Biodiversity

- The diversity (heterogeneity) of Biological organisation ranging from cellular macromolecules to biomes.
- Earth's remarkable diversity: Over 20,000 species of ants, 300,000 species of beetles, 28,000 species of fishes, and nearly 20,000 species of orchids.
- The term biodiversity was popularised by biologist Edward Wilson

Patterns of Biodiversity

i) **Genetic diversity:** Variations within a single species at genetic level. Eg: Rauwolfia vomitoria found in Himalaya shows genetic variation in potency & concentration of chemical reserpine (chemical use to treat high BP & Hyper tension).
India has different strains of rice (50000+) and various mango (1000+) varieties.

ii) **Species diversity:** The richness at the species level, exemplified by the Western Ghats' greater amphibian diversity compared to the Eastern Ghats as western ghats receive south-west monsoon hence more water which support amphibians.

iii) **Ecological diversity:** Ecosystem variety within a country, like India's deserts, rainforests, coral reefs, wetlands, mangroves, estuaries and alpine meadows(grassland).

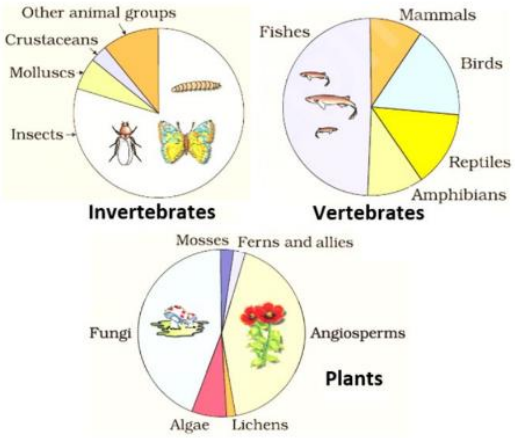
Threats to Biodiversity

- Habitat loss, over-exploitation (e.g., over-harvesting of marine fish), pollution, invasive species, and climate change.
- It took millions of years but we could lose all that wealth in less than two centuries if the present rates of species losses continue.

Species on Earth and in India

- Convention on Biological Diversity (CBD) and the IUCN Red List that documents threatened species.
- According to International Union for Conservation of Nature & Natural Resources (IUCN 2004) the total number of plant and animal species is slightly more than 1.5 million.
- Some extreme estimates range of species is 20 to 50 million, more to be discovered in Tropical Region.
- Robert May's estimate suggests about 7 million species on Earth. i.e. Only 22% of the total species have been recorded so far.
- More than 70% of all the species recorded are animals, while plants comprise no more than 22% of the total.
- Among animals, insects are most species rich-taxonomic group, making about 70% of the total
- India one of the 12 mega diversity countries has 8.1% of the world's species diversity with 2.4% of the world's land area.
- Nearly 45000 species of plant and twice as many of animal.
- According to May's global estimate in India more than 1,00,000 plant species and more than 3,00,000 animal species yet to be discovered and described.
- Biologists are not sure about total number of prokaryotic species because: i) Convectional taxonomic methods are not suitable for identifying microbial species.
  ii) In laboratory many species can not be cultured.
- Descending order of :

1) **Invertebrates:** Insects>Other animals>Molluscs> Crustaceans
2) **Vertebrates:** Fishes>Birds>Reptiles>Amphibians>Mammals
3) **Plants**: Angiosperm>Fungi>Algae>Mosses>Fern & allies> Lichens



Patterns of Biodiversity

i) **Latitudinal gradients**:

- Species diversity decreases as you move from the equator toward the poles.
- Tropics (latitudinal range of 23.5°N to 23.5°S) have more species than temperate or polar areas

- Ex: Number of Bird species:
  Colombia (near equator): 1,400 species
  India (tropical): 1200 species
  New York (temperate- 41°N): 105 species
  Greenland (Polar -71°N): 56 species.

• A tropical forest in equator has up to 10 times as many species of vascular plants as a forest of equal area in a temperate region like the mid-west of USA.

• Tropical Amazonian rainforest in South America has the greatest biodiversity on earth. It homes 40,000 species of plants, 3,000 of fishes, 1,300 of birds, 427 of mammals, 427 of amphibians, 378 of reptiles and of more than 1,25,000 invertebrates.

