Environmental Science (CHY1002)

Dr. Ganesh Babu S

Assistant Professor

Department of Chemistry

School of Advanced Sciences

Vellore Institute of Technology

ganeshbabu.s@vit.ac.in

Environmental Sciences

Module:1	**Environment and Ecosystem**	**7 hours**	**SLO: 1, 5, 12,14**
Key environmental problems, their basic causes and sustainable solutions. IPAT equation. Ecosystem, earth – life support system and ecosystem components; Food chain, food web, Energy flow in ecosystem; Ecological succession- stages involved, Primary and secondary succession, Hydrarch, mesarch, xerarch; Nutrient, water, carbon, nitrogen, cycles; Effect of human activities on these cycles.			
Module:2	**Biodiversity**	**6 hours**	**SLO: 1,5,11, 12,15**
Importance, types, mega-biodiversity; Species interaction - Extinct, endemic, endangered and rare species; Hot-spots; GM crops- Advantages and disadvantages; Terrestrial biodiversity and Aquatic biodiversity – Significance, Threats due to natural and anthropogenic activities and Conservation methods.			
Module:3	**Sustaining Natural Resources and Environmental Quality**	**7 hours**	**SLO: 1,2,3,5,8, 12, 13,14,20**
Environmental hazards – causes and solutions. Biological hazards – AIDS, Malaria, Chemical hazards- BPA, PCB, Phthalates, Mercury, Nuclear hazards- Risk and evaluation of hazards. Water footprint; virtual water, blue revolution. Water quality management and its conservation. Solid and hazardous waste – types and waste management methods.			

Environmental Sciences

Module:4	**Energy Resources**	**6 hours**	**SLO: 2,3,4,8,11, 12, 13,16**
Renewable - Non renewable energy resources- Advantages and disadvantages - oil, Natural gas, Coal, Nuclear energy. Energy efficiency and renewable energy. Solar energy, Hydroelectric power, Ocean thermal energy, Wind and geothermal energy. Energy from biomass, solar-Hydrogen revolution.			
Module:5	**Environmental Impact Assessment**	**6 hours**	**SLO: 1, 2, 9,17,19**
Introduction to environmental impact analysis. EIA guidelines, Notification of Government of India (Environmental Protection Act – Air, water, forest and wild life). Impact assessment methodologies. Public awareness. Environmental priorities in India.			
Module:6	**Human Population Change and Environment**	**6 hours**	**SLO: 2,11,16,17, 19,20**
Urban environmental problems; Consumerism and waste products; Promotion of economic development – Impact of population age structure – Women and child welfare, Women empowerment. Sustaining human societies: Economics, environment, policies and education.			
Module:7	**Global Climatic Change and Mitigation**	**5 hours**	**SLO: 1,2,3, 12, 13,14,20**
Climate disruption, Green house effect, Ozone layer depletion and Acid rain. Kyoto protocol, Carbon credits, Carbon sequestration methods and Montreal Protocol. Role of Information technology in environment-Case Studies.			

Environmental Science - CHY1002

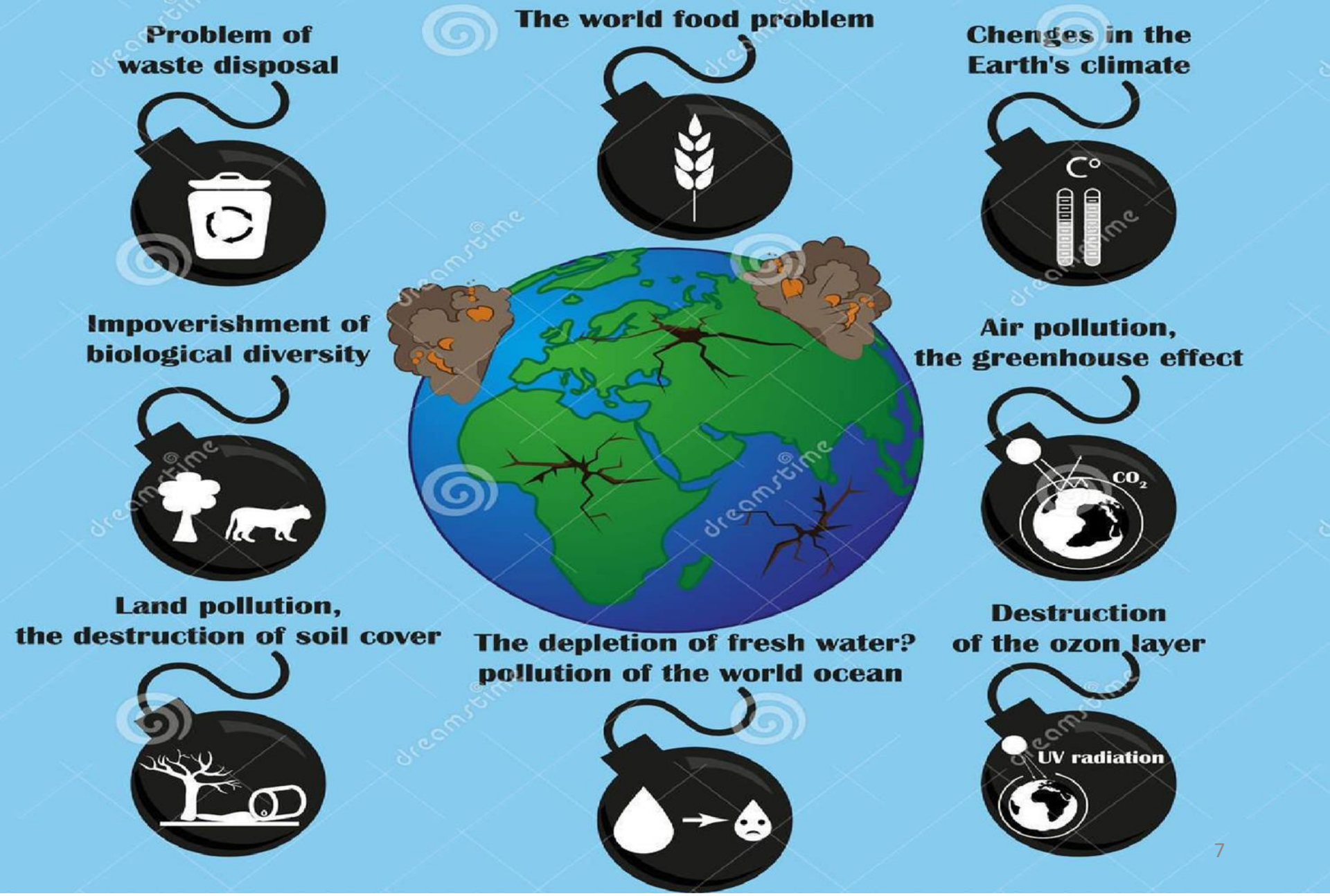
Module - 1

Environment and Ecosystem

Environment and Ecosystem

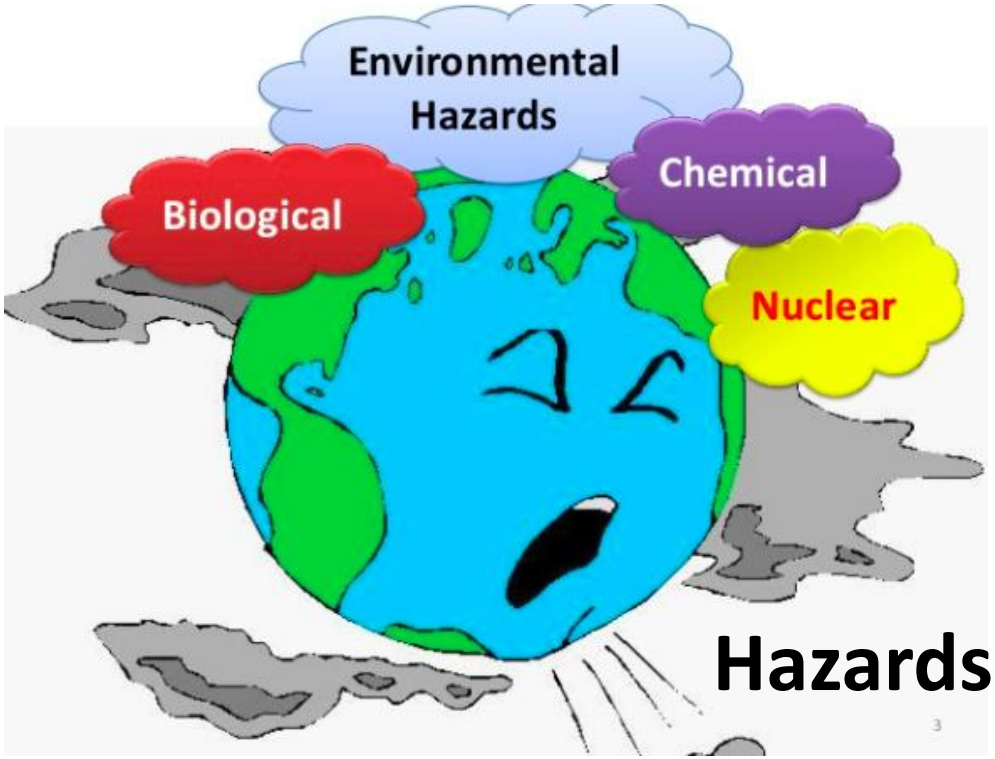
- Key environmental problems, their basic causes and sustainable solutions
- IPAT equation
- Ecosystem, earth – life support system and ecosystem components
- Food chain, food web, Energy flow in ecosystem
- Ecological succession – stages involved, Primary and secondary succession, Hydrarch, mesarch, xerarch
- Nutrient, water, carbon, nitrogen, cycles; Effect of human activities on these cycles

