates.

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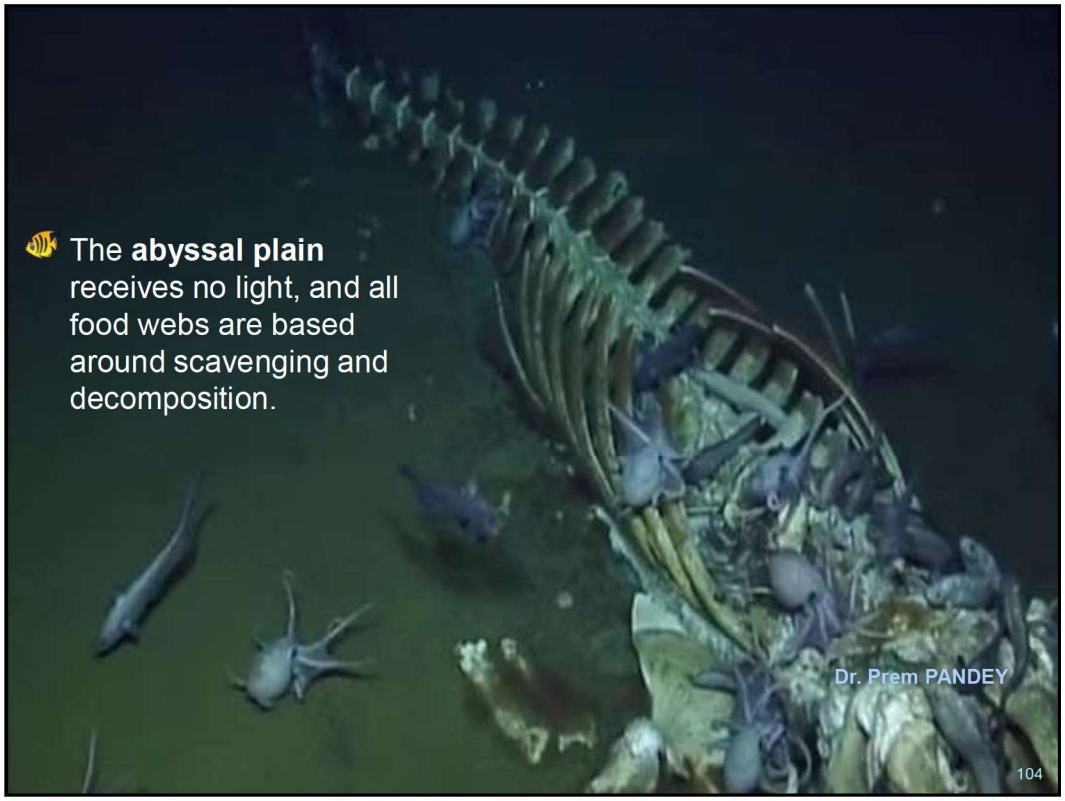
The **abyssal plain** receives no light, and all food webs are based around scavenging and decomposition.
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The abyssal plain receives a constant flow of detritus from above called **marine snow.**
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3.
Coastal ecosystems

Wetlands found along the shoreline and in shallow seas.

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Marine ecosystems

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Marine ecosystems are among the largest of Earth's aquatic ecosystems. Examples include

- salt marshes,
- Intertidal zones,
- estuaries,
- lagoons,
- mangroves,
- coral reefs,
- the deep sea, and the sea floor.

They can be contrasted with freshwater ecosystems, which have a lower salt content.

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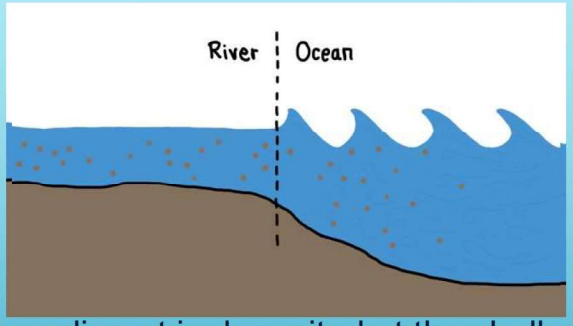
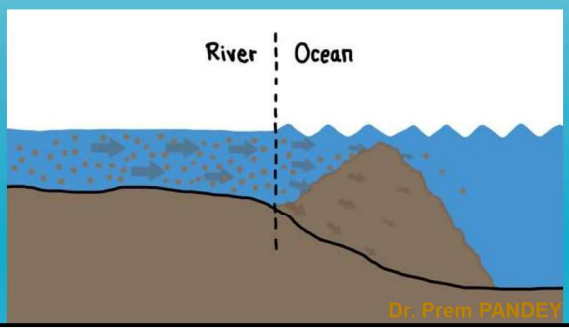
- **Tidal flats** are saltwater wetland areas that are continually covered and uncovered by the tides.
- **Coastal lagoons** are saltwater pools that are separated from the ocean by sandbanks or coral reefs.
- **Estuaries** are partially-enclosed bodies of water where river water mixes with sea water, forming brackish water.
- **Deltas** are landforms at river mouths formed by deposited sediment.

- As rivers reach the ocean, their current slows.
- Slow-moving waters cannot carry as much sediment.



- The sediment is deposited at the shallow ocean shore.



- Eventually the sediment expands the coastline and forms large landmasses.

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Salt marshes are tidal flats dominated by herbs and grasses.

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Seagrass beds contain submerged plants that resemble grass.
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Mangrove forests have trees with roots that can filter salt.
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- Mangrove forests provide coastal protection by dissipating up to 90% of wave energy.

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Watch this clip about a coastal mangrove forest.

- Why does the dissolved oxygen change from high to low tide?
- Identify an adaptation present in the larger fish to survive low tide.

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Ecosystems
Fresh Water Aquatic ecosystem- Rivers
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Fresh Water Ecosystem
Freshwater ecosystems are a subset of Earth's aquatic ecosystems.
They include lakes and ponds, rivers, streams, springs, and wetlands.
They can be contrasted with marine ecosystems, which have a larger salt content.
Freshwater plays a fundamental role in support of the environment, society and the economy.
Ecosystems such as wetlands, rivers, aquifers and lakes are indispensable for life on our planet.
Vital for directly ensuring a range of benefits and services such as:
drinking water,
water for food and energy,
habitats for aquatic life forms,
natural solutions for water purification and
climate resilience, among many others.
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River Ecosystem

- The ecosystem of a river is the river viewed as a system operating in its natural environment, and includes biotic (living) interactions amongst plants, animals and micro-organisms, as well as abiotic (nonliving) physical and chemical interactions.

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River Ecosystem

- River ecosystems are prime examples of lotic ecosystems.
- Lotic refers to flowing water, from the Latin *lotus*, washed.
- Lotic waters range from springs only a few centimeters wide to major rivers kilometers in width. (Brahmaputra river in Assam- 20 km wide; average depth of the river is 38 m and maximum depth- 120 m).
- Lotic ecosystems can be contrasted with lentic ecosystems, which involve relatively still terrestrial waters such as lakes and ponds.
- Together, these two fields form the more general study area of freshwater or aquatic ecology.

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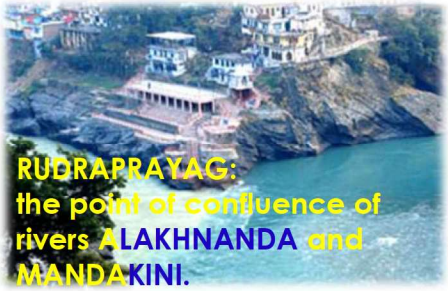
Ganges River in the Making

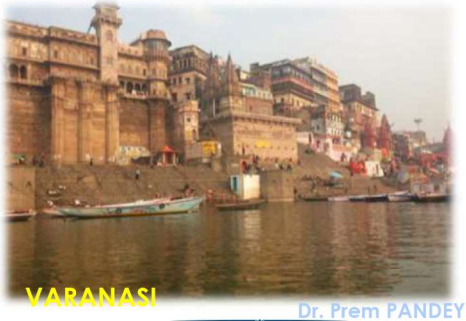
DEVPRAYAG: Alaknanda and BHAGIRATHI rivers meet and take the name GANGA or GANGES.

