Module II

Environment, Ecosystem and Biodiversity

Lecture 2 (7 July 2024)

Dr. Asib Ahmed

Department of Social Relations

EAST WEST UNIVERSITY

Review of class 1 (those who were absent in lec 1)
+
Lecture 2

Lecture 2:
Current Environmental Conditions

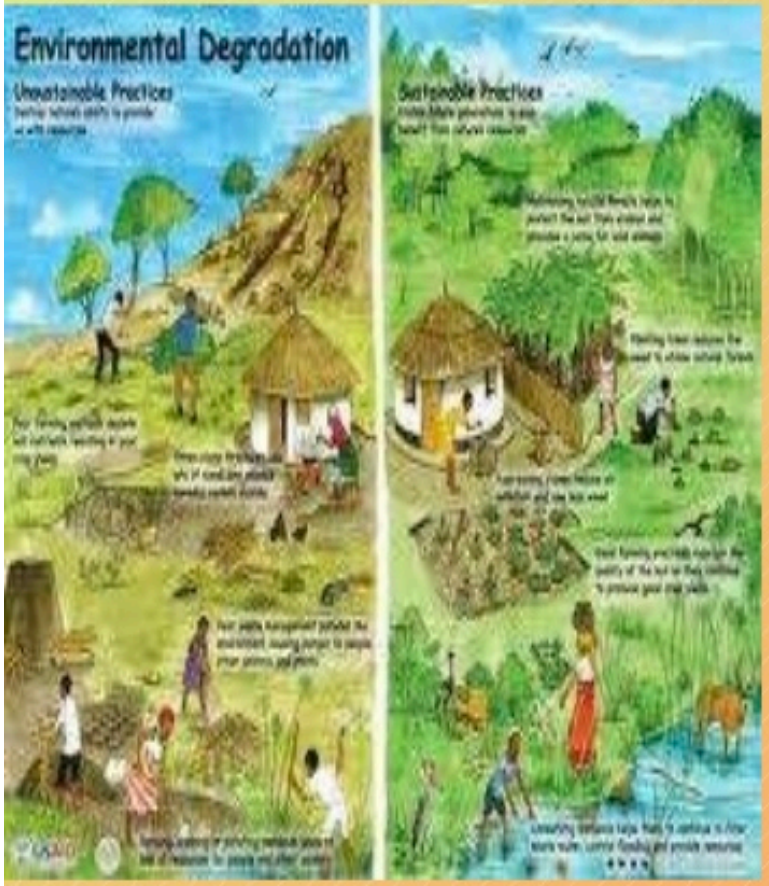
Widespread decline in the ability of the ecosystem to produce goods and services. Example:

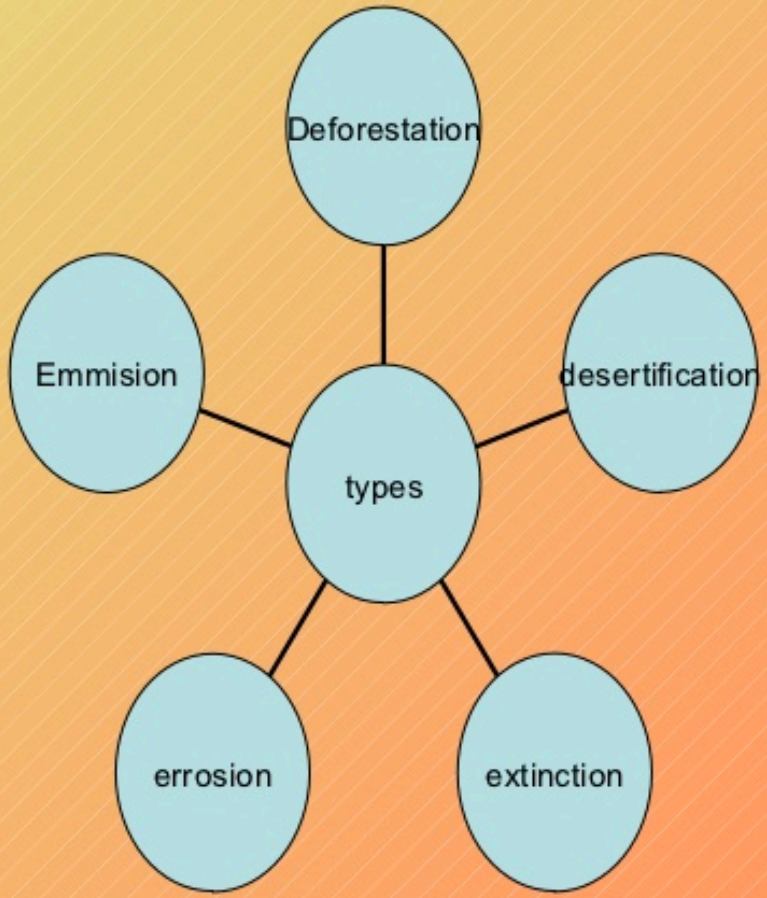
- Land conversion have shrunk the world's forest as much as half
- Soil degradation has affected two-thirds of the world's agricultural land
- Marine fish stocks are over harvested

Environmental degradation

- About 85 million people are added every year causing stress on resources and services
- More land needed for housing and food production
- More urbanization causes air pollution, hazardous waste generation
- Extraction of ground water, fossil fuel and resources increase
- Surface and ground water pollution threatens natural water habitats

Types of environmental degradation





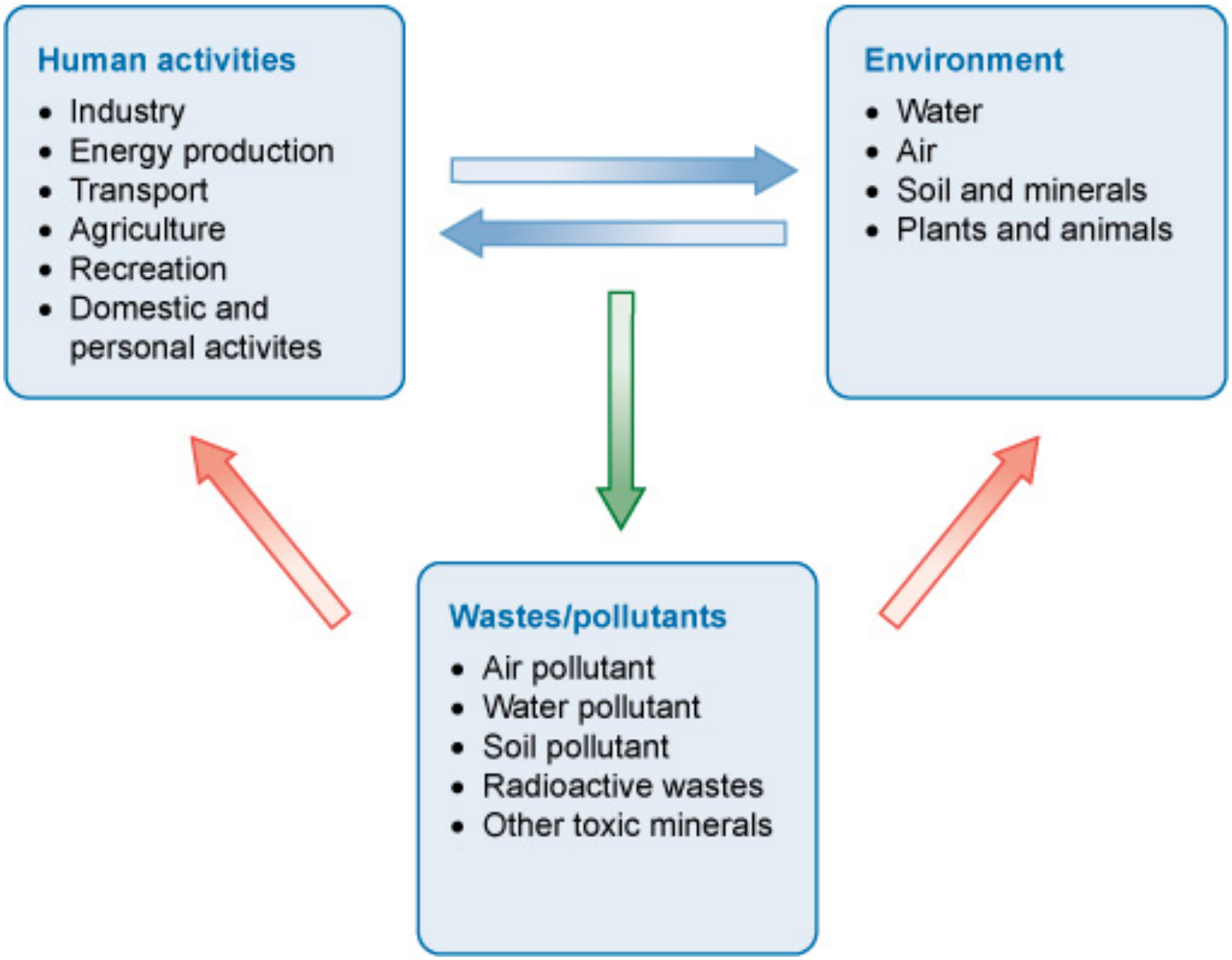
Top-most causes of environmental degradation