Global environmental problems



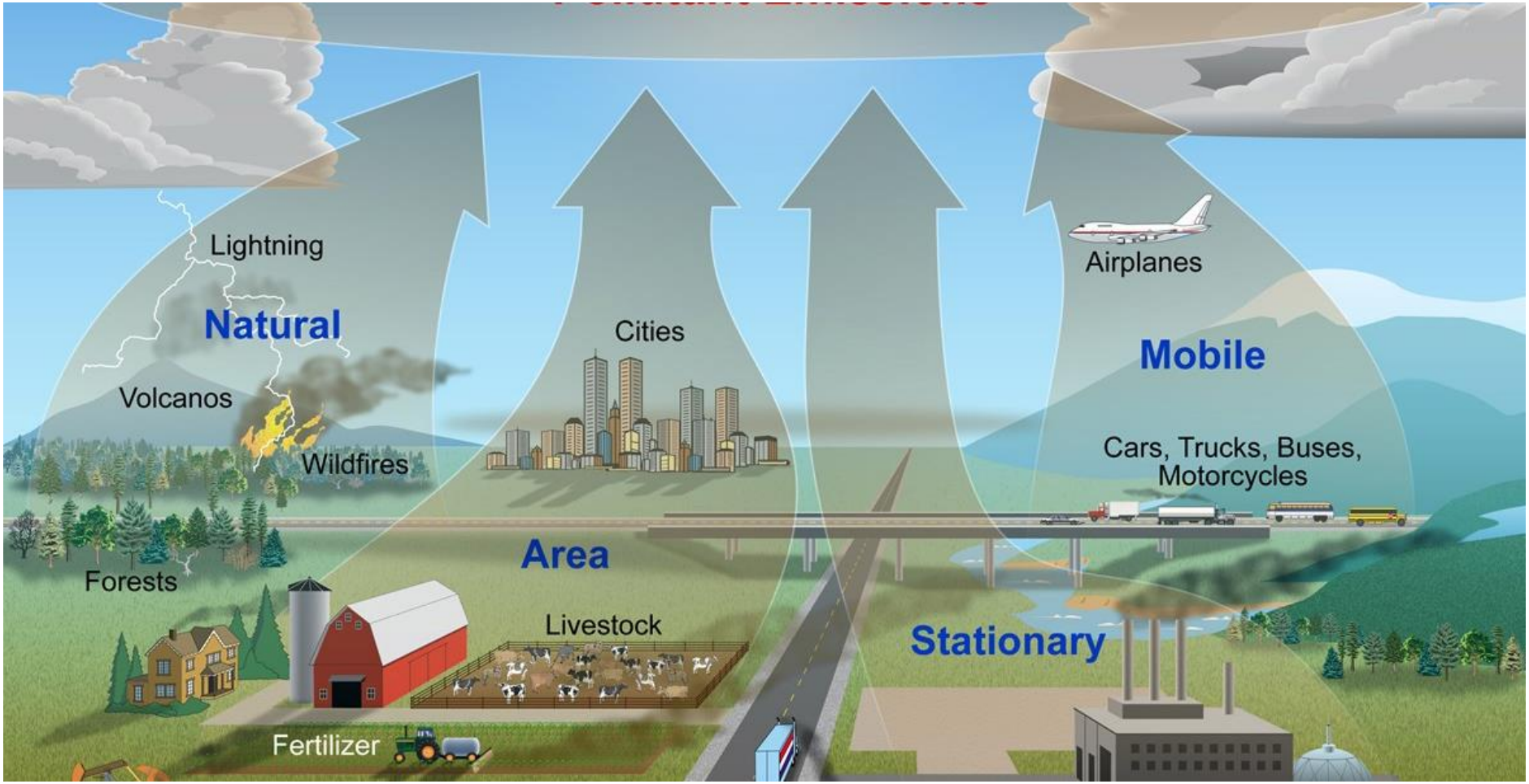
Key environmental problems

- A **hazard** is any agent that can cause harm or damage to humans, property, or the environment.

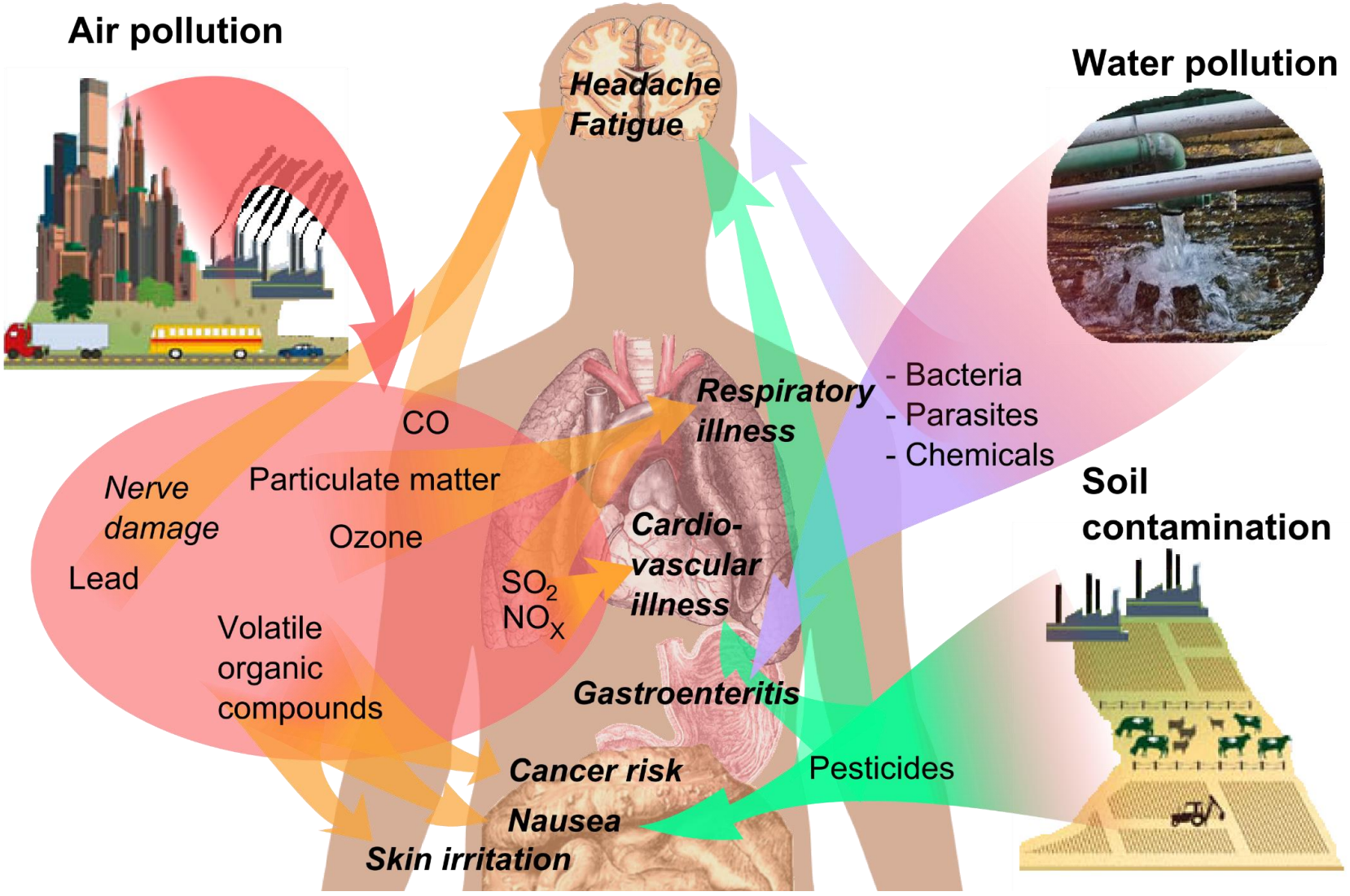


- **Hazard** - Something which has the potential to cause harm

Key environmental problems



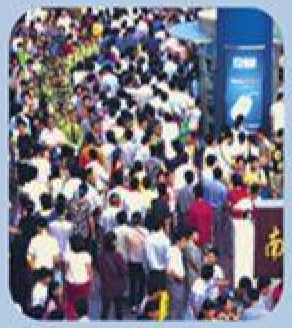
Health effect of pollution



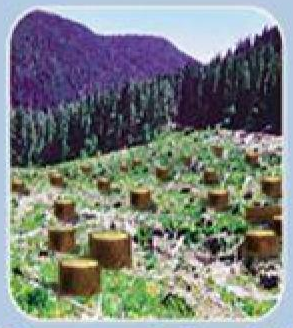
Experts Have Identified Four Basic Causes of Environmental Problems

1. Population growth
2. Wasteful and unsustainable resource use
3. Poverty
4. Failure to include the harmful environmental costs of goods and services in market prices

Causes of Environmental Problems



Population growth

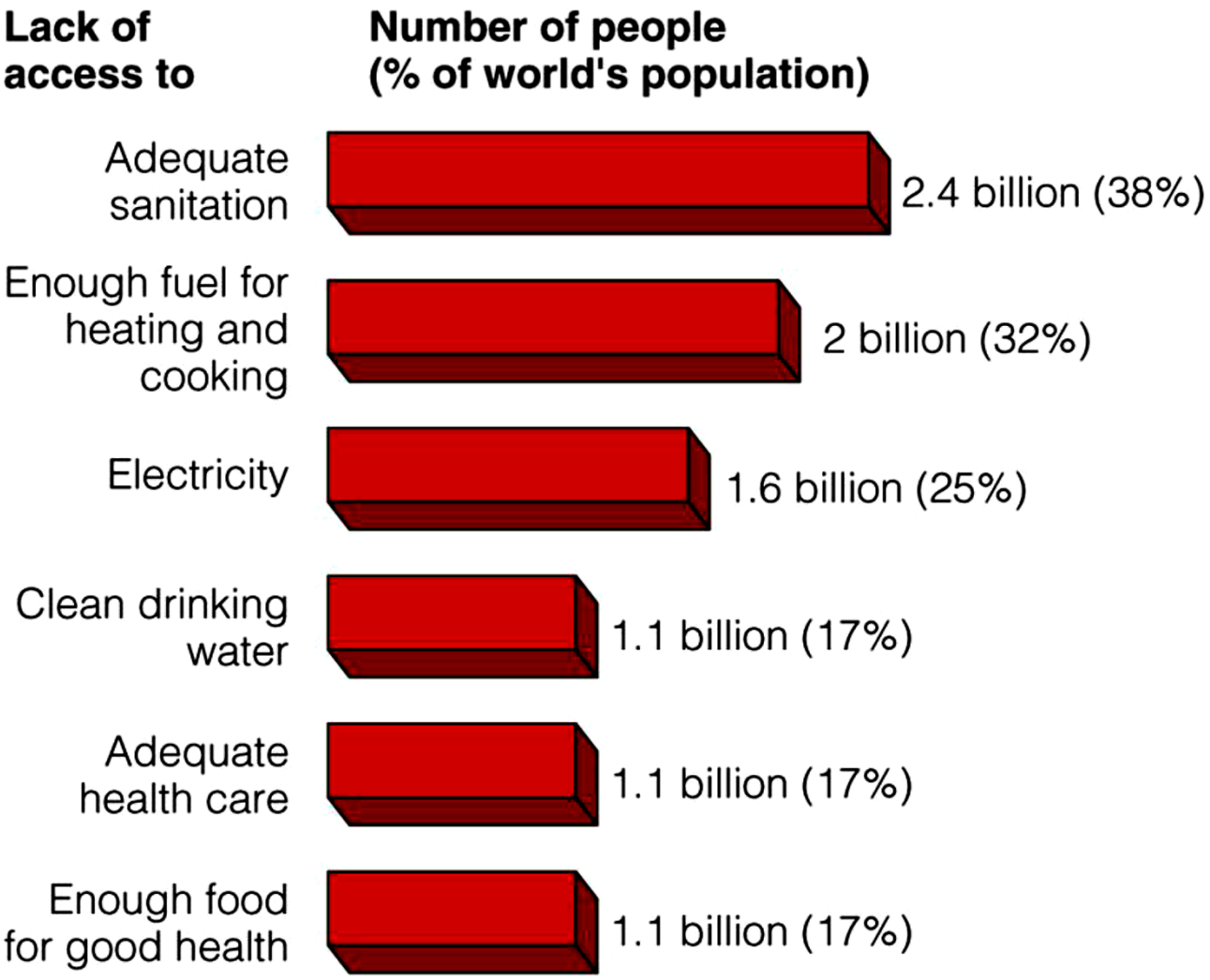


Unsustainable resource use

Poverty

Excluding environmental costs from market prices

Lack of access



Sustainable development

- **Sustainable development** is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Sustainable development

Key environmental problems and their basic causes

Our lives and economies depend on Sun's energy and on the natural resources and services (natural capital) provided by the Earth.

1. What is an environmentally sustainable society?

It means living off the Earth's natural income without consuming or degrading the natural capital that supplies it.

2. Why do we have environmental problems?

Due to excessive population growth and its associated pollution and poverty issues. Wasteful/unsustainable use of Earth's resources.

3. What are the remedial measures to combat environmental problems?

Population control, Forest conservation, Imposition of environmental tax, etc. We can live more sustainably by relying more on solar energy, preserving biodiversity, and not disrupting the earth's natural chemical-recycling processes.