BHAGIRATHI



RUDRAPRAYAG: the point of confluence of rivers ALAKHNANDA and MANDAKINI.

GANGES in RISHIKESH



VARANASI

River Ecosystem

The following unifying characteristics make the ecology of running waters unique from that of other aquatic habitats.

1. Flow is unidirectional.
2. There is a state of continuous physical change.
3. There is a high degree of spatial and temporal heterogeneity at all scales (microhabitats).
4. Variability between lotic systems is quite high.
5. The biota is specialized to live with flow conditions.

Rivers

- Flowing-water environments (Lotic): rivers
  - Vary dramatically from source to mouth (physical, chemical, biological)
  - From small, cold and swift to wide, deep, cloudy, and warmer
  - Change seasonally
  - Organisms are adapted to survive in strong currents.
  - Flora and fauna depend on river's clarity, flow and oxygen

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Humans and Rivers

The history of the Nile and Indus rivers, where the primary human habitation started, illustrates how organisms in the vicinity of a stream can be placed under considerable stress when significant changes occur in stream systems.

We tend to take streams/rivers for granted, but they perform many positive functions in today's society:

- **Bring water to irrigate crops**
- **Provide drinking water**
- **Supply coolant for power plants**
- **Transportation (barges, boats)**
- **Provide ecosystems for wildlife**
- **Recreation sites,**
- **Recharge ground water**

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Riverine Ecosystem

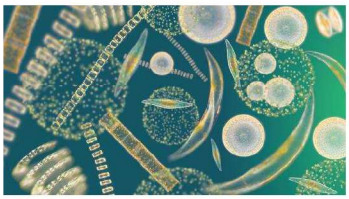
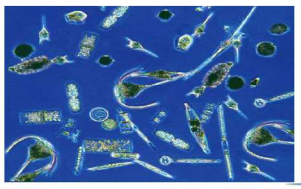
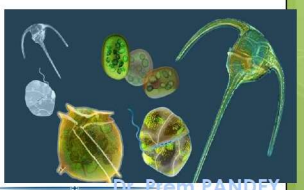
Riverine ecosystem, also called lotic **ecosystem**, any spring, stream, or **river** viewed as an **ecosystem**. The **waters are flowing (lotic)** and exhibit a longitudinal gradation in temperatures, concentration of dissolved material, turbidity, and atmospheric gases, from the source to the mouth.

Biotic Factors:

- **Bacteria: Bacteria are present in large numbers in lotic waters. Free-living forms are associated with decomposing organic material, biofilm on the surfaces of rocks and vegetation (Slime), in between particles that compose the substrate, and suspended in the water column.**
- **Bacteria play a large role in energy recycling, which will be discussed in the Trophic Relationships section.**

Riverine Ecosystem

- **Primary producers: Algae, consisting of phytoplankton and Periphyton,** are the most significant sources of primary production in most streams and rivers.
- ***Phytoplankton*** (microscopic marine algae) float freely in the water column and thus are unable to maintain populations in fast flowing streams. They can, however, develop sizable populations in slow moving rivers and backwaters.

Riverine Ecosystem

- Phytoplankton are the autotrophic components of the planktons community and a key part of oceans, seas and freshwater basin ecosystems.
- ***Periphyton*** are typically filamentous and tufted algae that can attach themselves to objects to avoid being washed away by fast current. In places where flow rates are negligible or absent,
- **Periphyton may form a gelatinous, unanchored floating mat.**

Riverine Ecosystem- Biotic Factors:
Periphyton and Water Hyacinth

- **Periphyton** is a complex mixture of algae, cyanobacteria, heterotrophic microbes and detritus that is attached to submerged surfaces in most aquatic ecosystems.
- It serves as an important food source for aquatic insects, frog tadpoles, and some fish,

Chalakudy River- Adhirapally Waterfalls, Trissur Kerala

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Lake ecosystem-Lentic

- The ecosystem of a lake includes biotic (living) plants, animals and micro-organisms, as well as abiotic (nonliving) physical and chemical interactions.
- Lake ecosystems are a prime examples of lentic ecosystems. Lentic refers to standing or relatively still water, from the Latin *lentus*, which means **sluggish.**
- Lentic waters range from ponds to lakes to wetlands, and much of this article applies to lentic ecosystems in general.

This small lake or mountain pool, together with its environment, can be regarded as forming a lake or **lentic ecosystem.**

Lake ecosystem

- **Lentic systems are diverse, ranging from a small, temporary rainwater pool a few inches deep to Lake Baikal, which has a maximum depth of 1740 m.**
- The general distinction between pools/ponds and lakes is vague, but one of the scientist **Brown states** that ponds and pools have their entire bottom surfaces exposed to light, while lakes do not.
- **Lake Baikal (Russia) is the largest freshwater lake by volume in the world, containing 22–23% of the world's fresh surface water.**
  - **With 23,615.39 km^3 (5,670 cu mi) of fresh water.**

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Baikal Lake

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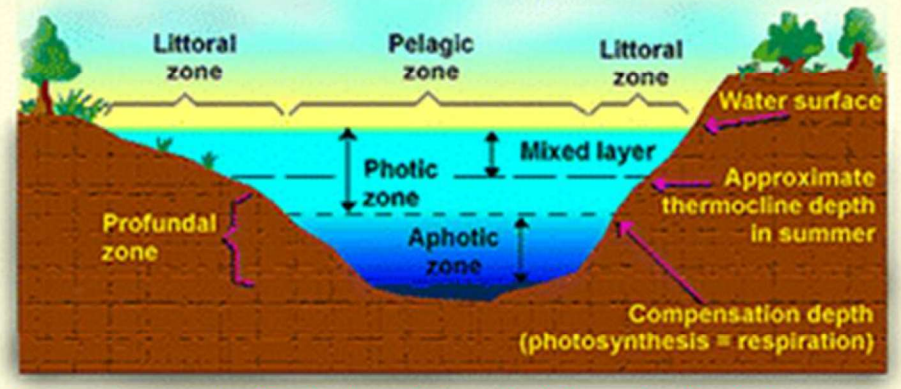
LAKE ECOSYSTEM

Ponds and pools have three regions:

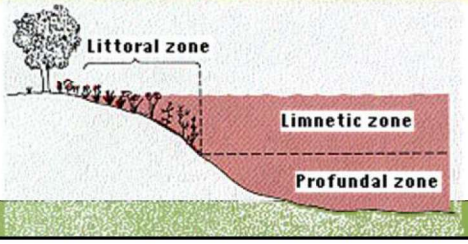
- the littoral zone,
- pelagic/limnetic open water zone, and
- the benthic zone, which comprises the bottom and shore regions.

- Since lakes have deep bottom regions not exposed to light, these systems have an additional zone, the profundal.
- These three areas can have very different abiotic conditions and, hence, host species that are specifically adapted to live there.

DIFFERENT ZONES OF A LAKE ECOSYSTEM



Compensation Depth - Depth where photosynthesis is equal to Respiration.