- Exhaust gas from factories and auto-emissions

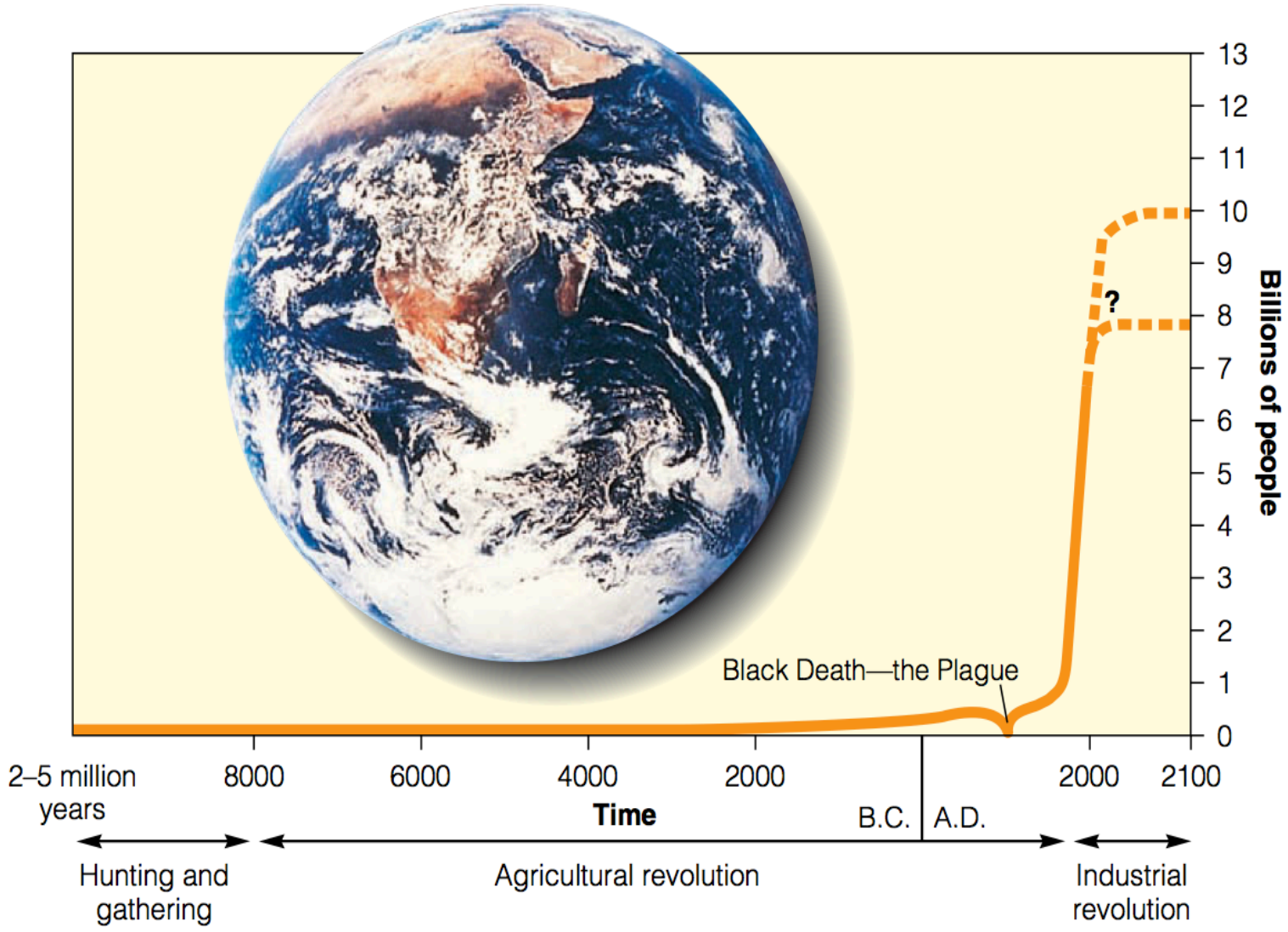
(One of the foremost reasons that causes pollution is the exhaust gas emitted from factories.)

- Deforestation
- Technocentrism
- Chemical Effluents
- Transport
- Unplanned Construction
- Secondary Pollutants (e.g. formation of Ozone)
- Defective Agricultural Policies
- Population explosion
- Arbitrary land-use policies

How the causes work



Population growth
(one most important reason for environmental degradation)



ECOSYSTEM

Concepts relevant to Ecosystem

- Ecology is the study of how organisms interact with each other and with their non living environment.
- Species refers to the organisms that resemble one another in terms of their appearance, behavior, chemistry and genetic makeup.
- Population is a group of interacting individuals of the same species living in a given area. Example: sunfish in a pond, white oak trees in a forest, people in a country.
- Habitat: The place where a population (or an individual organism) normally lives is its habitat. It may be large as an ocean or as small as the intestine of a termite.
- Community consists of all populations of different species of plants, animals, and microorganisms living and interacting in an area.

Ecosystem is a community of different species interacting with one another and with their physical environment of matter and energy in a particular area.

An ecosystem is formed by the interactions between all living and non-living components.

Classification of Ecosystem

In terms of origin ecosystems can be

- natural : Sahara desert, Sundarban forest, Atlantic ocean.
- artificial (human created) : crop fields, farm ponds.

In terms of their location ecosystems can be

- Terrestrial ecosystem : related to land
  - Forest
  - Mountain
  - Desert
  - Grassland
  - Urban ecosystem
- Aquatic ecosystem : related to water
  - Marine- Ocean
  - Freshwater- ponds, lakes, rivers etc.

Fundamental Characteristics of an ecosystem

Structure:

Two types of components make up the ecosystem:

Abiotic or nonliving components such as water, air, nutrients & solar energy. Also known as physico-chemical environment.

Biotic or living components such as plants, animals and microbes. Also known as ecological community.

Processes:

- Energy flow
- Cycling of matter (chemicals)

Change:

- Dynamic (not static)
- Succession, etc.

Major Components of Ecosystem

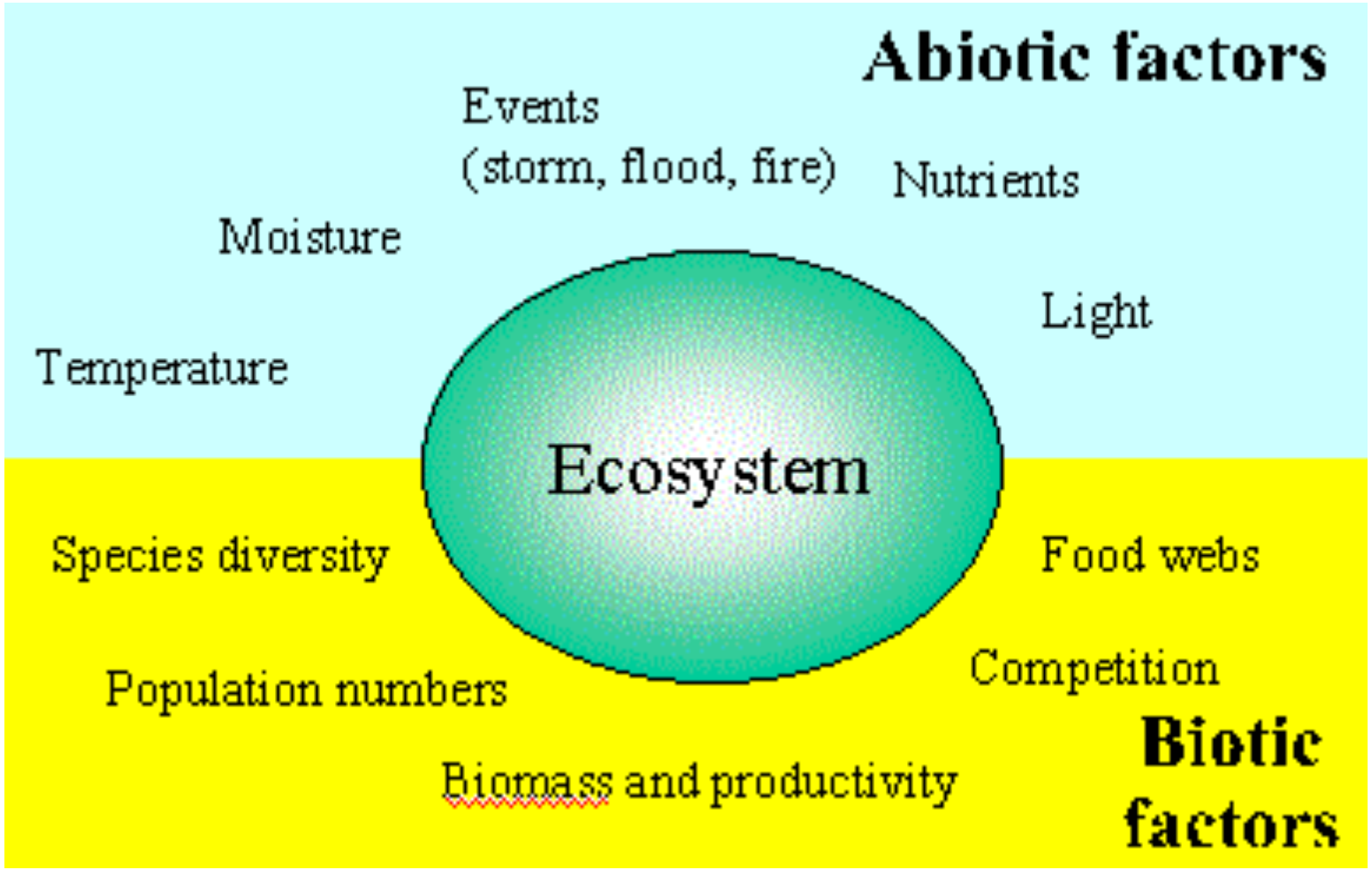
Any ecosystem includes two major components- the non living (abiotic) and living (biotic) components