Key environmental problems and their basic causes

4. Define natural capital, natural resources , and natural services:

- **Natural capital** is the **natural resources and natural services** that keep us and other forms of life alive and support our economies.
- ✓ **Natural resources** are materials and energy in nature that are essential or useful to living organisms. These resources are often classified as renewable (such as air, water, soil, plants, and wind) or nonrenewable (such as copper, oil, and coal).
- ✓ **Natural services** are processes in nature such as purification of air and water, which support life and human economies.

Sustainable Solutions

- Using renewable energy resources & Refining the existing technologies to utilize resources properly
- Conserving biodiversity
- Reducing impacts on natural chemical cycles
- Proper management of resources

IPAT Equation

- I = PAT is the mathematical notation of a formula put forward to describe the impact of human activity on the environment

$$I = P \times A \times T$$

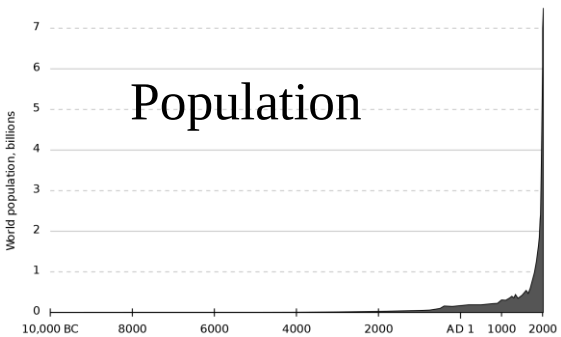
where;

I = human impact on the environment (which is a product of three factors)

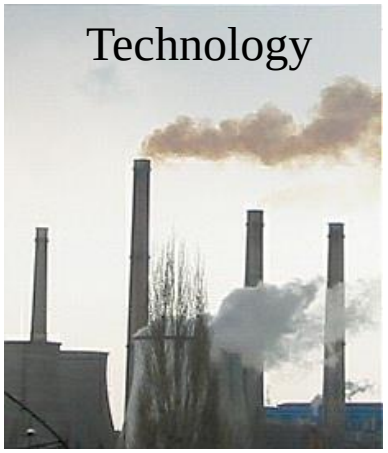
P = population

A = affluence

T = technology



Affluence (wealth)



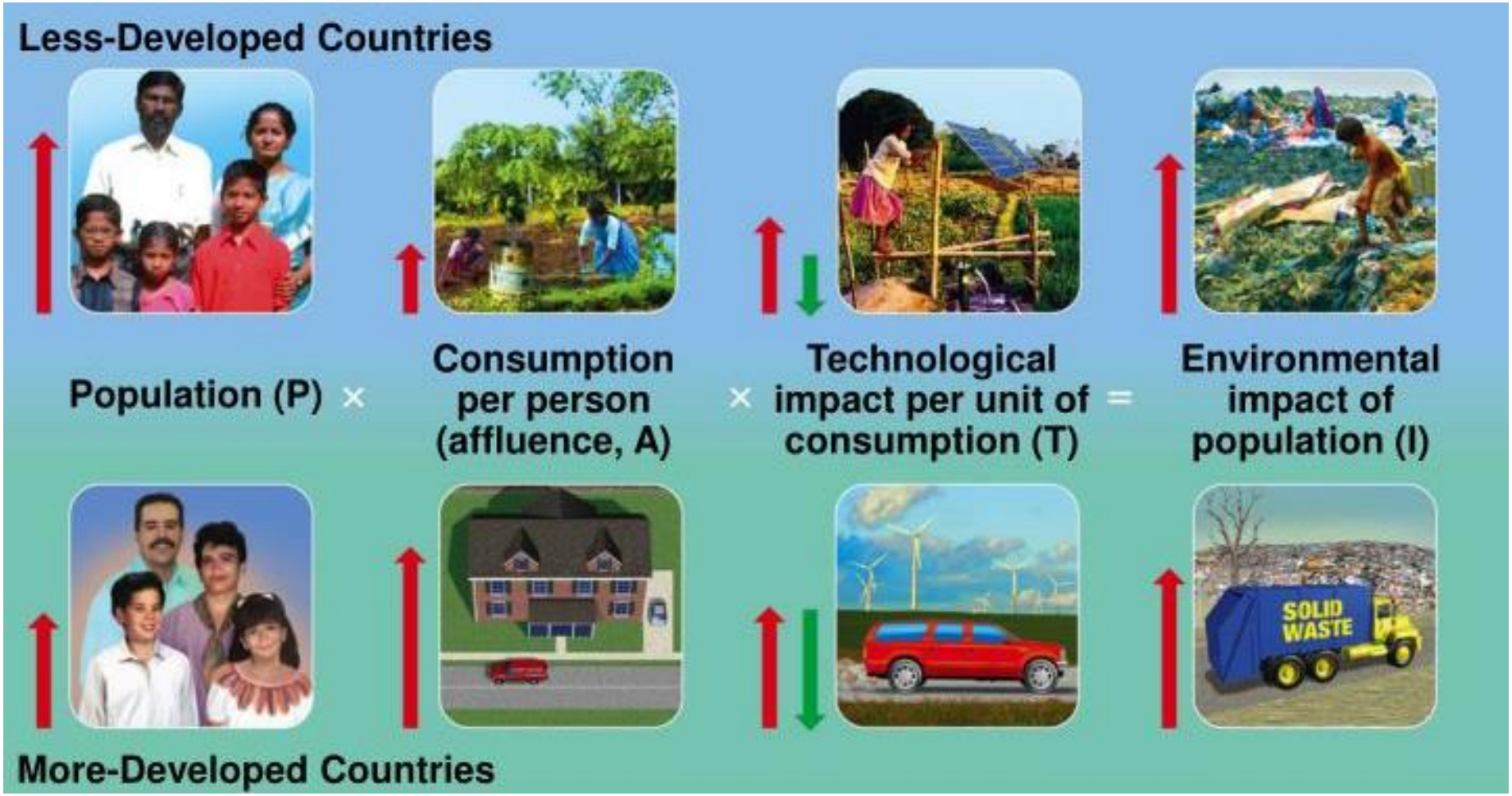
IPAT Equation

- The IPAT equation is a widely used simplification of the factors causing environmental degradation.
- It is crucial to remember that the three factors are intermediate causes, not root causes

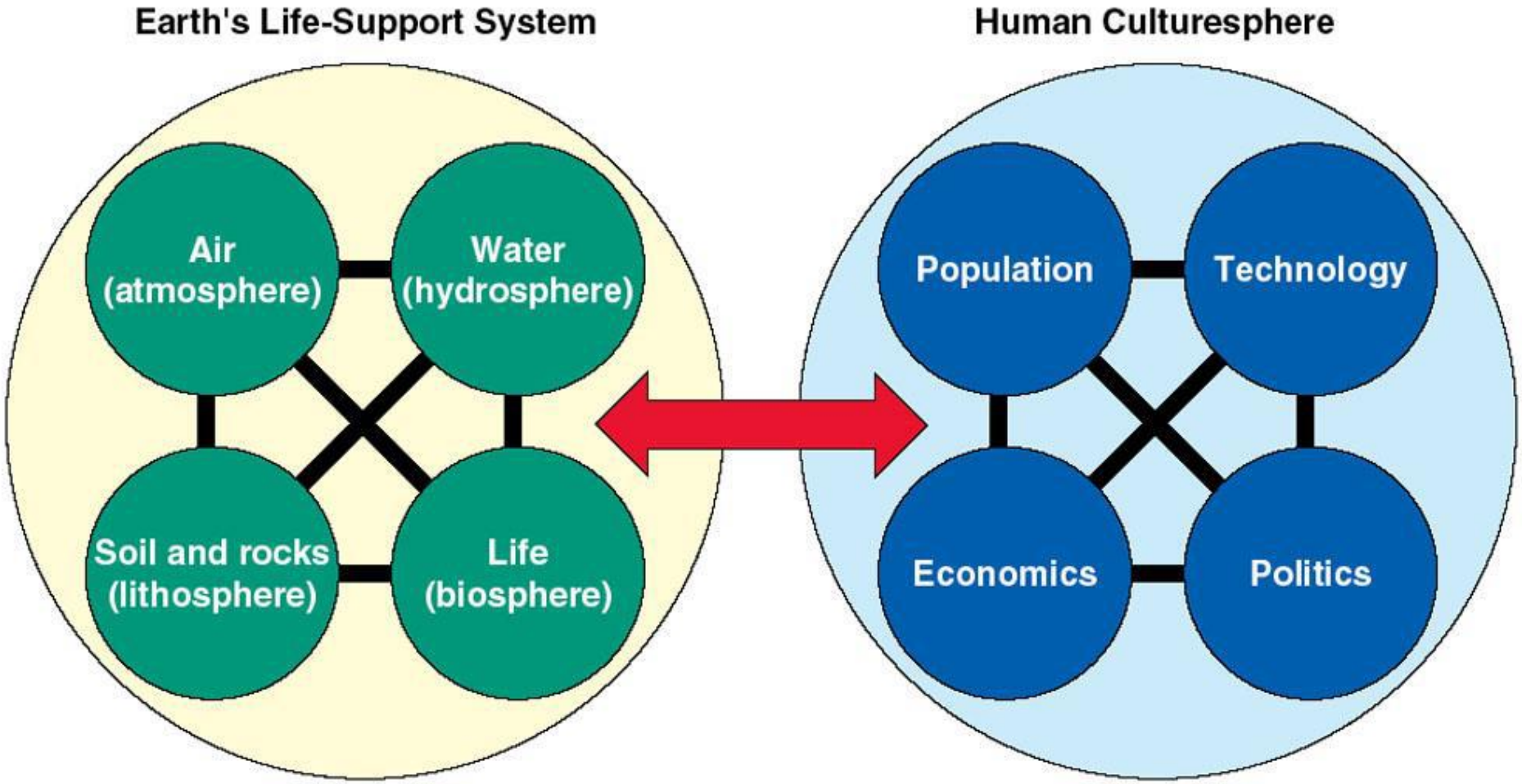
$$\text{Impact} = \text{Population} \times \frac{\text{consumption}}{\text{per person}} \times \frac{\text{impact}}{\text{per unit of consumption}}$$

$$I = P \times A \times T$$

IPAT Equation



Goal of Environmental Science

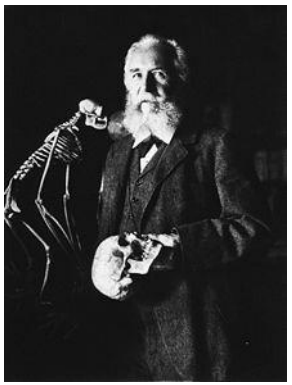


Ecology

- Rivers, lakes, oceans, mountains, deserts, forest, grasslands etc. differ in their structural composition and function.
- All the living entities interacts with each other and with the surroundings by exchanging matter and energy.
- How these entities derive their energy and nutrients to live ?
- How do they influence each other and regulate their stability ?