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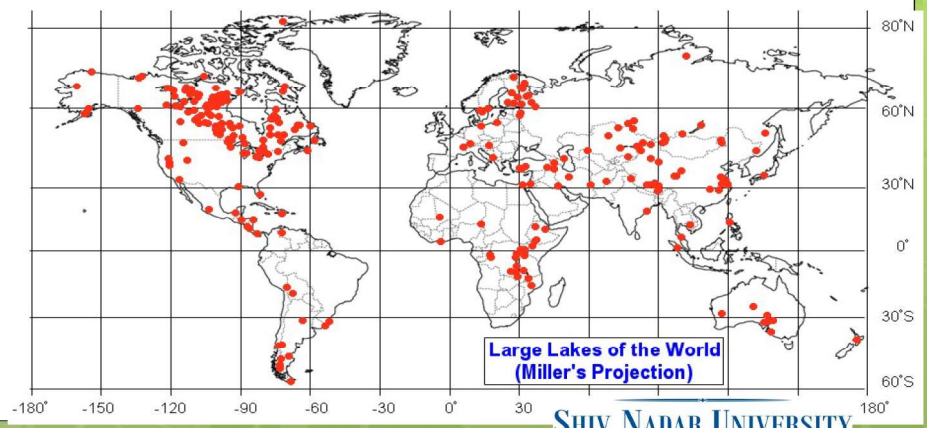
Lakes and Wetlands

Standing water (Lentic): lakes, ponds and wetlands

- Occupies a depression in the land, filled with freshwater
- Lakes contain several zones defined by depth, temperature, and distance from the shore
- Warmer zones tend to be more biologically productive



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Lakes in India

- Andhra Pradesh-5
- Assam -9
- Bihar -1
- Chandigarh (UT) -1
- Gujarat -7
- Haryana -8
- Himachal Pradesh -18
- Jammu and Kashmir -11
- Karnataka -14
- Kerala -11
- Madhya Pradesh -3
- Maharashtra -16
- Manipur -1
- Meghalaya -1
- Mizoram-2
- Odisha -4
- Puducherry -3
- Punjab -3
- Rajasthan -21 (Udaipur-4)
- Sikkim -5
- Tamil Nadu -11
- Telangana -11
- Uttar Pradesh -9
- Uttarakhand -5
- West Bengal -7

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LAKES IN INDIA

Keetham Lake near Agra

Vembanad (Vembanad Kayal or Vembanad Kol)

It is the longest lake in India, and the largest lake in the state of Kerala.

It is also counted as one of the largest lakes in India.

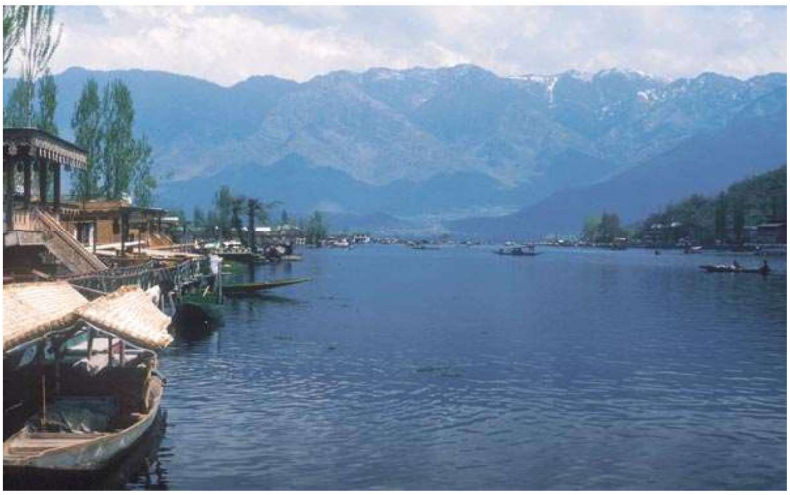
- The Vembanad wetland system covers an area of over 2033.02 km² thereby making it the second largest wetland system in India (after sundervan).
- Of this, an area of 398.12 km² is located below the MSL and a total of 763.23 km² area is located below 1 m MSL.
- Kuttanad, form the southern most part of the Vembanad.

Vembanad Lake

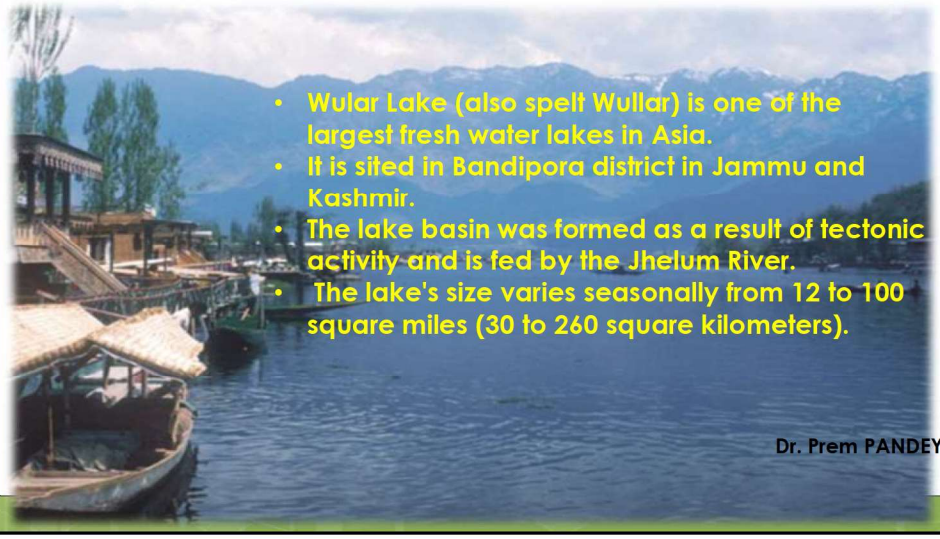
Chilka Lake, Orissa- a Ramsar Site

- It is a brackish water lagoon.
- spread over the Puri, Khurda and Ganjam districts of Odisha
- On the East coast of India,
- at the mouth of the Daya River,
- covering an area of over 1,100 km².

Dal Lake Srinagar, J & K



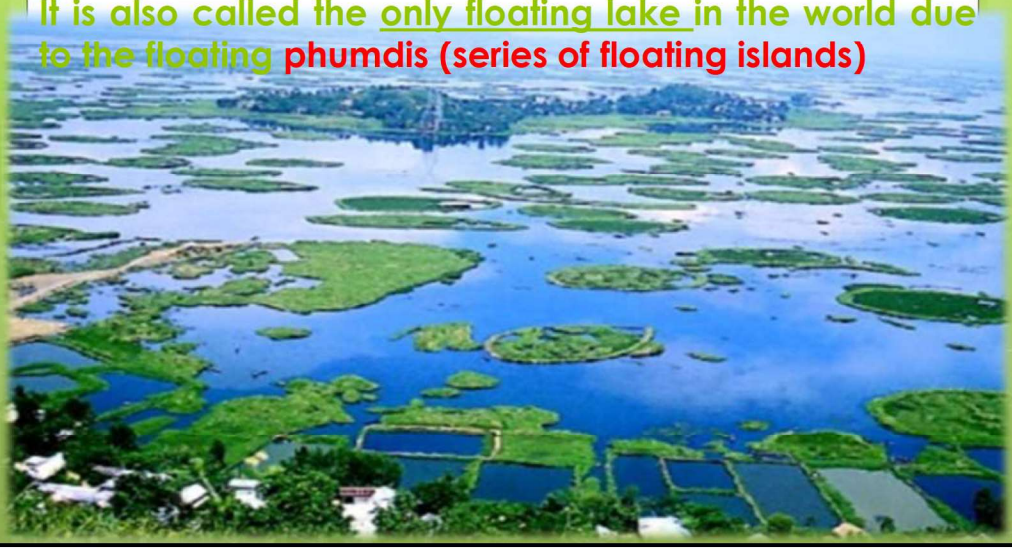
Wular Lake (J & K) is one of the largest fresh water lakes in Asia and the largest (24 km across) in India



- Wular Lake (also spelt Wullar) is one of the largest fresh water lakes in Asia.
- It is sited in Bandipora district in Jammu and Kashmir.
- The lake basin was formed as a result of tectonic activity and is fed by the Jhelum River.
- The lake's size varies seasonally from 12 to 100 square miles (30 to 260 square kilometers).

Loktak Lake is the largest freshwater lake in north-eastern India, located in Manipur.