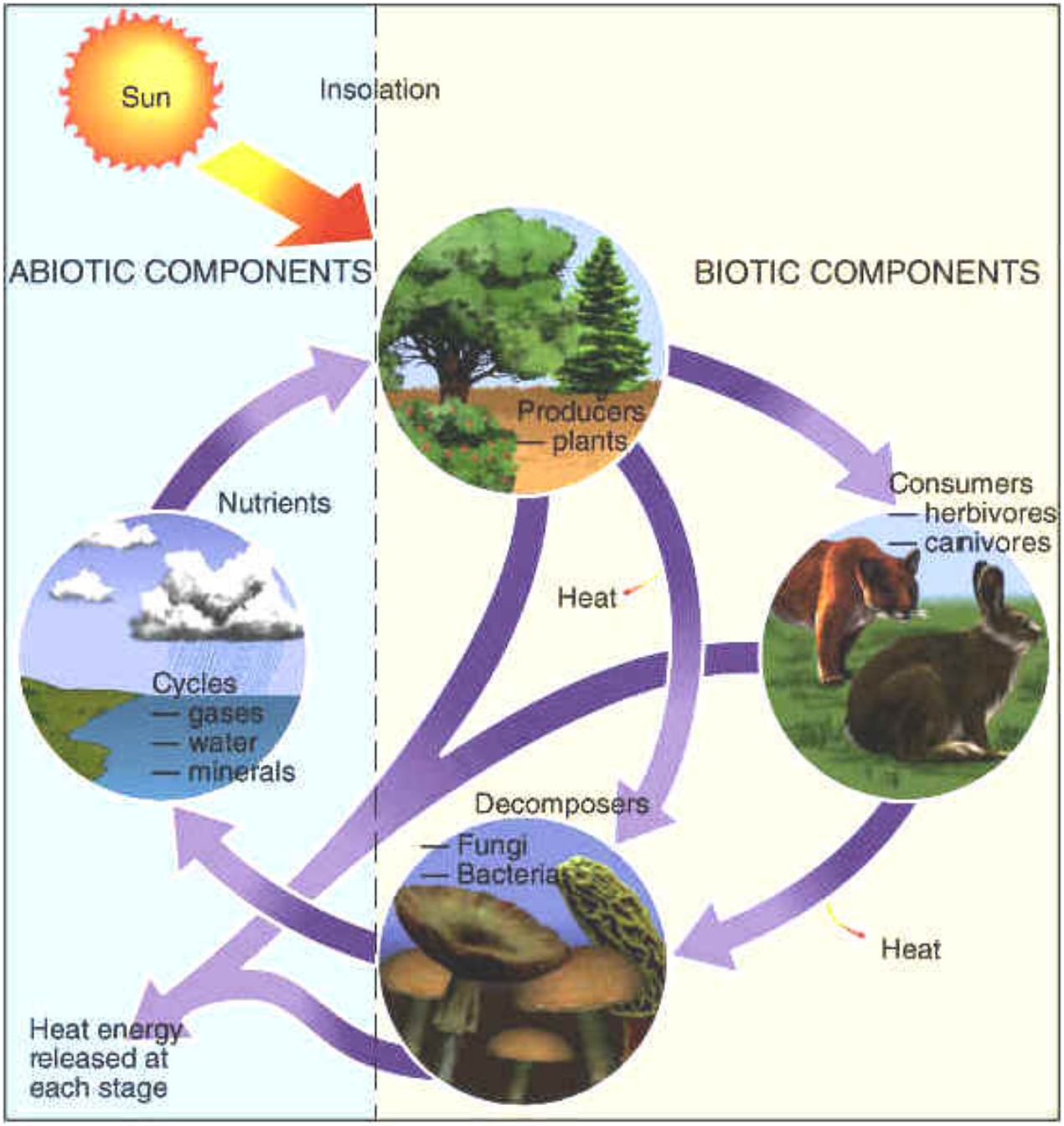
Some of the major non living components of ecosystem are

- soil,
- solar energy,
- local atmosphere,
- water

Major living components include the plants, animals and microorganisms which can be classified as

- producers,
- consumers and
- decomposers

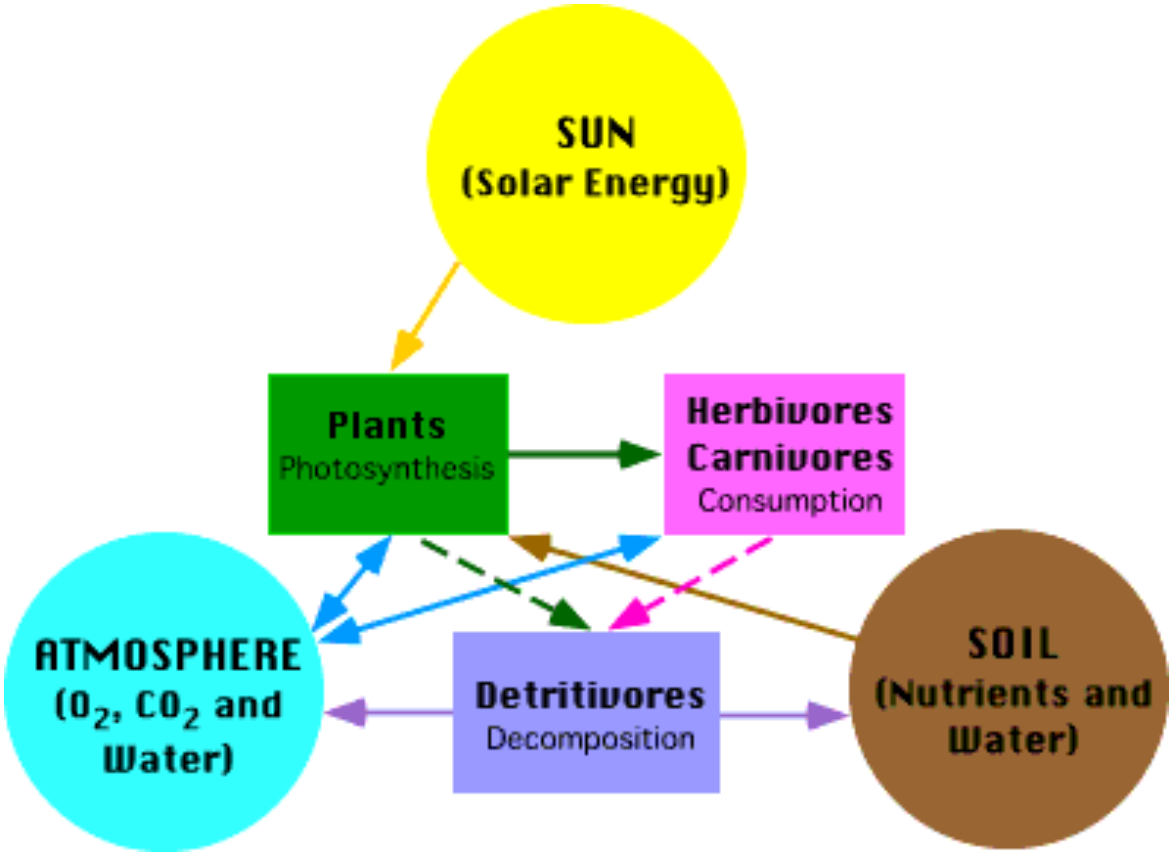

Abiotic factors
Events
(storm, flood, fire)
Nutrients
Moisture
Light
Temperature
Ecosystem
Species diversity
Food webs
Population numbers
Competition
Biomass and productivity
Biotic factors


Sun
Insolation
ABIOTIC COMPONENTS
BIOTIC COMPONENTS
Producers
— plants
Nutrients
Consumers
— herbivores
— carnivores
Heat
Cycles
— gases
— water
— minerals
Decomposers
— Fungi
— Bacteria
Heat
Heat energy
released at
each stage

Abiotic Components

- Soils contain a mixture of weathered rock fragments, minerals particles, organic matter and living organisms.
- Soils provide nutrients, water, air, a home and a structural growing medium for organisms.
- The atmosphere provides carbon dioxide for photosynthesis and oxygen for respiration for the organisms found in the ecosystem. Exchange of other essential gases also occur.
- The processes of evaporation, transpiration and precipitation are responsible for the cycling of water between the atmosphere and the earth's surface.
- Solar radiation is used in ecosystems to heat the atmosphere and to evaporate and transpire water into the atmosphere.
- Sunlight is also necessary for photosynthesis.
- Also regulates optimum temperature for favorable habitat.

- Most living tissue is composed of a very high percentage of water, up to and even exceeding 90%.
- Water is the medium by which mineral nutrients enter plants and are translocated in plants. It is also necessary for the maintenance.



Biotic Components of Ecosystem

- Producers- sometimes called autotrophs (self-feeders)- are organisms that can make their own food (the organic compounds they need as sources of energy and nutrients).

  Most producers are green plants that can manufacture their food through the process of photosynthesis.
- Consumers- or heterotrophs (other-feeders) get their energy and nutrients by feeding directly or indirectly on producers and also other organisms.

  - Plant eating animals are known as herbivores.

  - Organism that feed on herbivores known as carnivores.

  Carnivores can also consume other carnivores.