• Estimate -2 million insect species waiting to be discovered and named.

Que: Why Tropical Region have Greater Biodiversity?

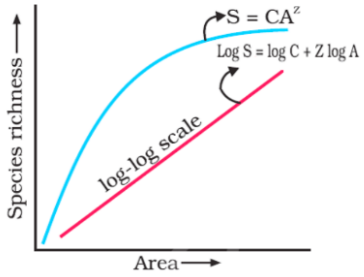
Ans: The temperate regions had frequent glaciation in the past, but the tropics have remained undisturbed and hence, had evolved more species diversity.

• Tropical environments, unlike temperate are less seasonal, relatively more constant and predictable.

• More solar energy is available in tropics, which contributes to higher productivity.

ii) **Species-Area relationships:** According to Alexander von Humboldt in South America jungles, The number of species increases with increase in explored area but only up to a limit.
Large areas have steeper slopes in these relationships.

- Relation between species richness and area gives a rectangular hyperbola.



$S = CA^Z$

- **Where,**
  S= Species richness A= Area
  C= Y-intercept
  Z= slope of the line (regression co-efficient)
- **On a logarithmic scale, the relationship is a straight line. The equation is**

Log S = log C + Z log A

- **Generally, for small areas, the Z value is 0.1 to 0.2.**
- **But for large areas (e.g. entire continents), slope of the line is steeper (Z value: 0.6 to 1.2).**
- **E.g. for frugivorous birds and mammals in the tropical forests of different continents, the Z value is 1.15**

Importance of Biodiversity

- According to ecologists, communities with more species tend to be more stable than those with less species.
- Attributes of a stable community are
  (a) It should not show too much variation in productivity from year to year.
  (b) It must be either resistant or resilient to occasional disturbances (natural or man made).
  (c) It must be resistant to invasions by alien species.
- David Tilman's- plots with more species showed less year-to-year variation in total biomass. Increased diversity contributed to higher productivity. Essential for ecosystem health & survival of human race.
- Economic value: Diverse resources like medicines, food, construction materials, industrial products (tannins, dyes), and traditional medicines.
- **Rivet popper hypothesis –** Paul Ehrlich.
  In an airplane (ecosystem) all parts are joined together using many rivets (species).
  If passenger travelling pop a rivet to take home (causing a species extinct), it may not affect flight safety (functioning of the ecosystem) initially, but as more and more rivets are removed, the plane becomes dangerously weak.
  Furthermore, Loss of rivets on the wings (key species that drive major ecosystem functions) is obviously a more serious threat to flight safety than loss of a few rivets on the seats or windows inside the plane.

Loss of Biodiversity

- Caused by the over population, urbanisation and industrialisation.
- Colonisation of tropical Pacific Islands by humans- 2,000 native birds extinct.

- IUCN Red list (2004) documents the extinction of 784 species (including 338 vertebrates, 359 invertebrates and 87 plants) in the last 500 years.
- Recent extinctions are dodo (Mauritius), Quagga (Africa), Thylacine (Australia), Steller's sea cow (Russia) and three sub-species (Bali, Javan and Caspian) of tiger.
- Last twenty years – 27 species extinct.
- Presently, 12% of bird, 23% of all mammal, 32% of all amphibian and 31% of all gymnosperm species in the world face the threat of extinction. Amphibians – vulnerable to extinction.
- The grim scenario of extinctions is the fact that more than 15,500 species world wide are facing the threat of extinction.
- Since origin of first cell (>3billion), there have been five mass extinctions on earth. Presently sixth is going on , the rate of species extinctions is 100 to 1,000 times faster than before, primarily due to human activities.
- More than 15,500 species worldwide are under the threat of extinction.

Results of Loss of Biodiversity in a Region

(a) Decline in plant production.
(b) Lowered resistance to environmental perturbations, such as drought.
(c) Increased variability in certain ecosystem processes such as plant productivity, water use, pest and disease cycles.