It is also called the only floating lake in the world due to the floating **phumdis (series of floating islands)**



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Loktak Lake

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Gurudongmar Lake is one of the highest lakes in the world (altitude of 5,425 m). This fresh-water lake is located northeast of the **Kangchenjunga range** in **Sikkim.**

4. Wetland Ecosystem

- A wetland is a distinct ecosystem that is flooded by water, either **permanently or seasonally**, where oxygen-free processes prevail (an aerobic processes).
- The primary factor that distinguishes wetlands from other land forms or water bodies is the characteristic vegetation of aquatic plants, adapted to the **unique hydric soil**.
- ***Wetlands* are lands transitional between terrestrial and aquatic systems**

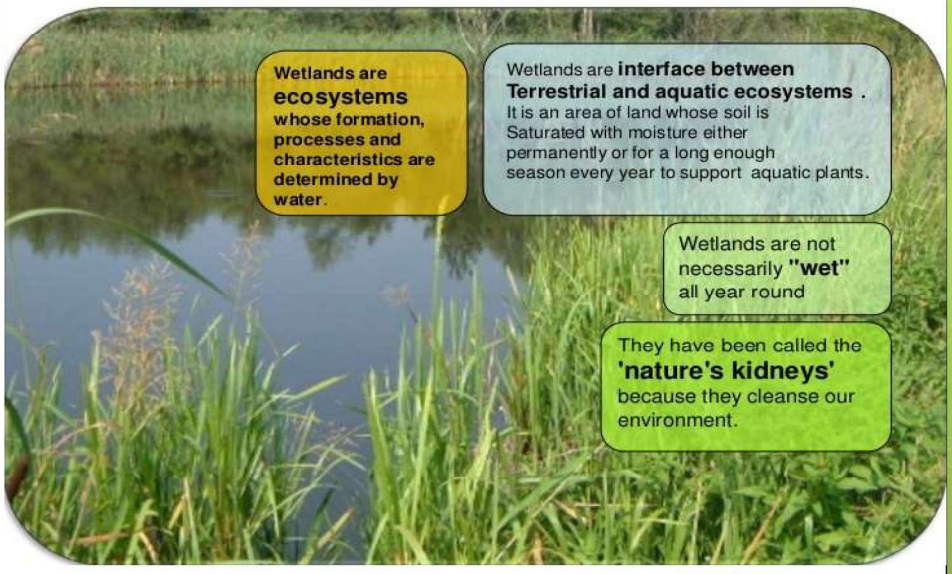
Wetlands

Wetlands must meet the following criteria:

1. **Hydrologic conditions** – water present on land surface, or **soils in root zone must be saturated** during growing season or longer.
2. **Hydrophytic vegetation** – specific plants that are water-tolerant and grow under wet conditions (e.g. cattails, wild rice, willows, sawgrass) **must be present**
3. **Hydric soils** – **poorly drained soils** that exhibit **anaerobic conditions** during growing season

Soil that is wet for extended periods of time because water is removed slowly.

What is a wetland?



Facts About Wetlands

- Wetlands are typically low-lying areas
- They can be natural or man-made
- They can be coastal or inland
- Floodplains, swamps, marshes, mangroves deltas and lakes are some types of wetlands.
- A paddy farm is also a wetland
- Wetlands can contain fresh water, salt water, or brackish (a combination of the two)

3

Typha - reed, cattail in wetlands

Kuttanad Wetlands, the 'Rice Bowl of Kerala'

- Kuttanad, the 'Rice Bowl of Kerala', lies at the very heart of the backwaters in Alappuzha district.
- Its wealth of paddy crops is what got it this unique nickname. Based in the inner regions of the district, it is a huge area of reclaimed land, separated by dikes from water which is higher than it appears.
- It has been speculated that it is perhaps the only place in the world where farming is done up to 2 meters below sea level.
- The area is serviced by 4 major rivers:
  Pampa, Meenachil, Achankovil and Manimala.

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Kuttanad, Kerala

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Kuttanad, Kerala

- **Kuttanad** is a region covering the Alappuzha and Kottayam Districts, in the state of Kerala, India,
- The **region has the lowest altitude in India,** and is one of the few places in the world where **farming is carried around 1.2 to 3.0 metres (4 to 10 ft) below sea level.**
- Farmers of Kuttanad are famous for **Bio-saline Farming.**
  - Bio-saline farming is a relatively new way of dealing with salinity in agriculture.
- **It develops crops tolerant to saline environments in combination with the use of saline soil- and water-resources and improved soil and water management.**

FAO has declared the Kuttanad Farming System as a Globally Important Agricultural Heritage Systems (GIAHS).

Some important wetlands in India

Ashtamudi (Wetland)
Bhitarkanika (Mangroves)
Bhoj (Wetland)
Chandertal (Wetland)
Chilika (Lake)
Deepor Beel
East Calcutta (Wetlands)
Harike (Lake)
Hokera (Wetland)
Kanjli
Keoladeo (National Park)
Kolleru (Lake)
Loktak (Lake)
Point Calimere (Wildlife and Bird Sanctuary)
Pong Dam (Lake)
Renuka (Lake)
Ropar
Rudrasagar (Lake)
Sambhar (Lake)
Sasthamkotta (Lake)
Surinsar – Mansar (Lakes)
Tsomoriri
Vembanad-Kol (Wetland)
Wular (Lake)
Upper Ganga River (Narora to Brijghat stretch)

4

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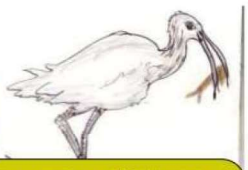
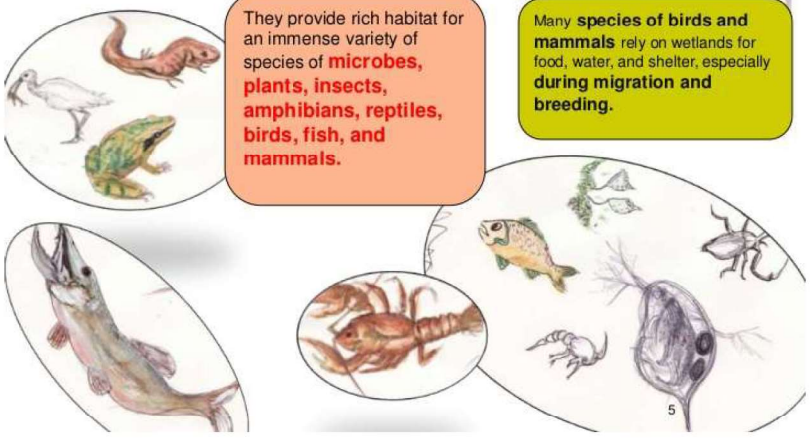
Importance of wetlands



Wetlands are among the most productive ecosystems in the world, comparable to rain forests and coral reefs.

They provide rich habitat for an immense variety of species of **microbes, plants, insects, amphibians, reptiles, birds, fish, and mammals.**

Many **species of birds and mammals** rely on wetlands for food, water, and shelter, especially **during migration and breeding.**



5

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Wetlands

Why should we care?

Wetlands perform many positive functions in the environment such as

- ***improving water quality in rivers* by filtering out sediments and contaminants,**
- ***providing breeding grounds for fish* and shellfish which supports commercial fishing,**
- ***providing ecological habitats* for migrating birds,**
- ***modifying the effects of flooding* by slowing runoff, and**
- ***providing food and recreation* for humans.**

Uses of wetlands

water management

Think of a wetland as a huge sponge

Wetlands store water when it is in excess and release it to the ground during dry periods

This helps in recharge and discharge of groundwater

They assist in flood control

They reduce the momentum of water as it flows to a river or a stream, thereby reducing soil erosion

They are also important to the nutrient cycle.