  - Consumers which feed on both plants and animals are called omnivores.
- Decomposers or detritivores, such as bacteria and fungi, decompose dead organisms. They break down organic materials into simpler inorganic compounds into soil and water where producers and other microorganisms can take them up as nutrients.

Biotic Components of Ecosystems:

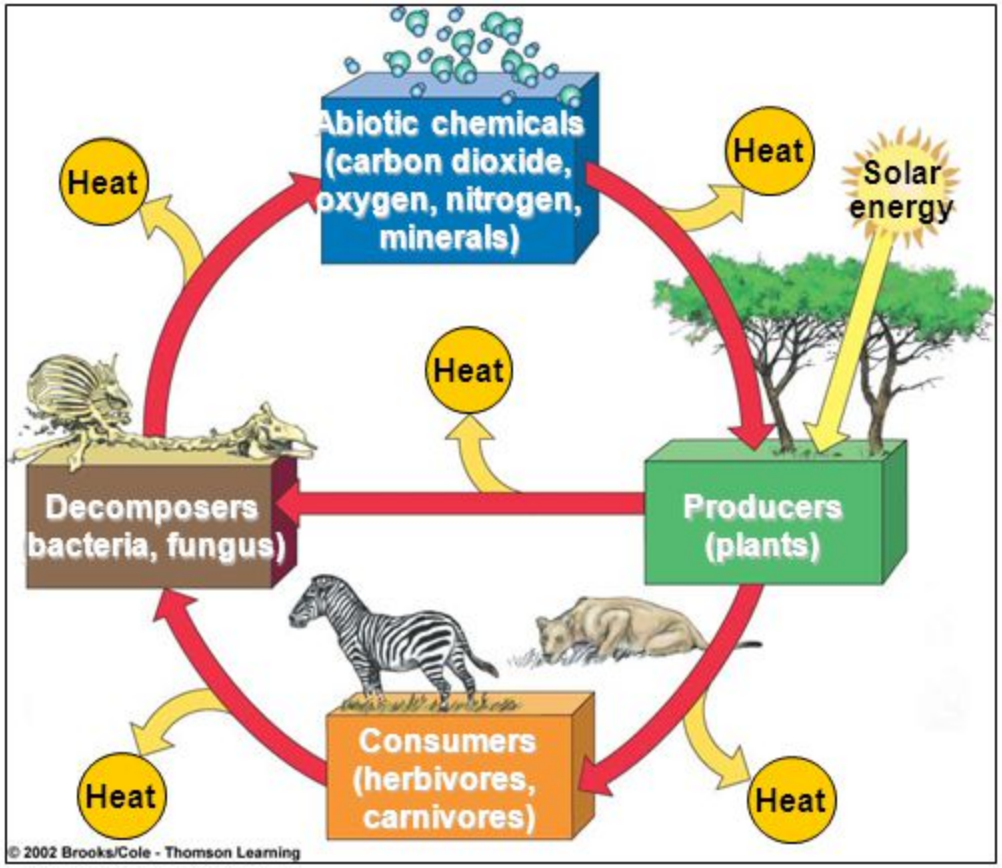
Producers (autotrophs)

-photosynthesis

Consumers (heterotrophs)

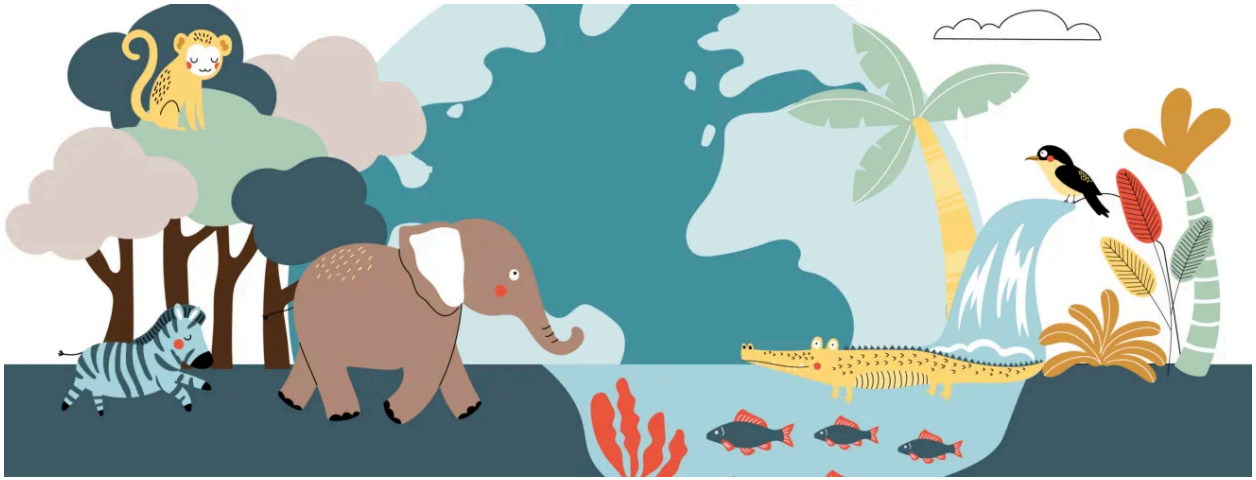
-respiration

Decomposers



Module II

Ecosystem and Biodiversity



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Food Chain and Food Web

- Food chain: simplistic representation of the feeding relationship among organisms.

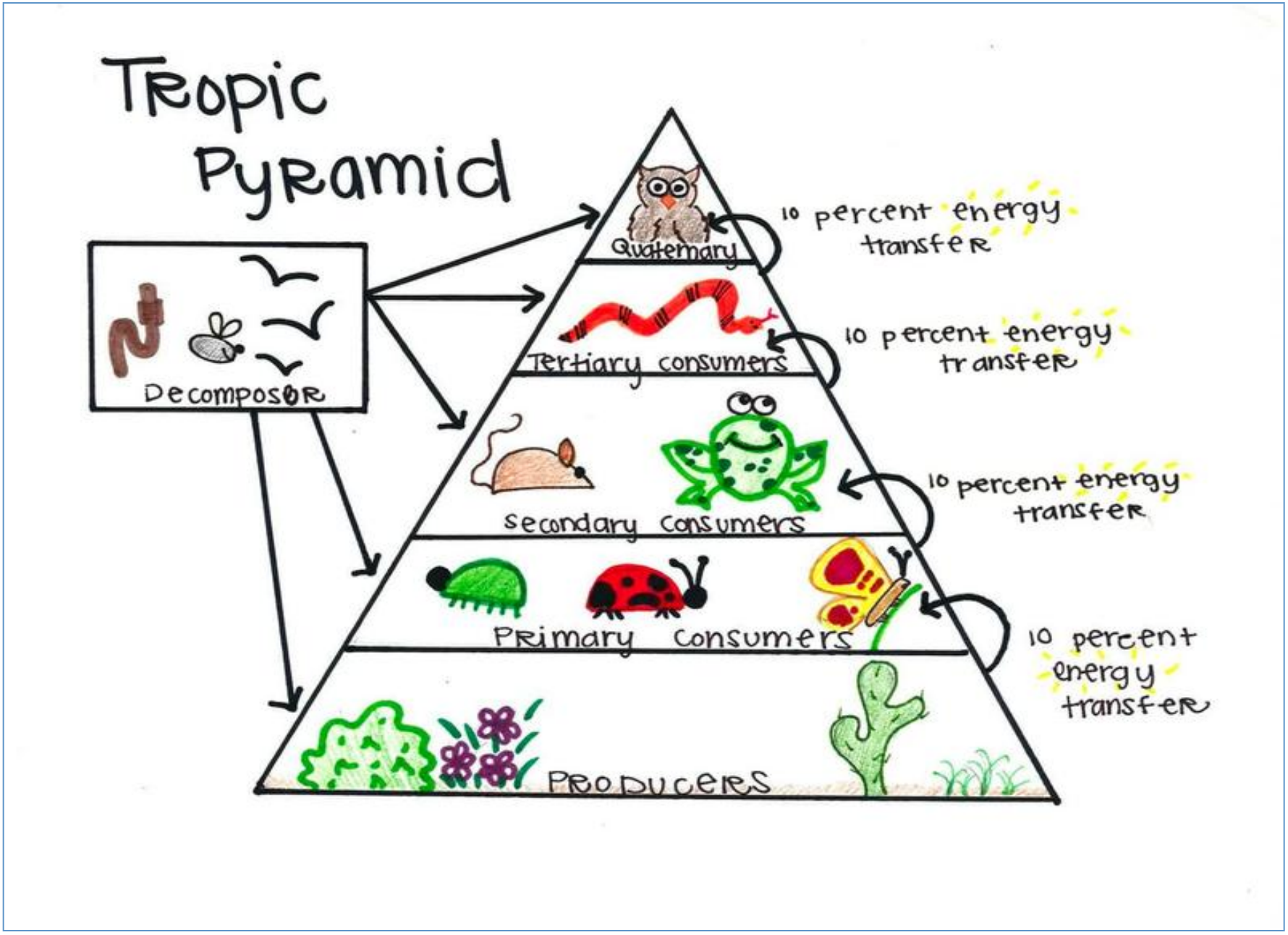
  A linear sequence of organisms, each of which serves as a source of food for the next, is called a food chain.

  It determines how energy and nutrients move from one organism to another through the ecosystem.