Ecology

- The name was coined by German Professor Earnst Haeckel in 1869.
- It is derived from Greek words Oikos – HOME, logos-STUDY



Ecology deals with the study of organisms in their natural home interacting with their surroundings

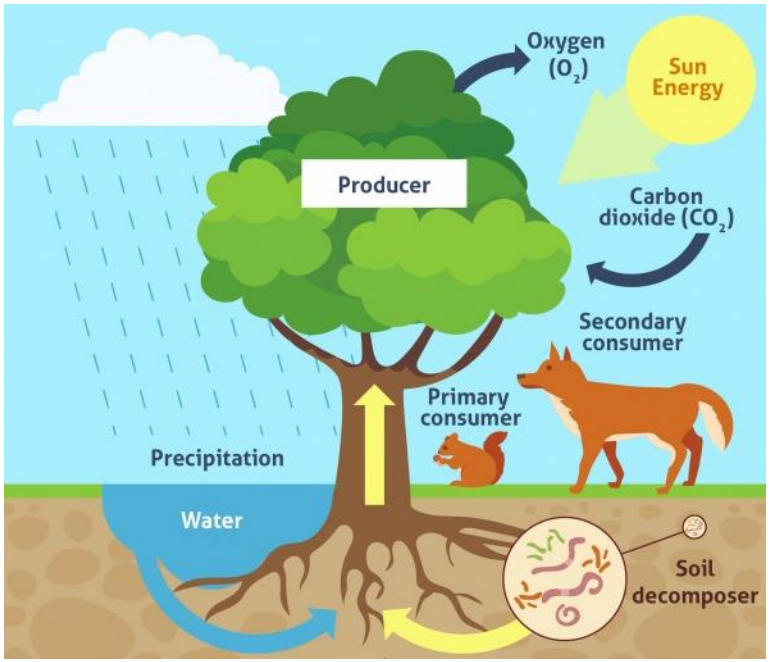
Ecology & Ecosystem

Ecology is nothing but study of Ecosystems

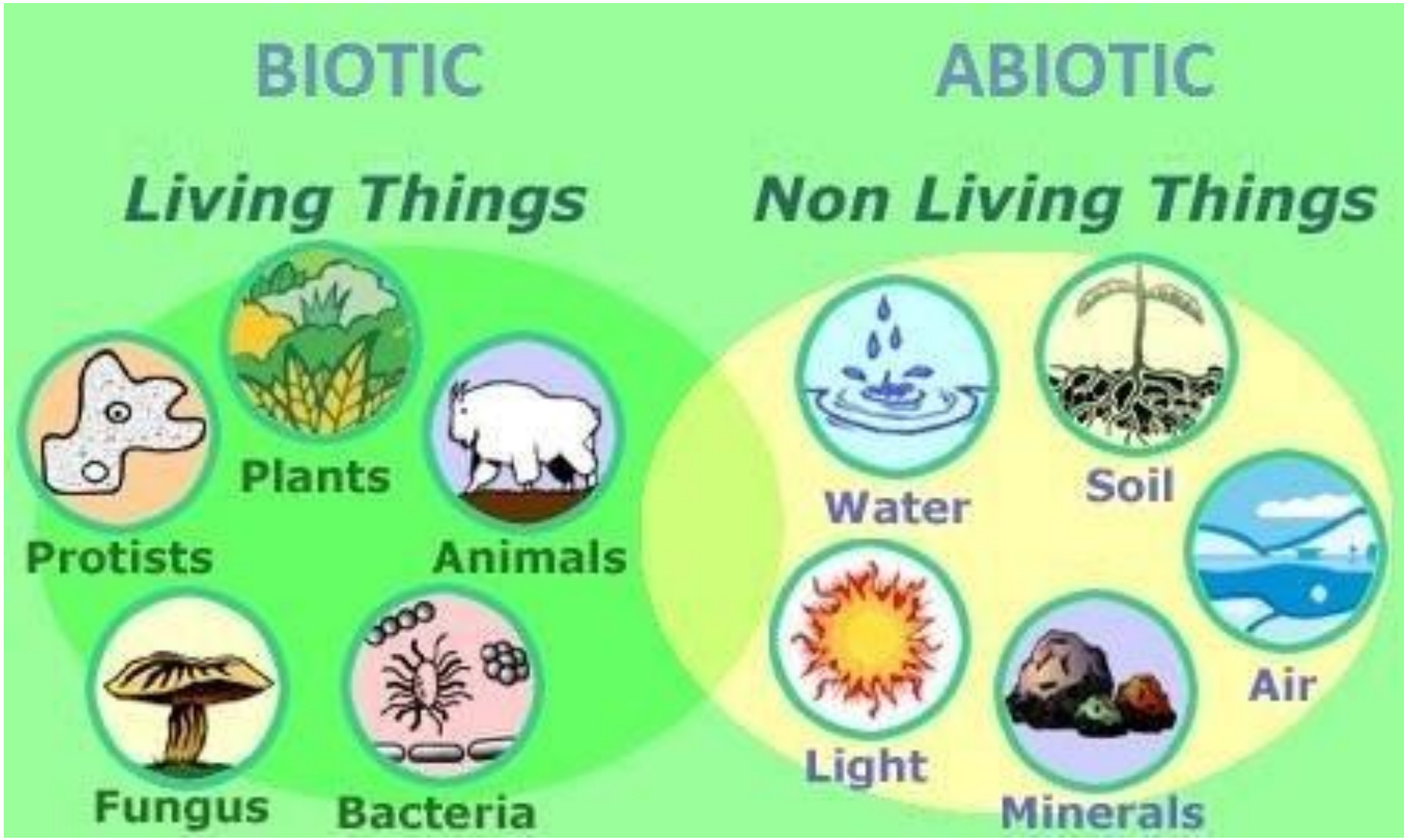
Then,

What is Ecosystem?

- An ecosystem is a self-regulating group of biotic communities of species Interacting with one another and with their non-living environment (abiotic) exchanging energy and matter.

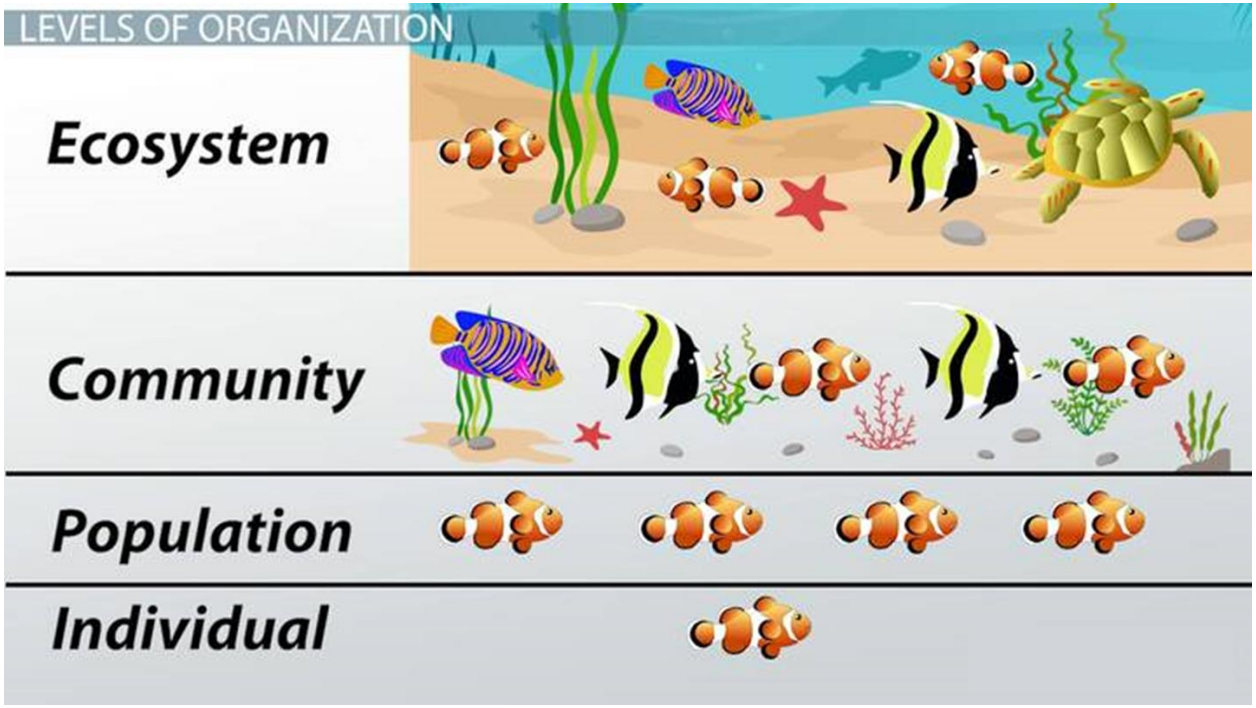


Biotic vs Abiotic



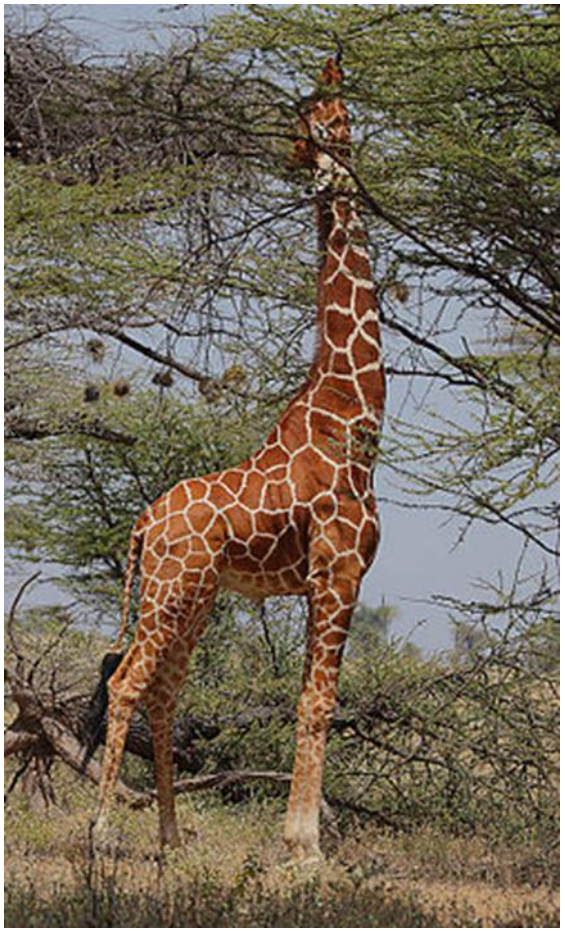
Ecosystem

Ecosystem: communities that live and interact with each other as well as with non-living things. It is here in the ecosystem that the communities depend on things like water, sun, and temperature.



Animals adjust to the climatic conditions

Animals adjust to the climatic conditions



Interaction between biological species

Biological species adapt to their surrounding, physical and chemical structure of earth

- Interaction between biological species and their environment
- Interacting with themselves as well as with non-living (sand, water, *etc.*) things.

What are the interactions and why do they need these interactions?

What are the interactions?

Take a grassland region in Africa where we find Lions

- How are lions surviving in grasslands? – **They do not eat Grass!!**
- Why do zebras eat grass? **They get energy**
- Where does grass get its energy from? **Soil and Sunlight**
- Why does Lion eat zebras but not grass? **It regulates the number of zebras**
- What regulates the number of Lions? **Their reproduction and Aging ….Bacteria**

Is there any restriction on zebra and lion number?

Otherwise the lions eat all zebras in no time and the zebras eat all available grass and they cannot survive after that.

What are the interactions?

The interactions are,

- Energy from the sun and nutrients from the soil
- Converting them to the biological materials
- Cycling the biological materials as food
- Decomposition of the biological matter to regenerate the nutrients

and

- Reproduction and population regulations
- Various adaptations to the abiotic components

Why are these interactions needed?

Through these interactions nature exists for ever.

- "Nature is capable of self sustaining or self regulating through the interactions in the natural world using sun as an energy source".

Do all animals need to interact with each and every other animal and every non-living thing?

- There are a group of living things interacting with certain non living things and sustaining for ever..
  - ➢ Sustenance is maintained in a small unit

Example: Desserts are one unit and grasslands are another unit.