Uses of wetlands environmental

Wetlands **plants and soil store carbon instead of releasing it to the atmosphere as carbon dioxide.** Thus they help moderate global climate

Wetlands help **retain sediments and increase soil fertility**

Plants that grow in wetlands are very effective in **filtering out water pollution**

Many wetlands **remove pollutants from surface runoff and small streams.**

Mangroves can protect shorelines from strong winds and can reduce the impact of hurricanes and tsunamis

7

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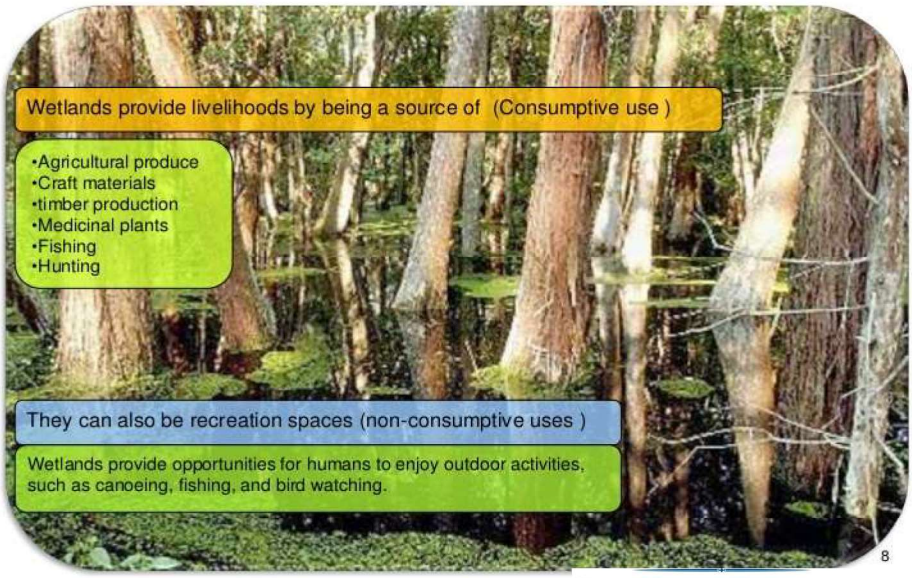
Uses of wetlands – economic



Wetlands provide livelihoods by being a source of (Consumptive use)

- Agricultural produce
- Craft materials
- timber production
- Medicinal plants
- Fishing
- Hunting

They can also be recreation spaces (non-consumptive uses)

Wetlands provide opportunities for humans to enjoy outdoor activities, such as canoeing, fishing, and bird watching.

8

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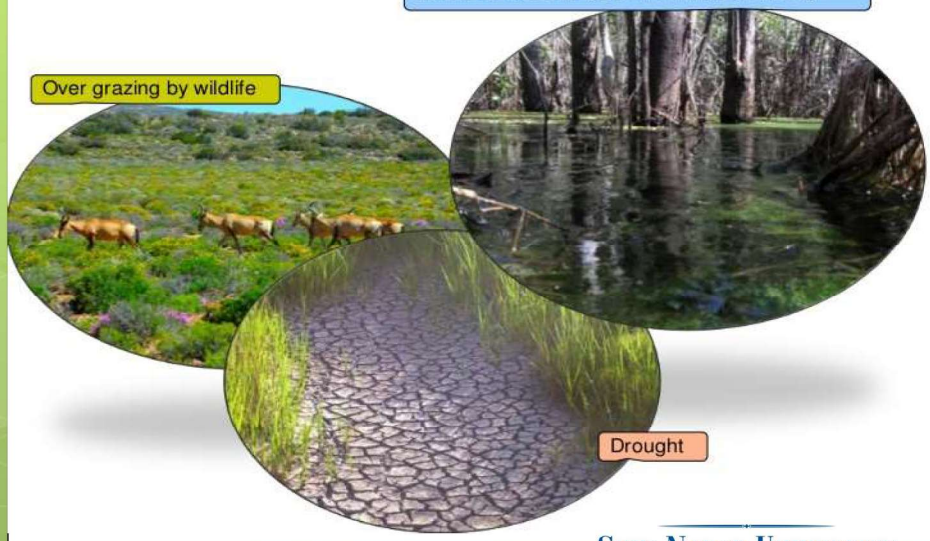
Threats to wetlands Natural

Natural disasters like hurricanes and floods

Over grazing by wildlife



Drought

Threats to wetlands Anthropogenic

1.Development

- Draining out wetlands for construction
- Damming them to form lakes or ponds
- Diverting water flow

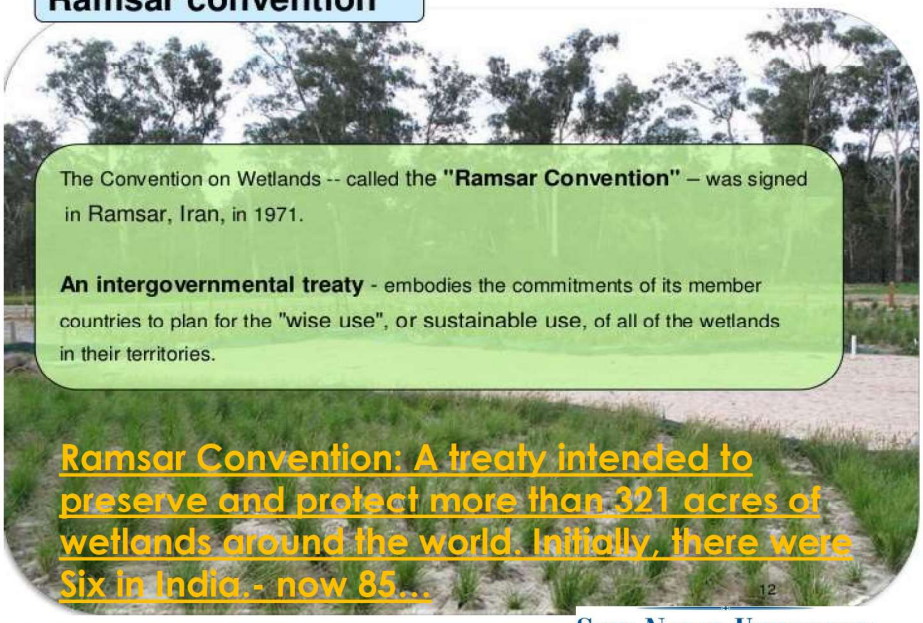
2.Pollution

3. Sand and gravel mining

4. Global warming

5. Acid rain

Ramsar convention



The Convention on Wetlands -- called the **"Ramsar Convention"** – was signed in Ramsar, Iran, in 1971.

An intergovernmental treaty - embodies the commitments of its member countries to plan for the "wise use", or sustainable use, of all of the wetlands in their territories.

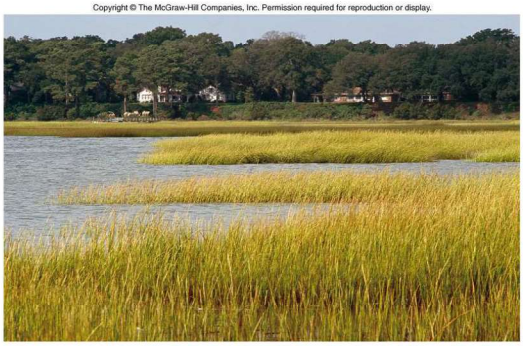
Ramsar Convention: A treaty intended to preserve and protect more than 321 acres of wetlands around the world. Initially, there were Six in India.- now 85…

Wetlands

Ramsar Convention:

To be a wetland an area must be saturated with water and have poorly drained soils and specific types of plants.

Two types: coastal and freshwater

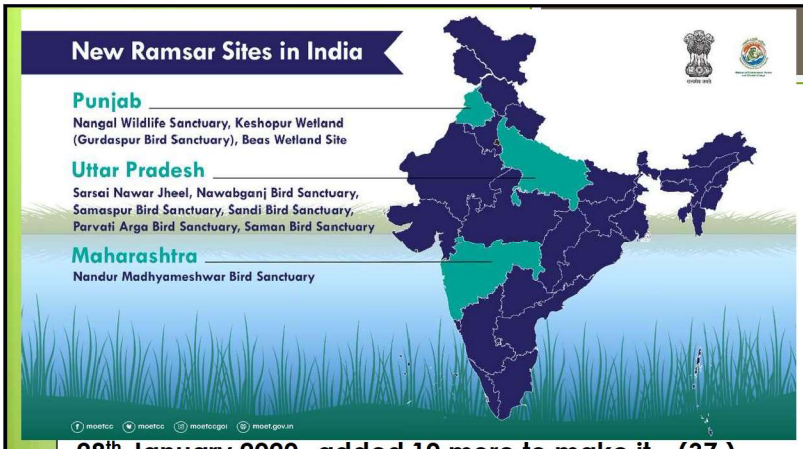


b.

d.