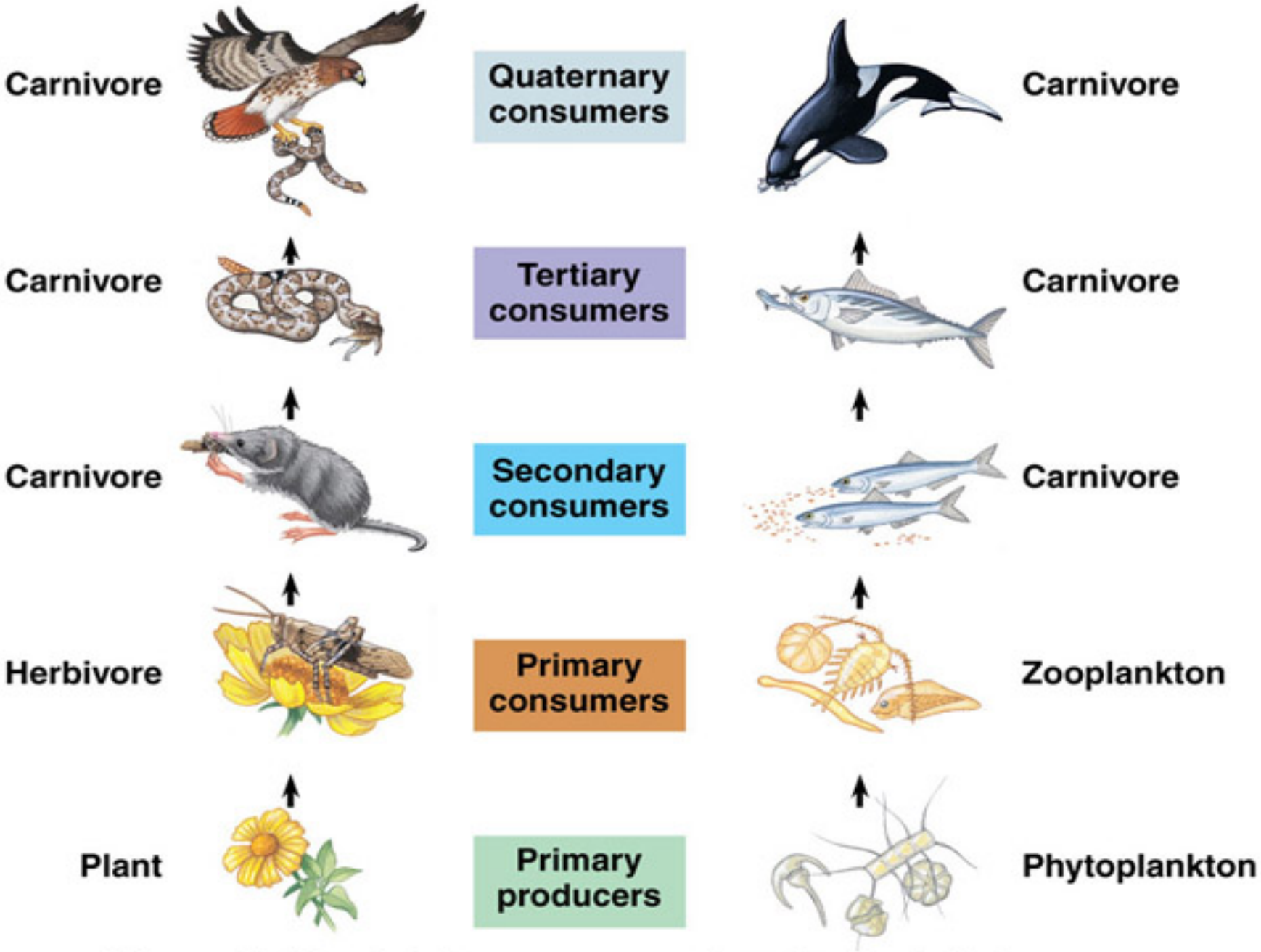
- Trophic level: Also known as feeding level. Each organism in the ecosystem is assigned to a trophic level depending on whether it is a producer or a consumer. The trophic level of an organism is the position it occupies in a food chain.

- Food web: Real ecosystems are more complex. Most consumers feed on more than one type of organism and most organisms are eaten by more than one type of consumer.

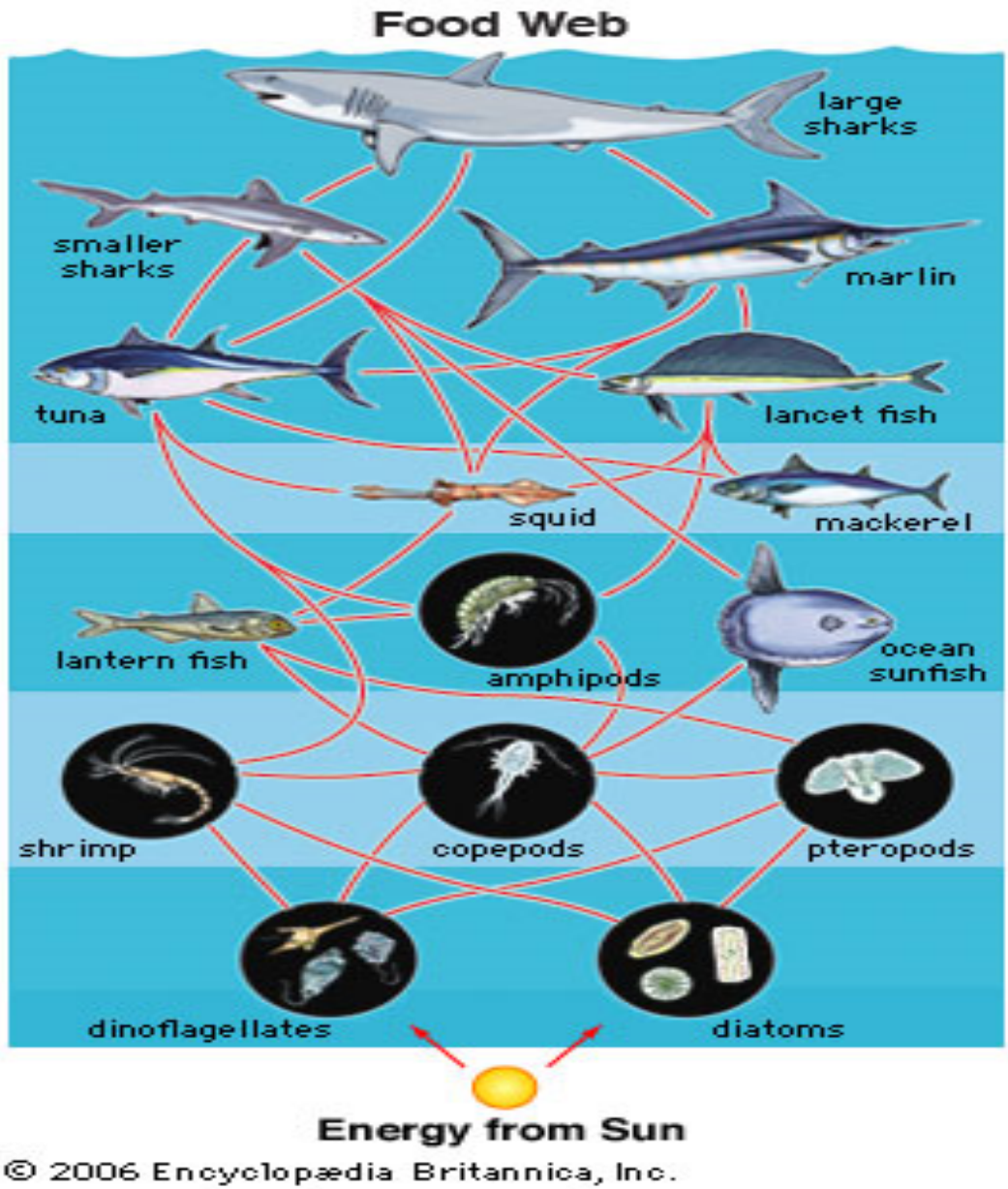
  The realistic and complex network of many interconnected food chains in the ecosystem is called a food web.