Examples for ecosystems

- **Those on land**
  - Grasslands
  - Forests
  - Desserts
- **Those in water**
  - River
  - Pond, lake
  - Ocean
  - Estuary

Biomes

- A biome is a large area with similar flora, fauna and micro-organisms and similar non-living components

- Biome is an area formed by all similar ecosystems put together

➢ Examples
  - Mountains
  - Tundras
  - Rainforests
  - Deserts
  - Grasslands

Habitat

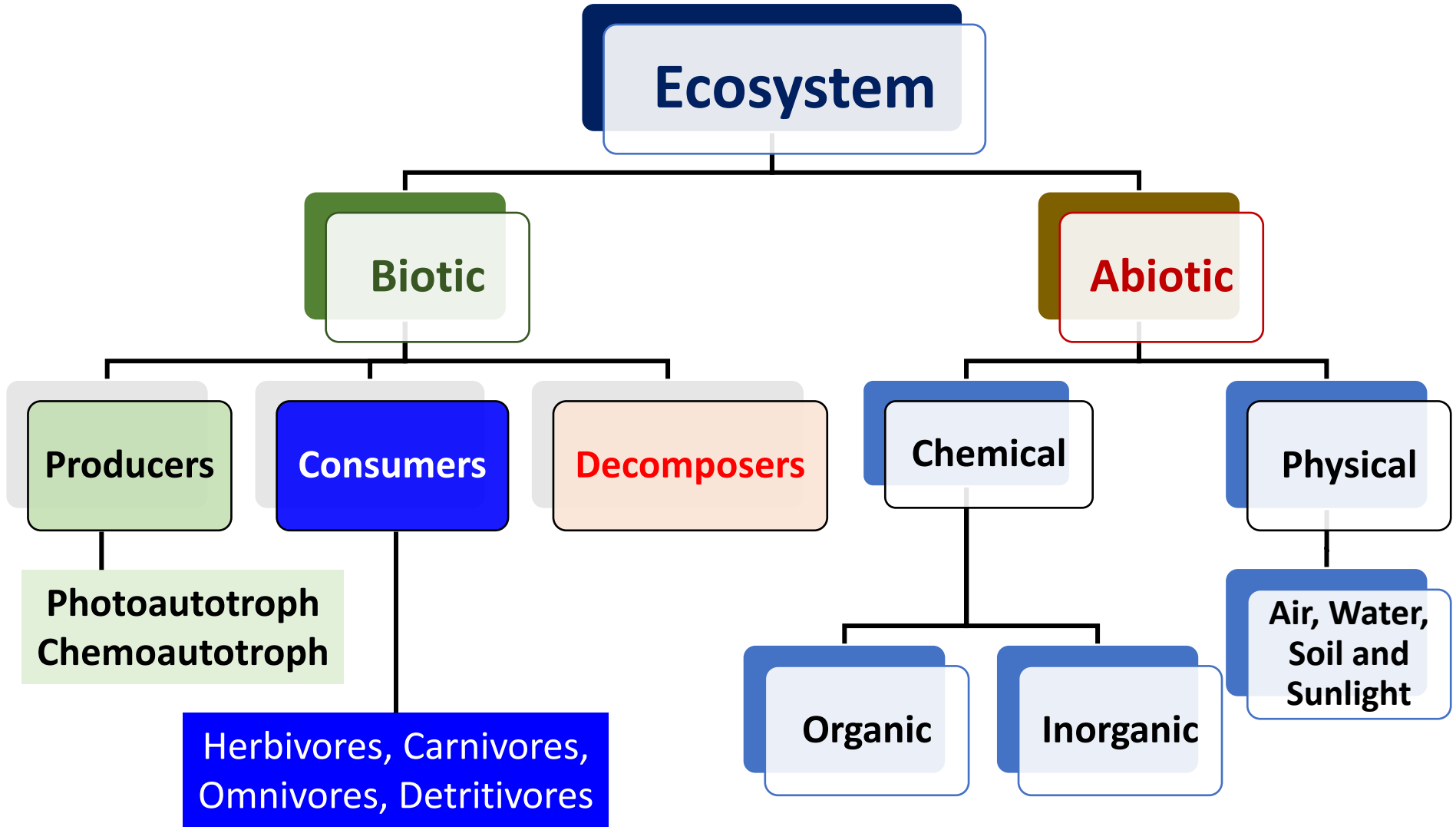
- Should not be confused with ecosystem
- Habitat is the physical area in which living organisms live
- The habitat of an organism may include many different areas
- Think of the various places you might find a mouse
    - In a field
    - In a garden
    - in the walls of your house
- Animals that migrate will have different habitats during different seasons

Structure of Ecosystem

It has an orderly structure and definite functions

- The biotic and abiotic components of an ecosystem form its structure
- Biotic components are biological species and abiotic components are non-living physical and chemical components with which biotic species interact.

Structure of Ecosystem



Abiotic components of an ecosystem

- All non-living components form the abiotic components
- The Abiotic (Physical and chemical) factors are:

Physical Factors:

- Sunlight, its intensity and duration -- necessary for photosynthesis
- Annual rainfall (water) -- all living things require some water to different extent
- Temperature -- all living things have a range of temperatures in which they can survive;
- Oxygen -- many living things require oxygen; it is necessary for cellular respiration; others are actually killed by the presence of oxygen (certain anaerobic bacteria)
- Soil– The type of soil, Its pH,
- Amount of water it holds,

Chemical Factors:

- Available nutrients, like C, N, P, K, H, O and S, Organic substances present in soil etc. determine what type of organism can successfully live in or on the soil;

Biotic Components

There are three groups of biotic components

- Producers
- Consumers
- Decomposers

Producers

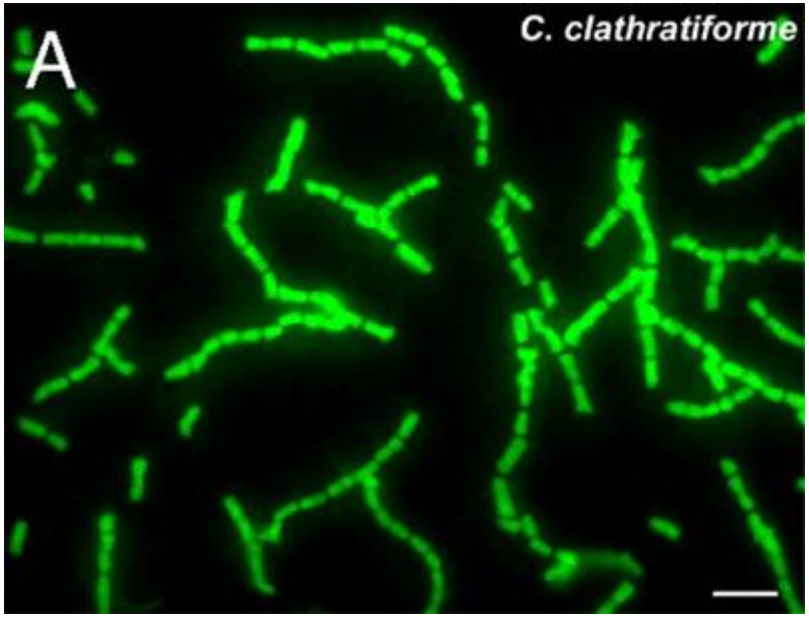
- Producers are plants and some bacteria that are capable of producing their own food from nature
- Producers are also called autotrophs

Producers are of two types

- ➢ Photoautotrophs: Produce using sunlight
- ➢ Chemoautotrophs: From chemicals
  - ❖ Deep ocean water Sulphur bacteria use heat to convert hydrogen sulfide and carbon dioxide to produce organic compounds

Chemotrophs

- Green Sulfur bacteria

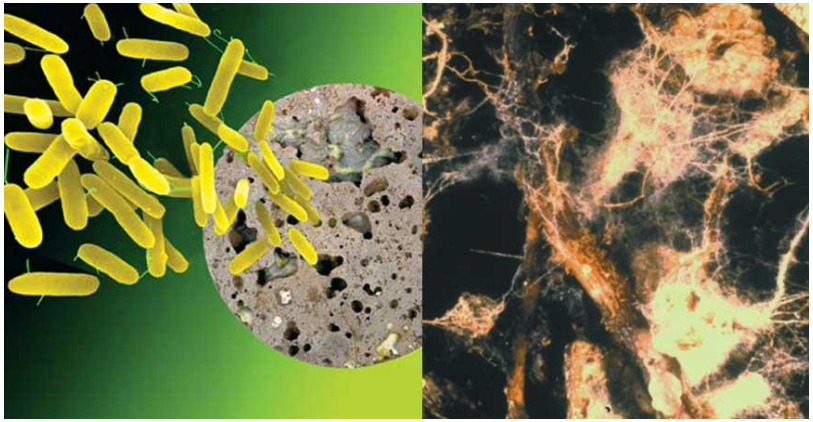


Consumers

1. Herbivores – primary consumers (plant eaters): rabbit
2. Carnivores – Secondary consumers (meat eaters): frog
   Tertiary consumers: snake
3. Omnivores – Eating both plants and animals: humans, rat, fox
4. Detritivores – Feeding on dead organisms: beetles, termites, ants

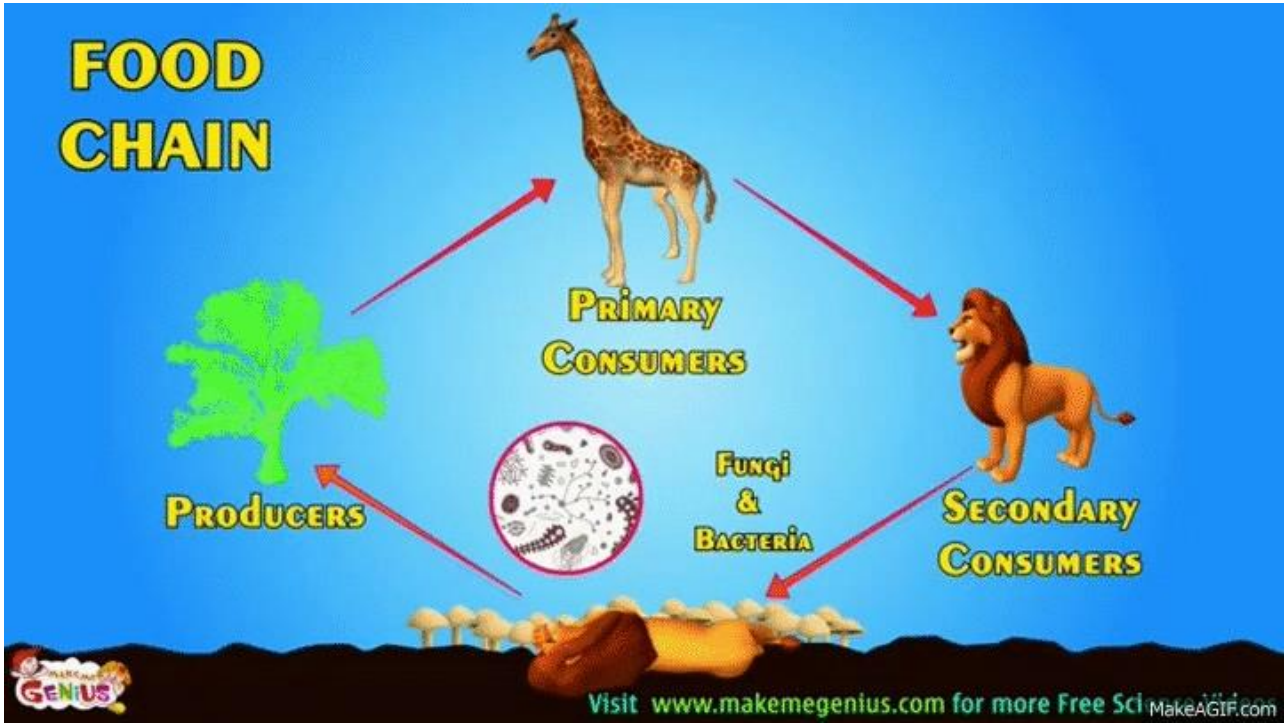
Decomposers

- Decomposers, also called recyclers
- are fungi, bacteria and other microorganisms that decompose organic matter to reusable inorganic form
- They derive their nutrition by breaking down the complex organic species to simple organic compounds and ultimately into inorganic nutrients