Ramsar Sites in India
85 Ramsar Sites

1. Ashtamudi Wetland, Kerala
2. Bhitarkanika Mangroves, Odisha
3. Bhoj Wetland, MP
4. Chandra Taal, HP
5. Chilika Lake, Odisha
6. Deepor Beel, Assam
7. East Calcutta Wetlands, West Bengal
8. Harike Wetland, Punjab
9. Hokera Wetland, J & K
10. Kanjli Wetland, Punjab
11. Keoladeo National Park, Rajasthan
12. Kolleru Lake, Andhra Pradesh
13. Loktak Lake, Manipur
14. Nalsarovar Bird Sanctuary, Gujarat
15. Point Calimere Wildlife and Bird Sanctuary, Tamil Nadu
16. Pong Dam Lake, HP
17. Renuka Lake, HP
18. Ropar_Wetland, Punjab
19. Rudrasagar Lake, Tripura
20. Sambhar Lake, Rajasthan
21. Sasthamkotta Lake, Kerala
22. Surinsar-Mansar Lakes, J & K
23. Vembanad-Kol Wetland, Kerala
24. Wular Lake, J & K



28th January 2020- added 10 more to make it – (37)

26th July 2022- Number increased to 54 from 49-

- Karikili Bird Sanctuary,
- Pallikaranai Marsh Reserve Forest,
- Pichavaram Mangrove in Tamil Nadu.
- Sakhya Sagar in Madhya Pradesh and
- Pala Wetland in Mizoram have made it to the coveted list.

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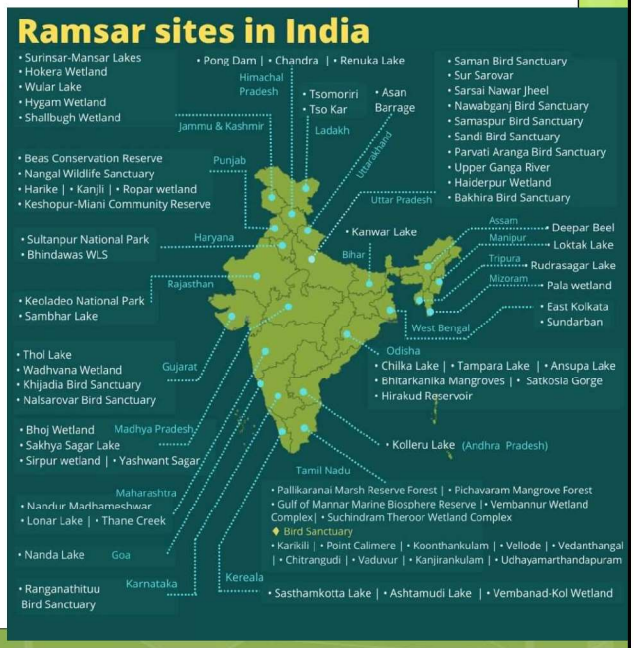
- **10 more added on 3rd August, and**
  - 11 wetlands are again added to the list on 14th August 2022 - making it total 75 Ramsar sites in INDIA during 2023.



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Ecosystems: Forests

Forests

Forest is a large area of land covered with trees or other woody vegetation.

- **Hanson (1962)** defines forest as "*a stand of trees growing close together with associated plants of various kinds*".
- According to United Nations Food and Agriculture Organization (**FAO**) "forest is a land **area of more than 0.5 ha**, with **a canopy cover of more than 10%,** which is not primarily tree under agricultural or other specific non-forest land".
- A forest is can also be defined as "an Ecosystem or assemblage of ecosystems dominated by trees and other woody vegetation. "

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Forests

- Consistent moderate-to-high precipitation that supports tree growth.
- Warm or seasonal temperatures.
- High net primary productivity across multiple layers.

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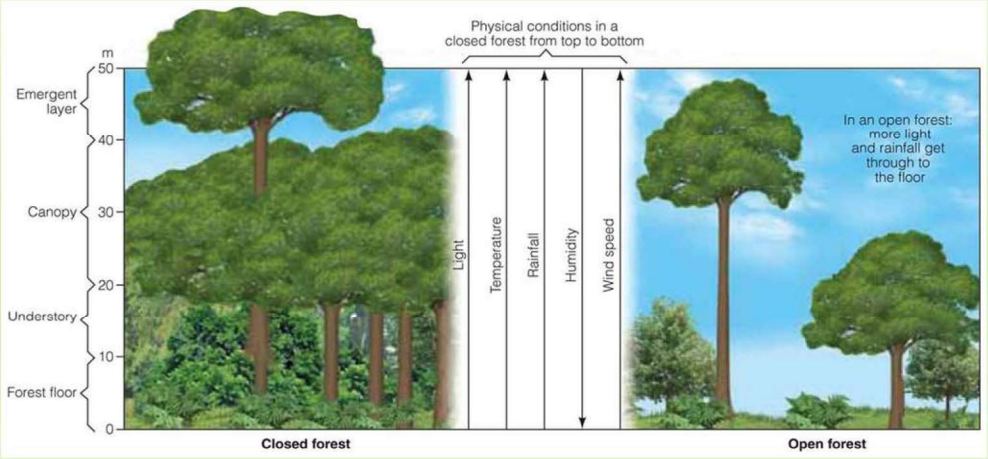
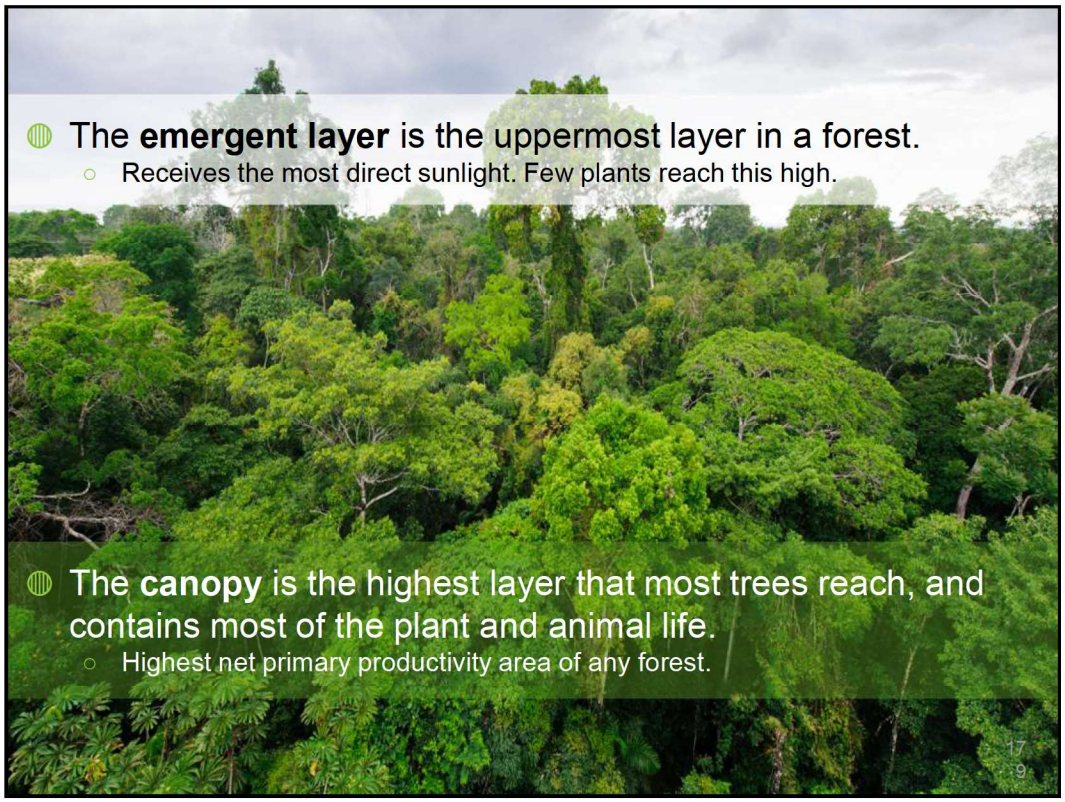
Forest Canopy

In forest ecology,

"Canopy " *refers to the upper layer or habitat zone, formed by mature tree crowns and including other biological organisms (epiphytes, lianas, arboreal animals, etc.).*

Sometimes the term canopy is also used to refer to the extent of the outer layer of leaves of an individual tree or group of trees.