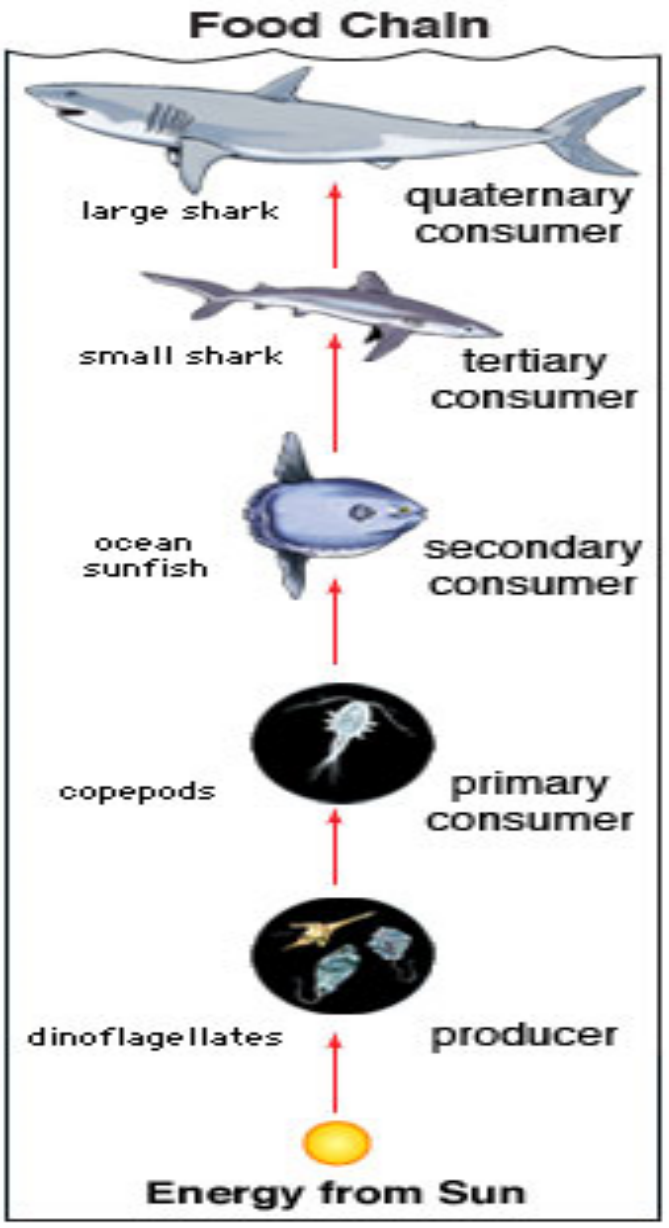


Example of a Food Chain

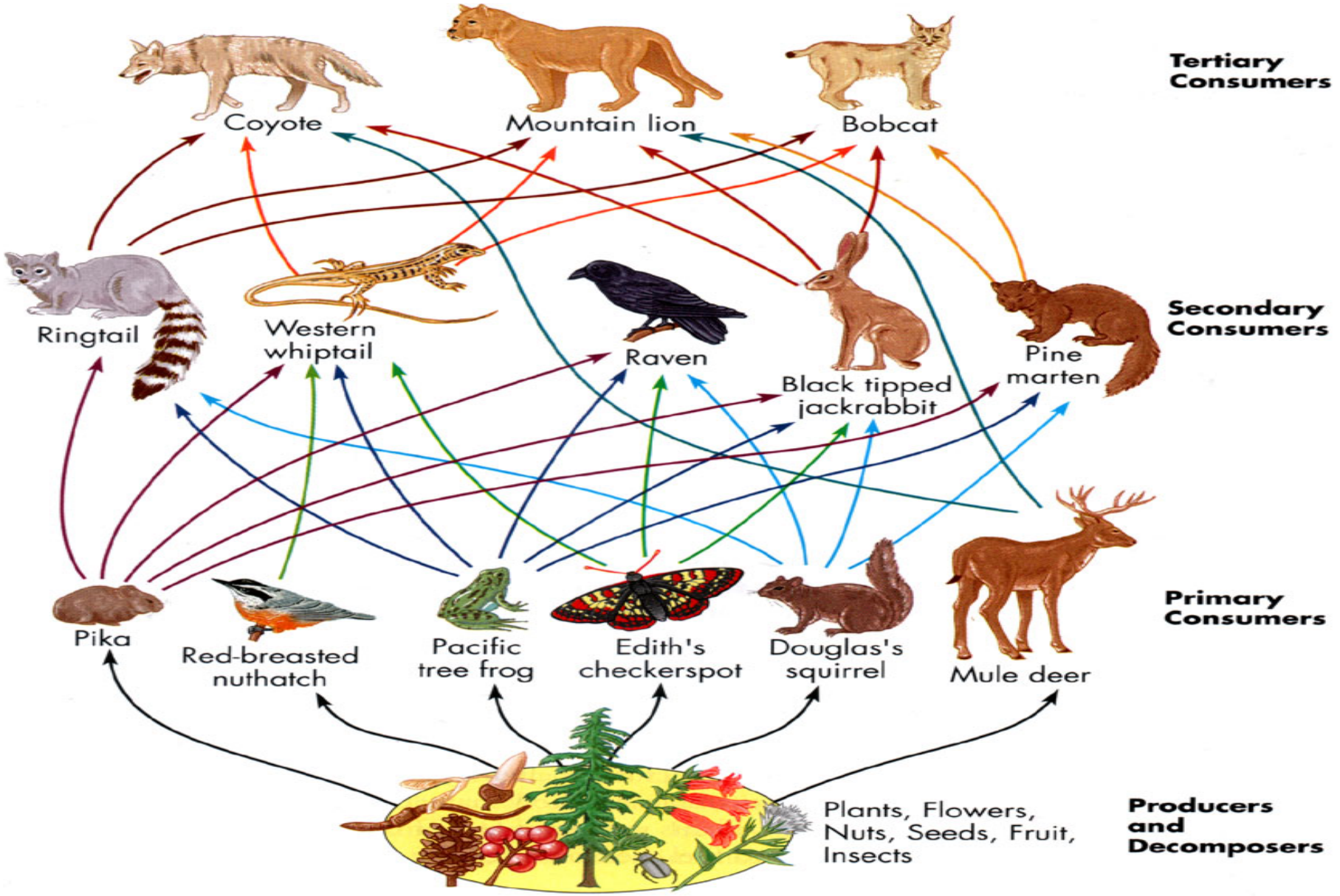


Marine food web and food chain





Terrestrial food web



Energy Pyramid

- Each trophic level in a food chain or web contains a certain amount of **biomass.** Biomass is the dry weight of all organic matter contained in its organisms. The chemical energy stored in biomass is transferred from one trophic level to another.
- There is a decrease in the amount of energy available from one trophic level to another in a food chain or web.
- The percentage of usable energy transferred as biomass from one trophic level to the next is called **ecological efficiency**. It ranges from 2-40% (that is a loss of 60-98%) depending on the types of species and ecosystem involved, but 10% is typical.
- Why energy is lost at each higher level of food chain-
  - Some of the food that organisms eat is undigested and does not provide usable energy.
  - Much of the energy that is absorbed is used in the daily processes of living or lost as heat when it is transformed from one form to another and thus isn't stored as biomass that can be eaten.

PYRAMID OF ENERGY FLOW

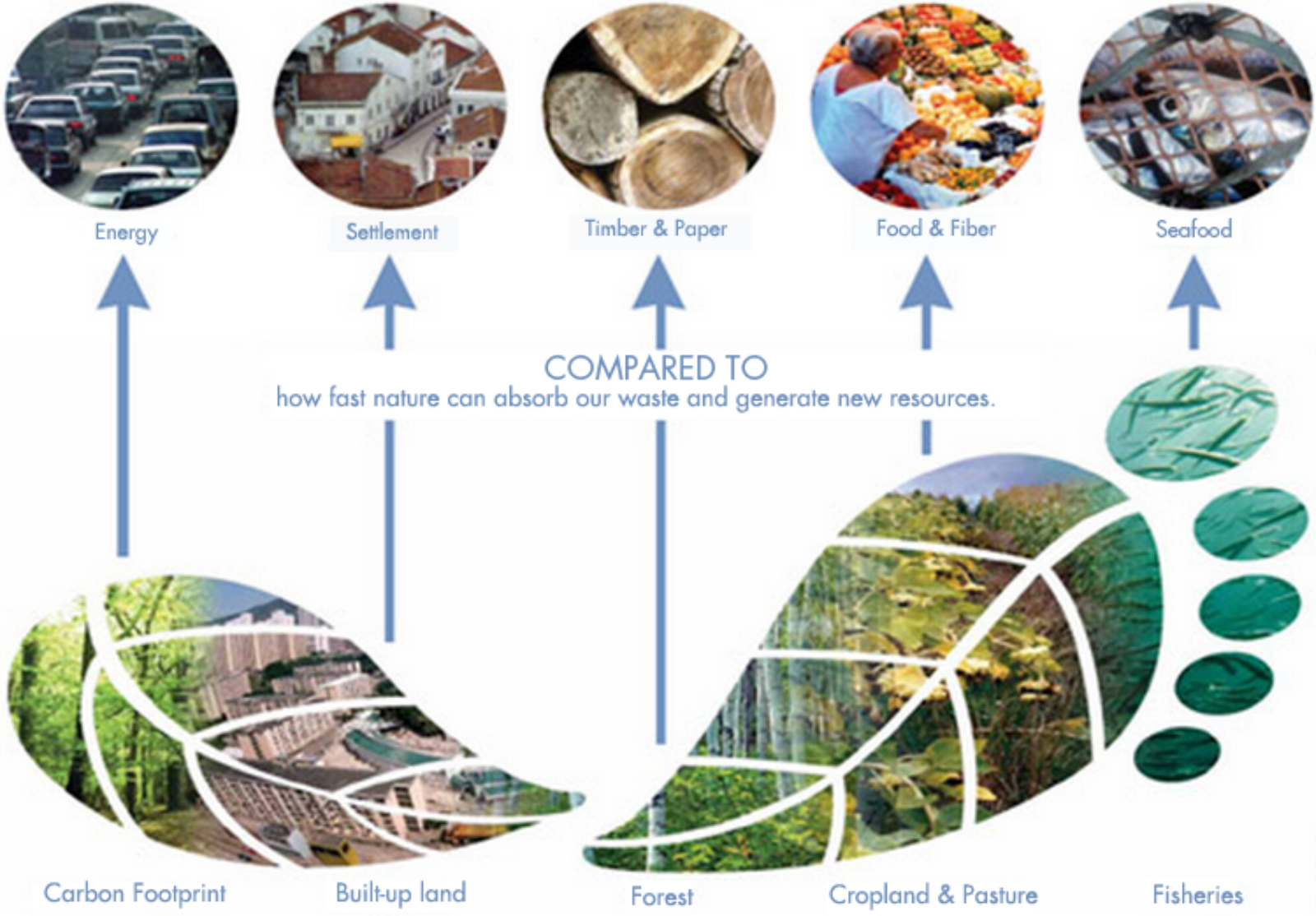
Ecological Footprint

The impact of human activities measured in terms of the area of biologically productive land and water required to produce the goods consumed and to assimilate the wastes generated.