Causes of Biodiversity Loss- "The Evil Quartet"

(i) **Habitat Loss and Fragmentation**

(a) Main cause of extinction of species is the destruction of their habitat ex: Tropical rainforests (14% of the land surface), now cover only 6% of land area.
(b) Amazon rainforest (called lungs of the planet) is being cut and cleared for the cultivation of soybeans and f grasslands for raising beef cattle.
(c) Large habitats are broken up into small fragments mammals & birds requiring large territories and certain animals with migratory habits are badly affected.
(d) The degradation of many habitats by pollution also threatens the survival of many species.

(ii) **Over-exploitation of natural resources** by humans results in degradation and extinction of the resources. Ex: Steller's sea cow, passenger pigeon and many marine fishes have extinct in last 500 years.

(iii) **Alien (exotic) Species Invasions**

Introduction of alien species cause harmful impact resulting in extinction of the indigenous species. Ex:
(a) Nile perch (fish) in Lake Victoria (East Africa) caused the extinction of 200 species of cichlid fish.
(b) Invasive weed -Parthenium (carrot grass), Lantana and Eichhornia (water hyacinth) caused environmental damage and pose threat to native species.
(c) African cat fish (Clarias gariepinus) introduced for aquaculture cause threat to the indigenous cat fishes.

Co-extinctions When a species become extinct, the plant and animal species associated with it also extinct. Ex: Extinction of parasites if host become extinct.
In coevolved plant pollinator mutualism- plant extinct if its pollinator is extinct.

Why Conserve Biodiversity?

- **Narrow Utilitarian** benefits like economic value food, wood, medicines by 25000 species) and essential ecosystem services (like pollination and oxygen production). >25% drugs by plants.
- **Broad Utilitaria:** Amazon forest produce 20% O_2, Pollination by bees, bumble bees, bats bird etc.
- Ethical duty: Recognizing the intrinsic value, regardless of its economic importance, and our moral obligation to protect them.
- Ecological balance: Different species contribute to the stability and functioning of ecosystems.
- Cultural and aesthetic values
- Scientific knowledge: Biodiversity is crucial for scientific understanding and research.

Conservation of Biodiversity

In-situ (on site) conservation, preserving entire ecosystems, and their biodiversity.

- Biodiversity (34), hotspots (**25+9 new),** biosphere reserves (14), national parks (90), and wildlife sanctuaries (448).
- **Biodiversity hotspots** regions with very high levels of species richness and high degree of **endemism** (species found in that particular region only)
- Three of these hotspots – Western Ghats and Sri Lanka, Indo-Burma & Himalaya.
- Hotspots species richness reducing by 30%.
- **Sacred groves** – As per culture in a forest all the trees and wildlife within were venerated and given total protection that is vital for preserving unique and threatened species. It is found in Khasi and Jaintia Hills in Meghalaya, Aravalli Hills of Rajasthan, Western Ghat (Karnataka) and Maharashtra and the Sarguja, Chanda and Bastar(MP).

Ex-situ conservation, safeguarding species outside their natural habitat like in cryopreservation, Zoological parks, botanical gardens etc.
Seeds of different genetic strains of commercially important plants can be kept for long periods in seed banks, Eggs can be fertilised in vitro fertilization, and plants can be propagated by the tissue culture.

The Earth Summit (in Rio de Janeiro) in 1992,called upon all nations to take appropriate measures for conservation of biodiversity.
The World Summit on sustainable development (2002, Johannesburg, South Africa)- 190 countries pledged their commitment for significant reduction in the current rate of biodiversity loss at global, regional & local levels by 2010.

Que: Define Cryopreservation .
Ans: A process that preserves organelles, cells, tissues, gametes or any other biological constructs by cooling the samples to very low temperatures.
Gametes of threatened species can be preserved in viable and fertile condition for long periods of time.

Que: Differentiate between In-situ & Ex-situ conservation.

***In situ* conservation**	***Ex situ* conservation**
This method involves protection of endangered species in their natural habitat.	It involves placing of threatened animals and plants in special care unit for their protection.
It helps in recovering populations in the surroundings where they have developed their distinct features.	It helps in recovering populations or preventing their extinction under stimulated conditions that closely resemble their natural habitats.
e.g. national parks, biosphere reserves, wildlife sanctuaries, etc.	e.g. botanical garden, zoological parks.