Broadleaf Trees

Wide, flat leaves that maximize sun absorption.

Prone to moisture loss via transpiration.

Shed in winters or prolonged dry seasons.

Coniferous Trees

Narrow, wax-coated leaves.

Absorb less sunlight and transpire less water.

Not shed during cold or dry seasons.

Open and Closed Forests

Open Forests

Open forests are mixtures of trees, shrubs and grasses.

Tree canopies do not form continuous closed cover.

Occur in savanna environments in the semi-arid, sub-humid and humid tropics.

Shed in winters or prolonged dry seasons.

Closed Forests

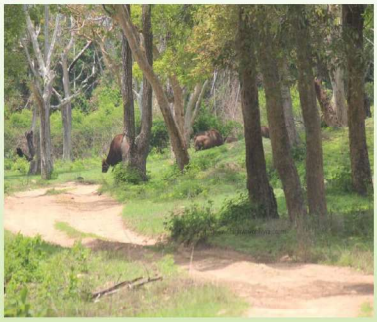
A Closed forest is a forest with a tree canopy coverage of 60 to 100%.

Absorb less sunlight but transpire less water.

Not shed during cold or dry seasons.

Open and Closed Forests

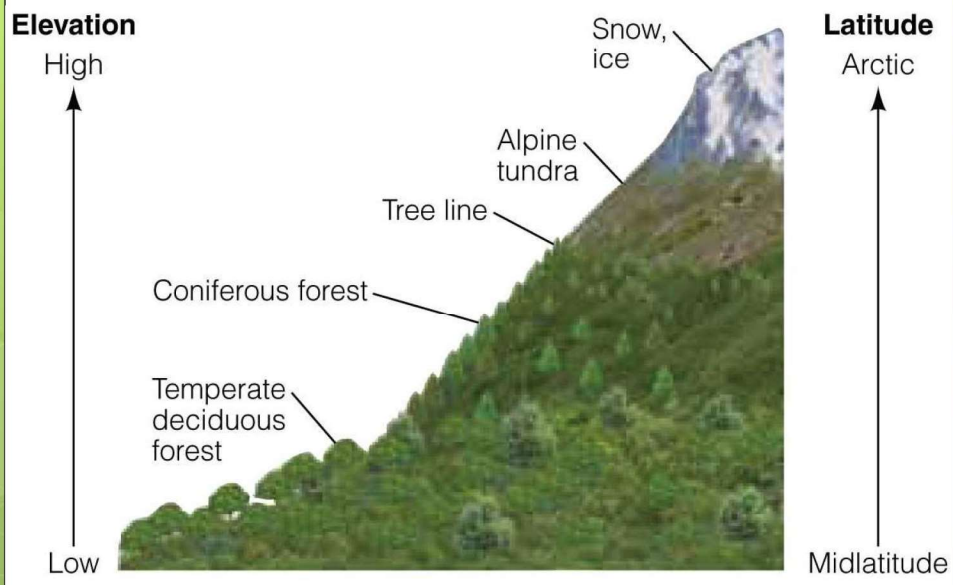
Open forests- Mudumalai and Bandipur Wildlife Sanctuaries



Tropical forests with closed canopy

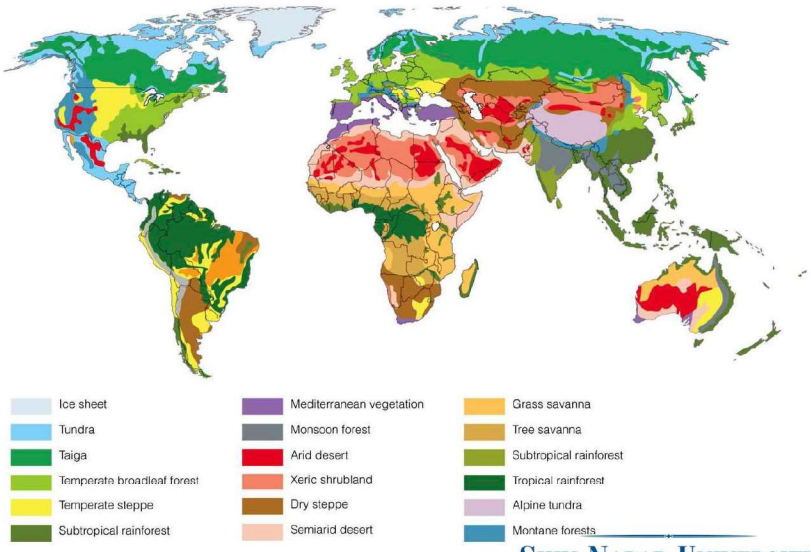
A Closed forest is a forest with a tree canopy coverage of 60 to 100%.

Forest types



Alpine variations of terrestrial biomes

Earth's Forest Zones



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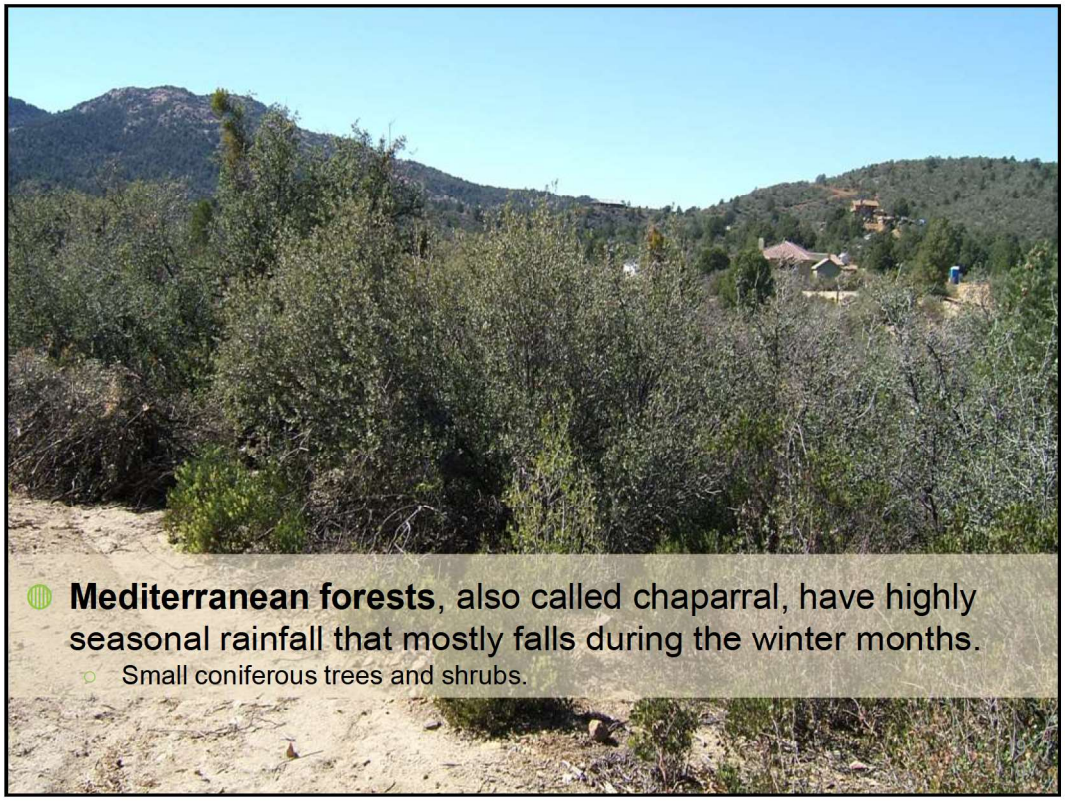
Tropical rainforests receive high rainfall and are consistently warm.
Broadleaf trees only.
Highest net primary productivity of all land-based ecosystems.
18


Temperate rainforests also receive high rainfall but have seasonal temperature changes.
Broadleaf or coniferous trees.
18
7