The Ecological Footprint

MEASURES

how fast we consume resources and generate waste



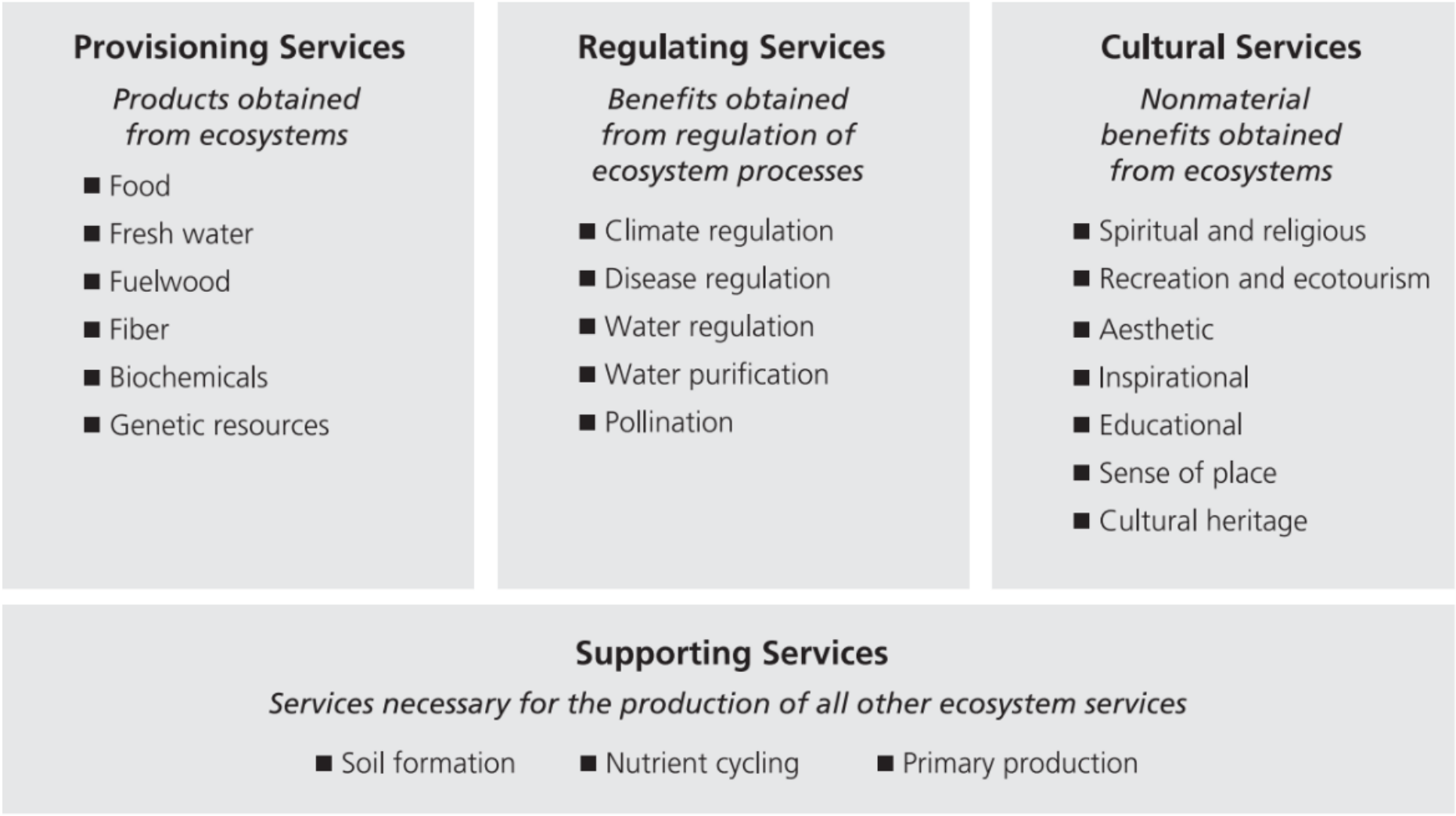
ECOLOGICAL FOOTPRINTS

WHAT IS YOUR FOOTPRINT?

Ecosystem services

Ecosystem services are the benefits people obtain from ecosystems.

These include **provisioning services** such as food and water; **regulating services** such as regulation of floods, drought, land degradation, and disease; **supporting services** such as soil formation and nutrient cycling; and **cultural services** such as recreational, spiritual, religious and other nonmaterial benefits.


Provisioning Services
Products obtained from ecosystems
Food
Fresh water
Fuelwood
Fiber
Biochemicals
Genetic resources
Regulating Services
Benefits obtained from regulation of ecosystem processes
Climate regulation
Disease regulation
Water regulation
Water purification
Pollination
Cultural Services
Nonmaterial benefits obtained from ecosystems
Spiritual and religious
Recreation and ecotourism
Aesthetic
Inspirational
Educational
Sense of place
Cultural heritage
Supporting Services
Services necessary for the production of all other ecosystem services
Soil formation
Nutrient cycling
Primary production

BIODIVERSITY

Biodiversity

Refers to the incredible variety of life found in our planet.

Specifically, biodiversity refers to the number, variety and variability of all life forms on earth. These include millions of plants, animals and micro-organisms, the genes they contain and the intricate ecosystems of which they are a part.

Three **kinds** of diversity –

Genetic diversity: different genes & combinations of genes within populations.

Species diversity: describes the number of different kinds of organisms within individual communities.

✓Species richness: the total number of species
✓Species evenness: the relative abundance of species
✓Species dominance: the most abundant species

Ecological diversity : assesses the richness & complexity of a biological community

-different habitats, niches, species interactions

- **How many species are there:**
  - Over 100 million
  - Only 1.8 million named
  - Between 150 to 200 species become extinct every day!

Extinction-

- elimination of a species
- Normal process of natural world
- In undisturbed ecosystem rate is about one species lost every decade
- Human impacts have accelerated that rate causing hundreds or perhaps thousands of species, subspecies & varieties to become extinct every year.

- **Species extinction due to**
  - Destruction of habitat
  - Expansion of cities
  - Deforestation
  - Pollution
  - Global warming (20-30% species are at risk)
  - Introduction of Invasive species

Biological Evolution

Refers to the change in inherited characteristics of a population from generation to generation.

New species arise as a result of:

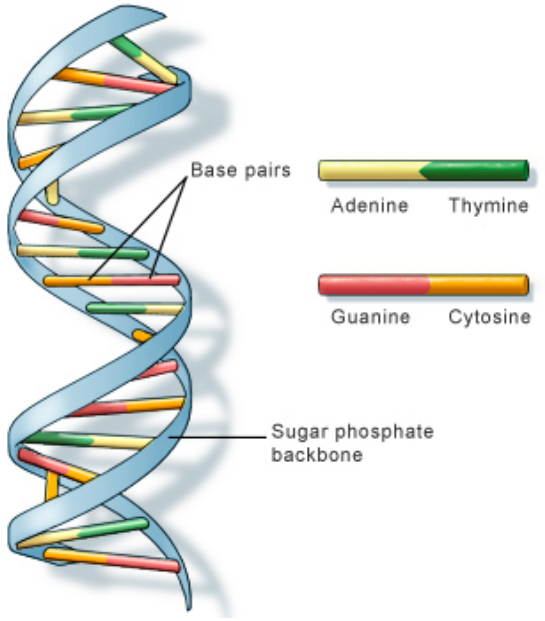
- ✓Competition for resources
- ✓Difference among individuals in their adaptations to environmental conditions

Four processes lead to evolution

- ❑Mutation
- ❑Natural selection
- ❑Migration
- ❑Genetic drift

Mutation

- ✓ Genes, contained in chromosomes within cells, are inherited - passed from generation to generation.
- ✓ Genes are composed of DNA (Deoxyribo Nucleic Acid)
- ✓ The information in DNA is stored as a code made up of four chemical bases: Adenine (A), Guanine (G), Cytosine (C), and Thymine (T)
- ✓ How these letters combined in long strands determine the "message" it inherits.



- ✓ When a new cell divides, DNA is reproduced so that each new cell gets a copy. If there is an error in this process, can change DNA structure thus the inherited characteristics.

- ✓ External environmental factors like radiation, toxicity can also cause for such abnormality in cell reproduction

- ✓ When DNA changed due to any of the reasons, it is said to have undergone Mutation

- ✓ A mutation is a permanent change in the DNA sequence of a gene.
- ✓ Offspring from mutation:
  - Sometimes they cannot survive
  - Sometime add new varieties
  - Sometimes so changed and different from parents that it can be considered as a new species

Natural selection

- ✓ "Survival of the fittest"
- ✓ When there is variation within species, some individuals may be better suited to the environment than others and flourish in offspring.
- ✓ Especially, to adjust or adapt to new environment, such capability of organism is important.
- ✓ If natural selection takes place for long time, a number of characteristics of a species can be changed significantly.
- ✓ Four primary characteristics
  - Genetic variability
  - Environmental variability
  - Differential reproduction that varied with the environment
  - Influence of the environment on survival and reproduction

Migration

- ✓ Migration, either direct or just the seed is moved by wind, birds etc and landed at a new environment.
- ✓ The separated portion of the species will try to survive through natural selection.
- ✓ Especially, if they are separated geographically for long time, they can be changed significantly.
- ✓ Natural selection, combined with migration can produce new species, which can be completely different from their ancestors.