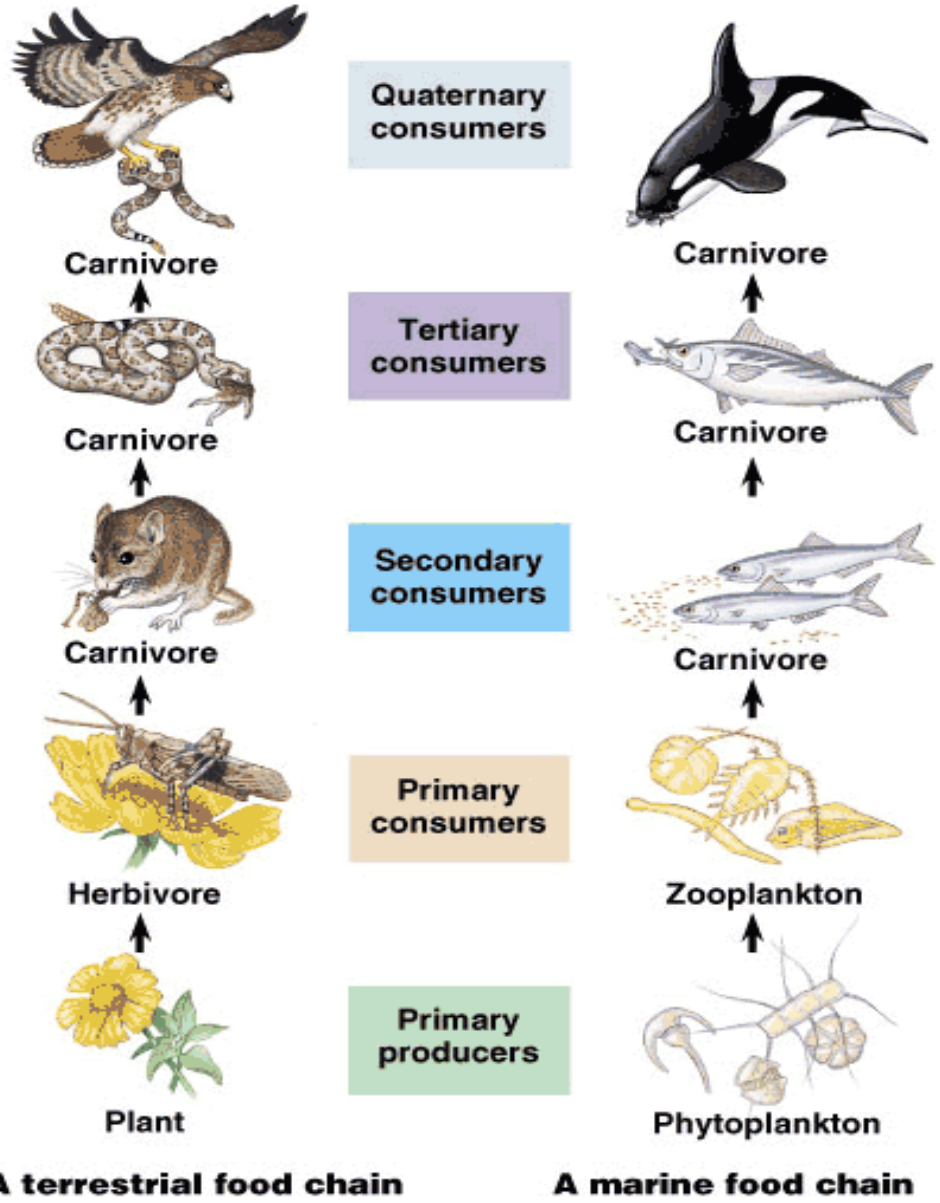


Food Chain

- Biomatter transfers in the form of food
- The transfer of food energy from the source plants through a series of organisms.



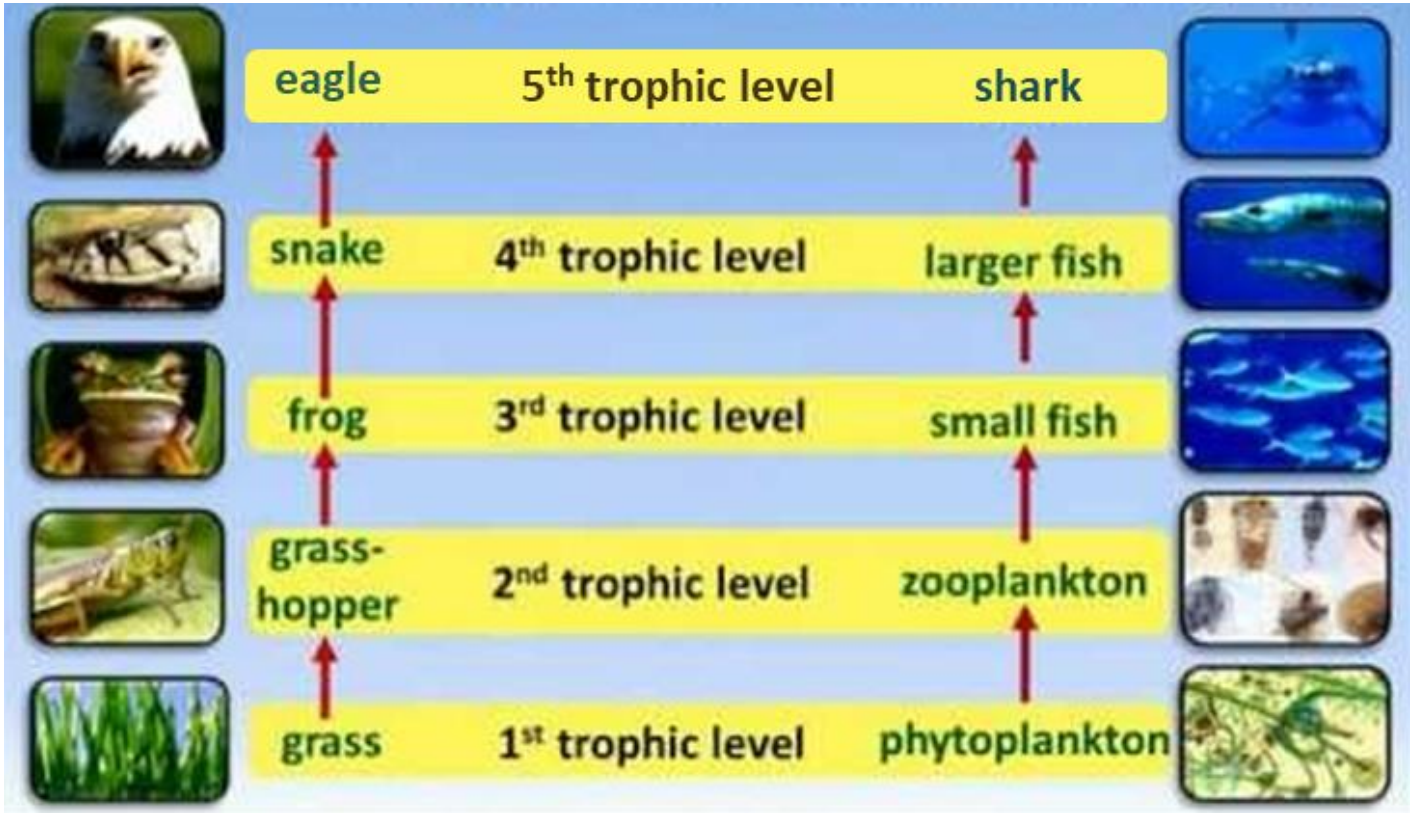
Examples of Food Chains



Trophic Levels in Food chain

Trophic Level

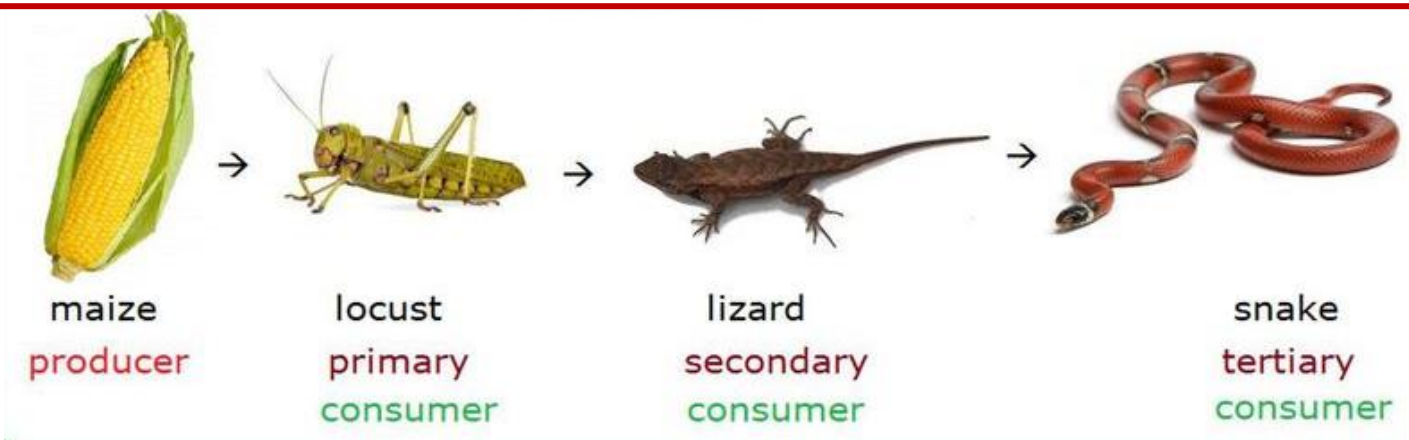
- It is the position an organism occupies in a food chain
- Each link in the chain represents one trophic level



Types of food chain

Food chains are classified as Grazing and Detritus

Grazing food chain



Detritus food chain

Dead Organic maters → Soil microbes → earth worms

Comparison between the two types of food chains

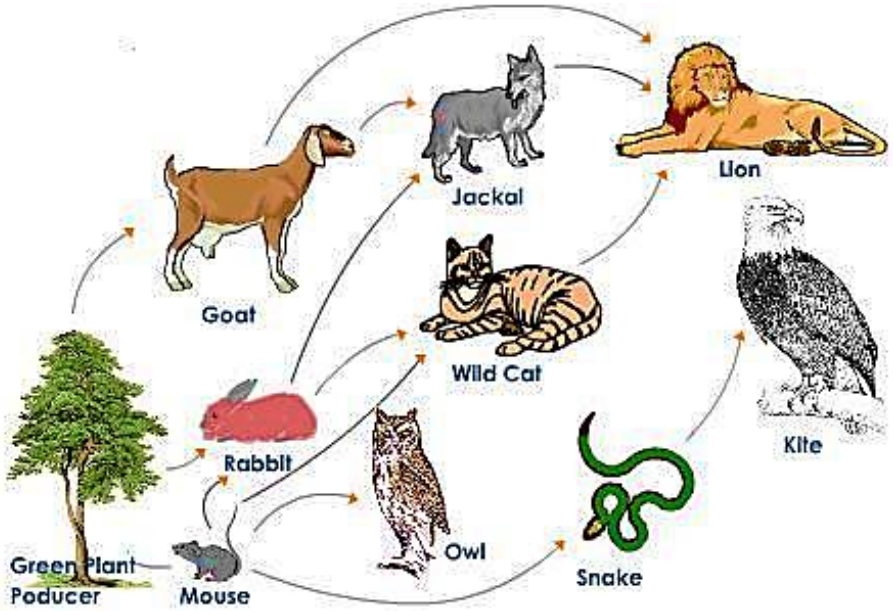
Grazing food chain	-	Detritus food chain
In this food chain, energy is derived from the sun	-	In this food chain, energy comes from organic matter generated in the trophic levels of the grazing food chain
It begins with producers, present at the first trophic level. The plant biomass is then eaten by herbivores, which in turn are consumed by a variety of carnivores	-	It begins with detritus such as dead bodies of animals or fallen leaves, which are then eaten by decomposers or detritivores. These detritivore are in turn consumed by their predators
This food chain is usually large	-	It is usually smaller as compared to the grazing food chain

Food web

A food web is the interlocking pattern of various food chains of an ecosystem put together

Advantage of Food web over food chain

- Suppose there are no food webs but only food chains.
- In a food chain if one species gets affected (or) becomes extinct, all other species also affected
- The species lower in the series will increase in number
- Creates an imbalance
- But in food web even if one species in the chain is lost, the animals above in the chain survive because of the other chains.