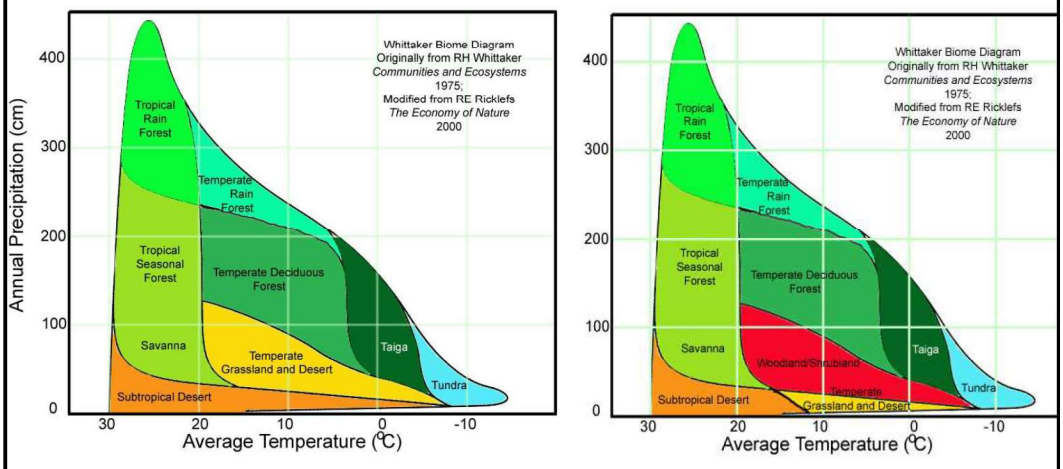

Deciduous forests have moderate precipitation and significant seasonal temperature changes.
Mostly broadleaf trees that shed their leaves each winter.
18
8


Boreal forests, also called taiga, are the coldest and driest of all the forest biomes.
Coniferous trees only.
18
9



- **Mediterranean forests**, also called chaparral, have highly seasonal rainfall that mostly falls during the winter months.
  - Small coniferous trees and shrubs.

Robert Whittaker Graph



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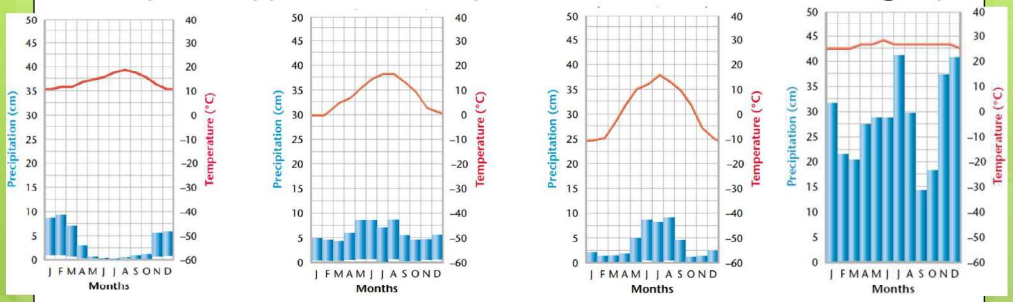
1

Identify the type of forest present in each climatograph:



Wet winters, Warm to hot -dry summer temperatures

Seasonal precipitation

Seasonal temperatures

Moderate precipitation

Seasonal/cold temperatures

Seasonal precipitation

Warm temperatures

High precipitation

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Tropical Rainforest

- The tropical rainforest is a biome with a constant temperature and a high rainfall. The level of humidity and density of the vegetation give the ecosystem a unique water and nutrient cycle.
- Rainforests around the world are threatened by human expansion.
- The tropical rainforest biome has four main characteristics:
  - very high annual rainfall,
  - high average temperatures,
  - nutrient-poor soil, and
  - high levels of biodiversity (species richness).

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Forests in India

- Champion (1936) recognized 13 major types of forest in India.
- Champion and Seth (1968) recognized sixteen types of forest which are listed below.
- The following types of forests are found in India which cover nearly 22 per cent of the total area of Indian territory.

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Forests of India

- The most important factors influencing the physiognomy, species composition, phenology etc. of Indian forests are temperature, rainfall, local edaphic and biotic factors.
- These factors have been used in the classification of Indian forests.
- Most detailed classification of Indian forests is by Champion and Seth (1967) in which 16 major types of forests have been recognized.
- These 16 major types can be grouped into 5 major categories viz. moist tropical, dry tropical, montane sub-tropical, temperate and alpine forests.

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Forests in India

Forest type	Plants	Common animals	Rare animals
Himalayan coniferous	Pine, Deodar	Wild goats and sheep, Himalayan black beer	Snow leopard, brown beer, musk deer, wolf
Himalayan broad leaved	Maple, Oak		
Evergreen (northeast, western Ghats, Andaman)	Jamun, Ficus, Dipterocarpus	Tiger, leopard, sambar, malabar pied hornbill, frogs	Pigmy hog, rhinoceros, macaque
Deciduous dry	Teak, Ain, Terminalia	Tiger, chital, baring deer, babbles	
Deciduous moist	Sal		
Thorn and scrub, semi-arid forests	Babul, Ber, Neem	Blackbuck, chinkad, partridge, lizard	Bustard, florican
Mangrove delta forests	Avicennia	Crocodiles, fish, crustaceans	Water lizard

Forests in India

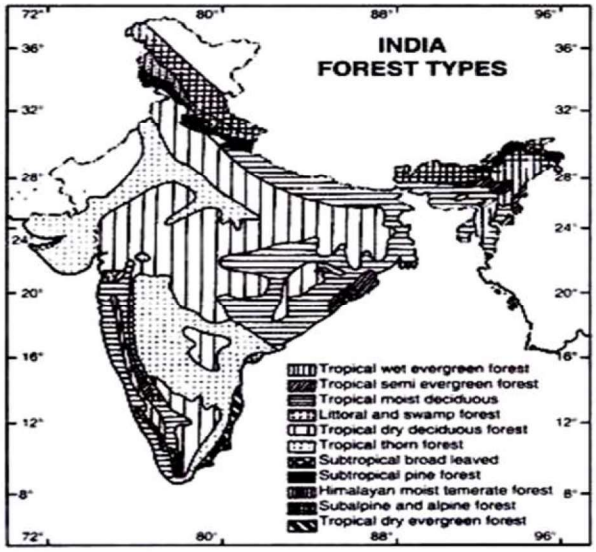
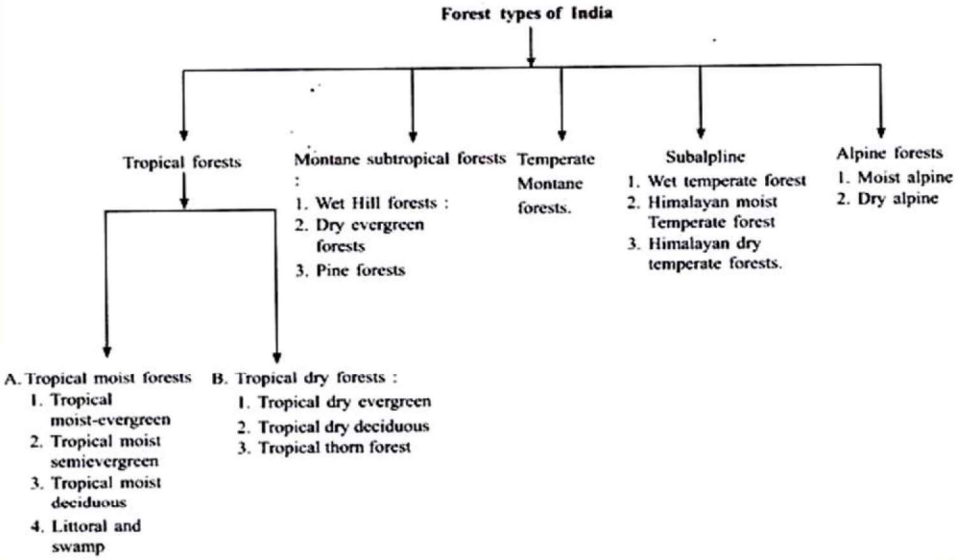


Fig. 11.2. Outline map of India showing distribution of different forest types (*After Champion and Seth, 1968*).

Forest Types



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