Genetic drift

- ✓ Refers to change in the frequency of a gene in a population as a result of chance rather than mutation, selection or migration
- ✓ Chance may determine which individuals become isolated in a small group from a larger population and thus which genetic characteristics are changed.
- ✓ The individuals may be better, poorly or neutrally adapted to the environment
  - Example: bighorn sheep live in a mountains of the southwestern desert of US
  - Before human settlement, they could migrate and move freely
  - With human settlement on that region, many population of bighorn sheep have become isolated and that cause problem to their survival.

Ecological Niche

- ✓ A **niche** (French word nicher which means 'to nest') is the match of a species to a specific environmental condition. It describes how an organism or population responds to the distribution of resources and competitors and how it in turn alters those same factors.

- ✓ Ecological Niche: Role of certain species play in its ecosystem.

- ✓ Niche includes:
  - Range of tolerance, like temperature/water availability
  - Resource use: food/nutrition
  - How it interacts with others like search for food
  - Role play in energy and nutrient cycling

- ✓ Fundamental Niche: the actual range of Niche

- ✓ Realized Niche: Niche after compromising with other competing species

Ecological Niche

Broad and narrow Niche:

- Generalist species/ broad niches: can survive on varieties of food and environmental conditions. Suitable where there are huge diversity or fluctuation in environmental conditions. Human, cockroach, rats etc.

- Specialized species/Narrow Niches: can tolerate narrow range of climatic and environmental condition. Polar bear, panda etc. Good for suitable environment but bad for places with fluctuations.

- Sometime best utilization of resources for broad Niches.

Competitive Exclusion Principle

Two species that have exactly the same requirements cannot coexist in exactly the same habitat.

- Example: British Red Squirrel and American Grey Squirrel

Terms related to Species Habitat

- ✓ Exotic species: a species introduced into new geographic area
- ✓ Endemic species: a species that is native
- ✓ Cosmopolitan species: a species with a broad distribution, occurring all over the world wherever the environment is appropriate. Example: house mouse
- ✓ Ubiquitous species: species that are found almost anywhere.
- ✓ Interaction between species:
  - Competition: usually outcome is negative for both
  - Symbiosis: benefits both
  - Predation-parasitism: benefits one affect another

Environmental factors that influence diversity

A. Factors that tend to increase diversity

- A physically diverse habitat
- Moderate amounts of disturbance (fire or storm)
- A small variation in environmental condition (temperature, precipitation etc.)
- High diversity at one trophic level increase the diversity at another trophic level
- An environment highly modified by life (exp. Rich organic soil)
- Middle stage of succession
- Evolution

B. factors that tend to decrease diversity

- Environmental stress
- Extreme environments (conditions near to limit of what living things can withstand)
- A severe limitations in the supply of essential resources
- Extreme amount of disturbance
- Recent introduction of exotic species (species from other area)
- Geographic isolation.

Importance of biodiversity

- At least 40% of the world's economy and 80% of the needs of poor are derived from the biological resources.

- The greater opportunity for medical discoveries, economic development and adaptive response to such new challenges as climate change.

- The natural environment provides the basic conditions without which humans could not survive. We need to breathe, eat, drink and shelter ourselves and we get all these from the natural world.

A. Ecological importance

- ✓ Trees provide habitat and food for birds, insects, other plants and animals, fungi and micro-organism
- ✓ Birds, insects and other animals serve as pollinators
- ✓ Parasites and predators act as natural population controls
- ✓ Various organisms, such as earthworms and bacteria are responsible for recycling organic materials and maintaining the productivity of the soils
- ✓ Green plants remove carbon dioxide from the atmosphere and replenish it with oxygen. Forests are particularly important "sinks" for the absorption of carbon dioxide and these are the key factors in reducing global climate change.

- ✓ Wetland serves as sponges to reduce the impacts of flood and to cleanse streams by filtering sediments, nutrients & contaminants from inflowing waters.

- ✓ The interaction of all these natural processes forms a complex web of life. If any part of the web suffers to break downs, the future of the other parts is threatened. Humans are in many cases degrading and destroying the ability of the biological diversity to perform the services mentioned above.

B. Economical importance

- ✓ Food: species are hunted, fished, gathered, as well as cultivated for agriculture and aquaculture.
- ✓ Fuel: timber and coal are only two examples of natural resources used to produce energy
- ✓ Shelter and cloth: timber and other forest products are used as building materials for shelter. Fibers such as wool and cotton are used to make clothes
- ✓ Medicines: both traditional and processed drugs are obtained from biodiversity
- ✓ Other goods: paper and pencils come from raw materials provided by earth's diversity

C. Cultural and Aesthetic

- ✓ Plants and animals are often used as symbols, for example in flags, paintings, sculptures, photographs, stamps and legends.

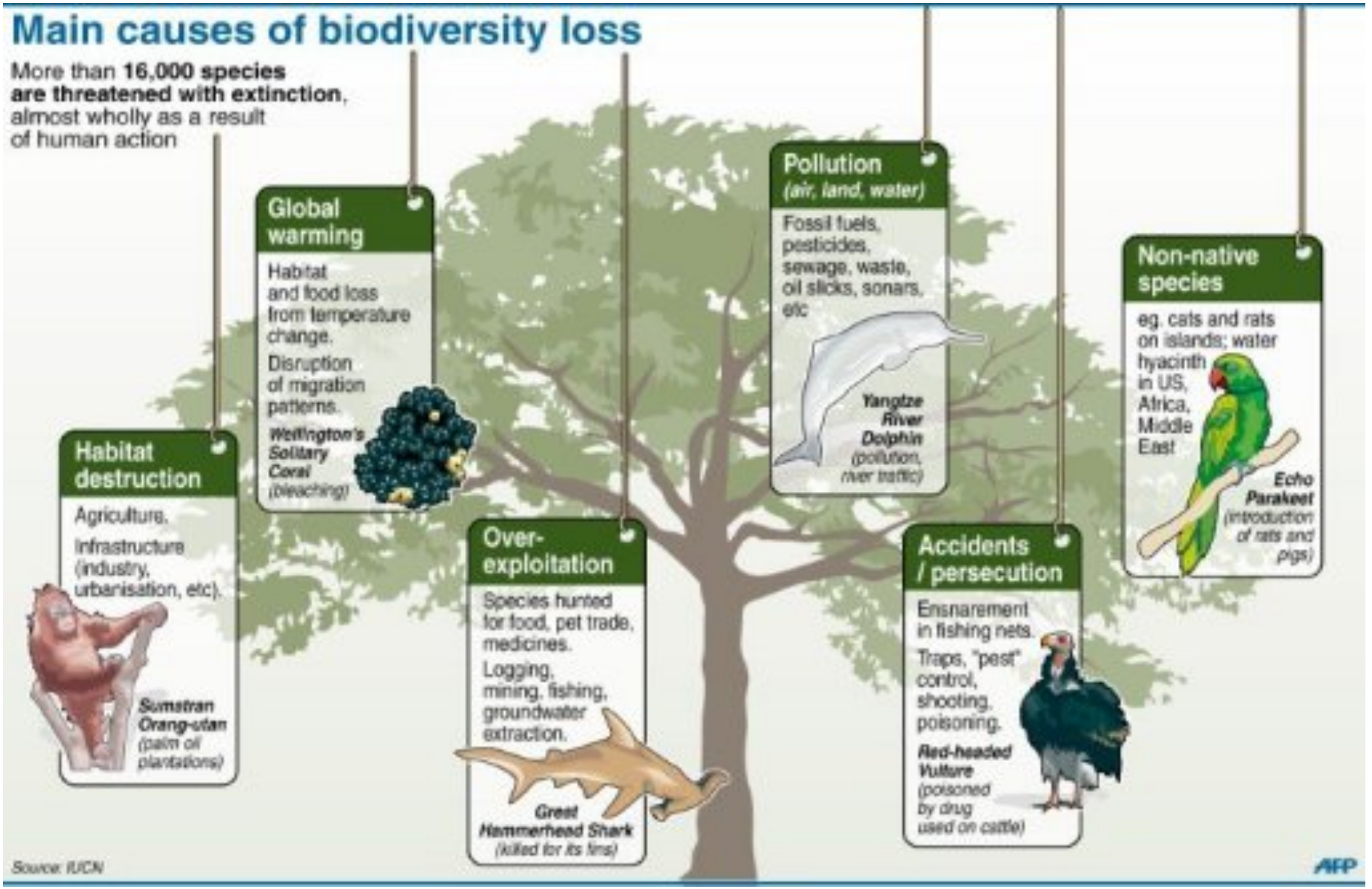
- ✓ Biodiversity is also beautiful; it is a pleasure to see and smell flowers in a field, to listen to birds singing etc.

- ✓ Each and every living being in this earth has some role to play and has the right to exist irrespective of its usefulness to human.

Human impact on biodiversity : Loss of biodiversity : causes and consequences

- Unplanned development and habitat destruction
- Changing agricultural and forestry practices
- Invasion by introduced species
- Over-exploitation for commercial gain
- Environmental pollution
- Global climate change
- Nature of legal systems
- Nature of management systems
- International trade
- Growing demands

Loss of biodiversity: causes and consequences



Conserving/Preserving biodiversity

- National conservation strategies
- Community participation in biodiversity conservation
- International conservation strategies