Food Web in a Forest

Importance of food chains and food webs

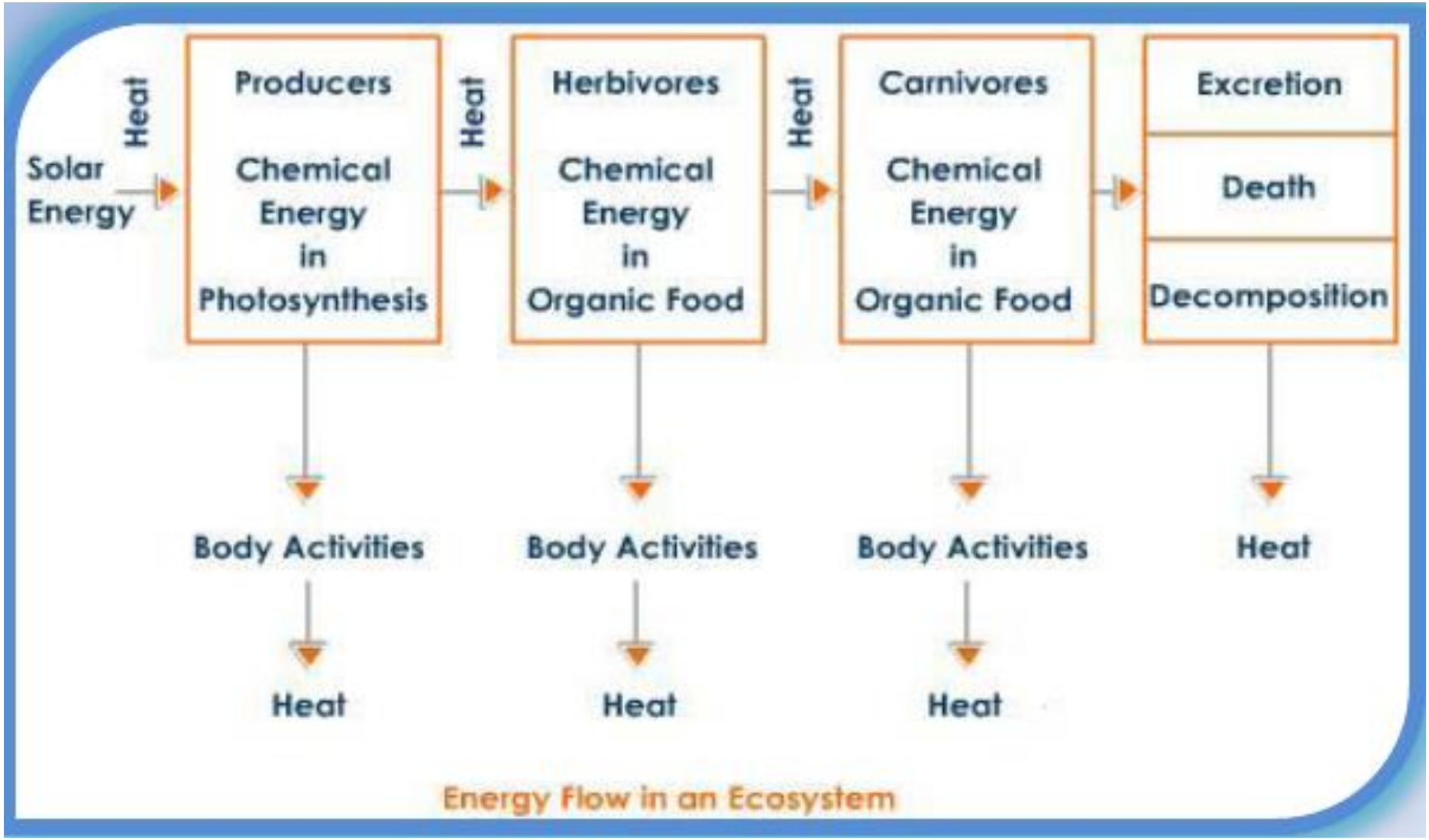
- They are responsible for the energy flow and nutrient flow in the ecosystem
- Help maintaining and regulating the population size of different animals and thus, help maintain the ecological balance

e.g.: Deer controls the extent of growth of grass.

Tigers control the number of deer.

- If deer are not present too much of grass grows and nutrients from the soil are lost. Then no further grass growth.
- If no grass is present deer cannot survive. Tigers cannot survive.
- If instead, No tiger is present the number of deer increases and they ultimately eat all the grass and cannot survive further after all the grass is lost.

Energy flow in Ecosystem



GPP (P_G) & NPP (P_N)

- Distinguish between gross primary production (GPP) and net primary production (NPP) and explain their importance.

GPP or PG = total amount of energy captured

NPP or PN = GPP – respiration

- NPP is thus the amount of energy stored by the producers and potentially available to consumers and decomposers.

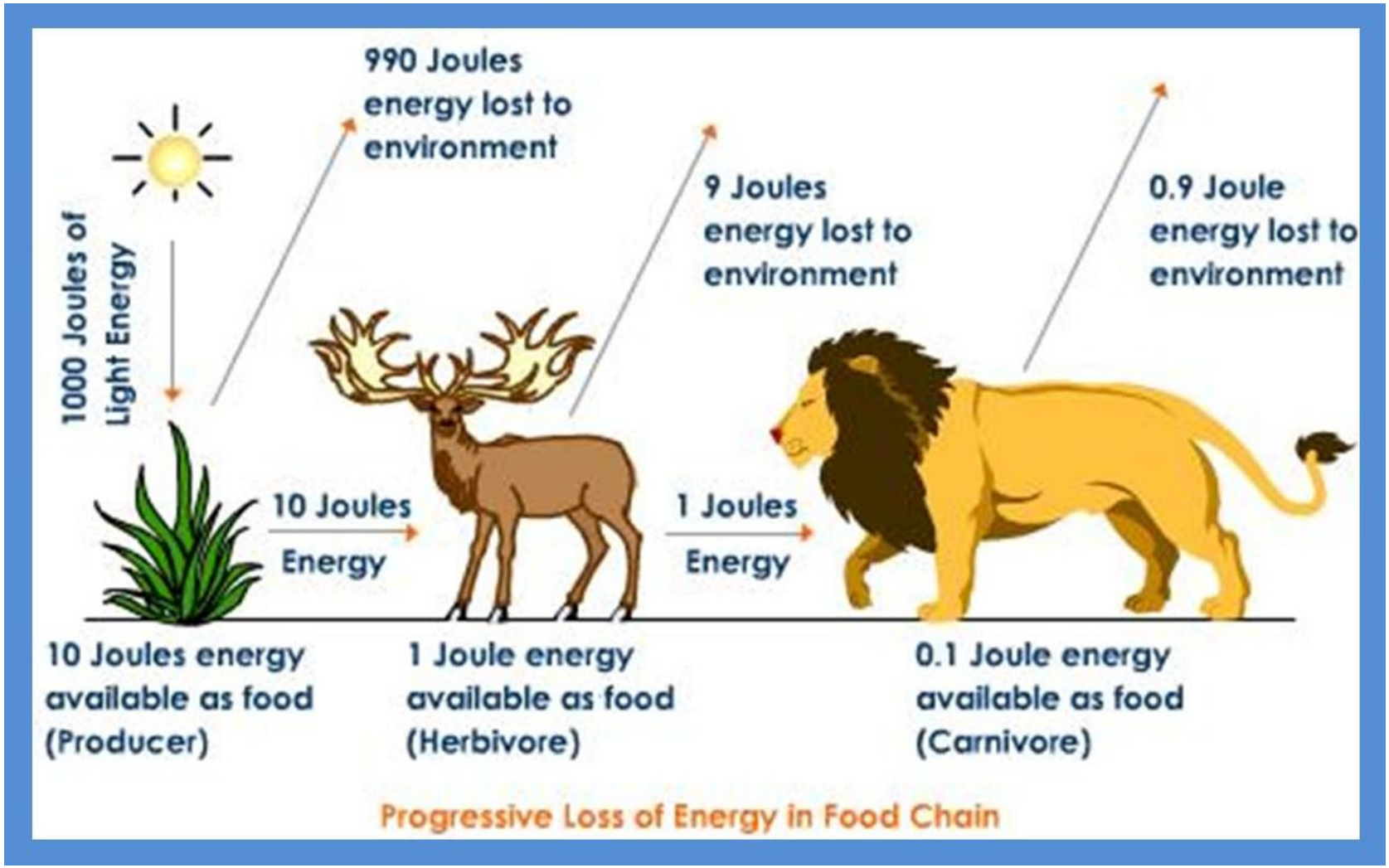
Energy flow – Thermodynamics

- Energy flow in an ecosystem follows the laws of thermodynamics
- The flow of energy follows the two laws of thermodynamics

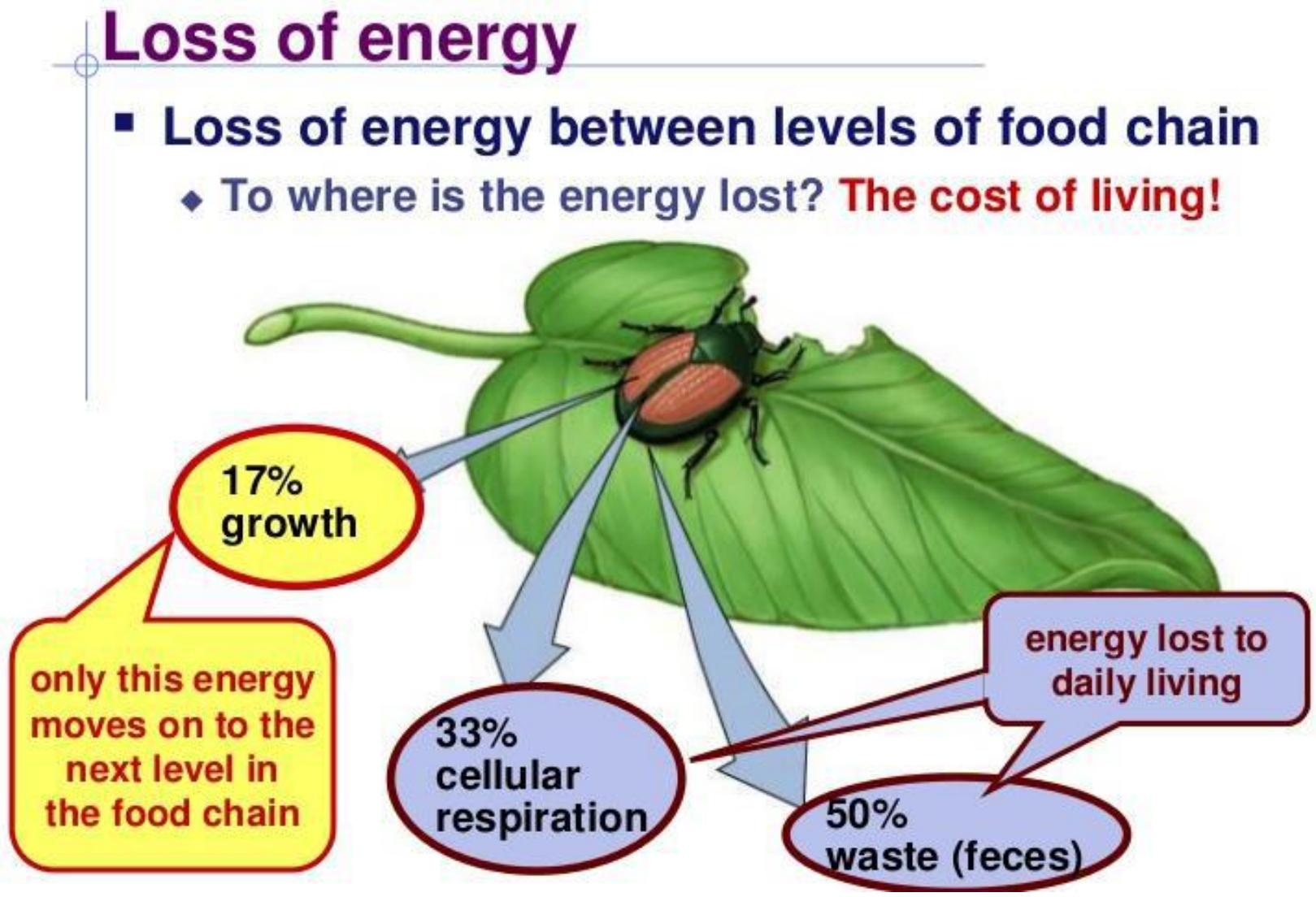
Ist law of thermodynamics: The law states that energy can neither be created nor be destroyed but it can be transformed from one form to another. Similarly, solar energy utilized by green plants (producers) in photosynthesis converted into biochemical energy of plants and later into that of consumers.

IInd law of thermodynamics: The law states that energy transformation involves degradation or dissipation of energy from a concentrated to a dispersed form. We have seen dissipation of energy occurs at every trophic level. There is loss of 90% energy, only 10% is transferred from one trophic level to the other.

Energy Flow in an Ecosystem



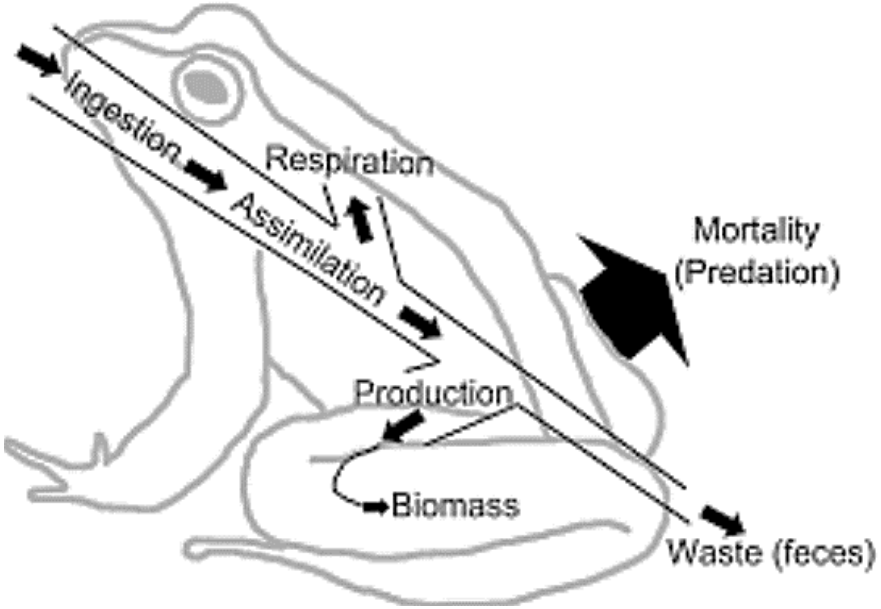
Energy Loss in Ecosystem



Energy Flow Models

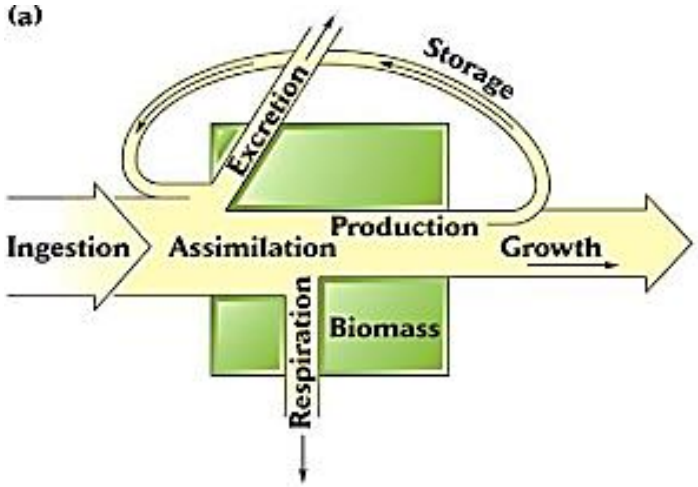
Energy flows through various trophic levels in an ecosystem:

- Universal Energy Flow Model
- Single Channel Energy Flow Model, and
- Double Channel Or Y-shaped Energy Flow Model



Universal Energy Flow Model

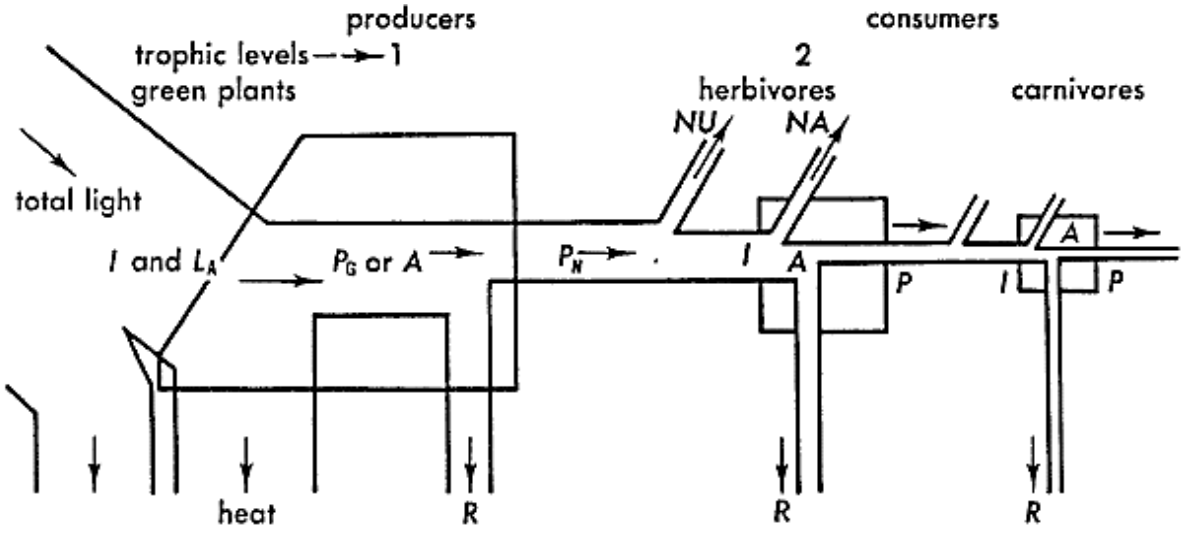
- Applicable to all living components.
- There is gradual loss of energy at every trophic level.
- This loss of energy is mainly Energy “Not Utilized” (NU) (being lazy)
- Other energy losses: locomotion, excretion, respiration (R).
- Rest of the energy (growth) is used for Production (P).



A single trophic level

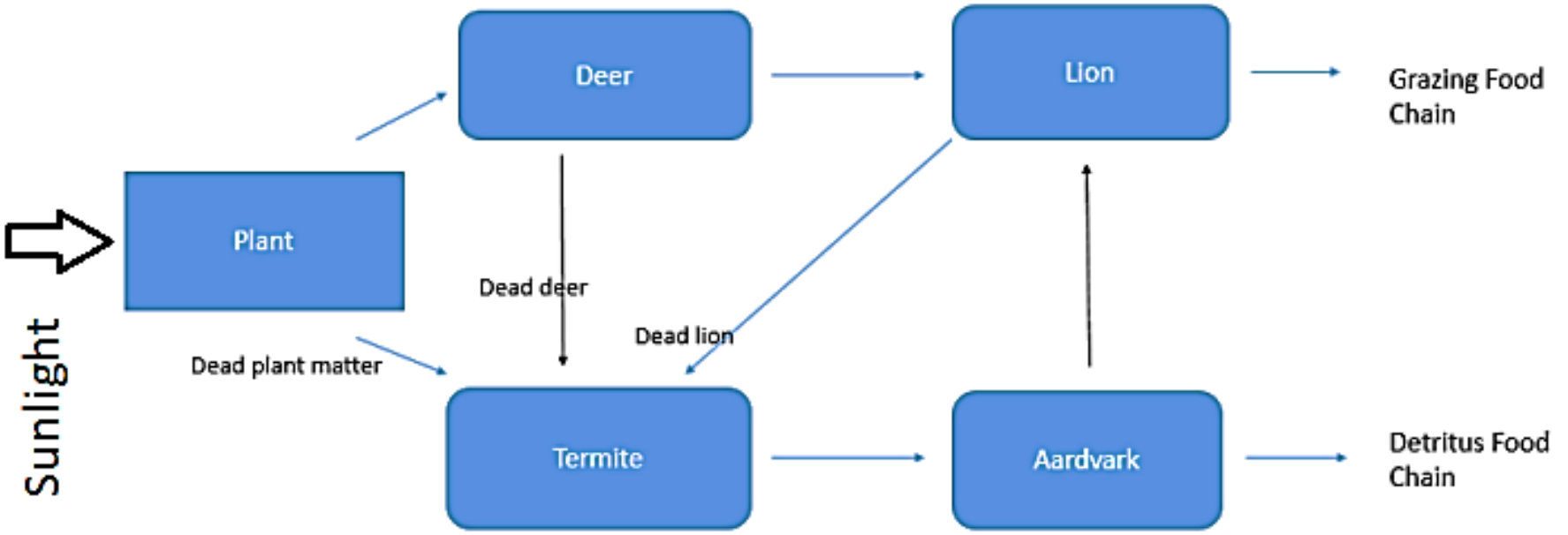
Single-Channel Energy Flow Model

- Energy flows in one-way direction
- Energy captured by autotrophs does not revert back to solar input but passes to herbivores which does not go back to autotrophs but passes to consumers.
- Entire system would collapse if primary source of energy were cut off.
- Energy not utilized (NU) and not assimilated (NA).
- Both stored energy and flowing energy decrease while moving through a food chain.



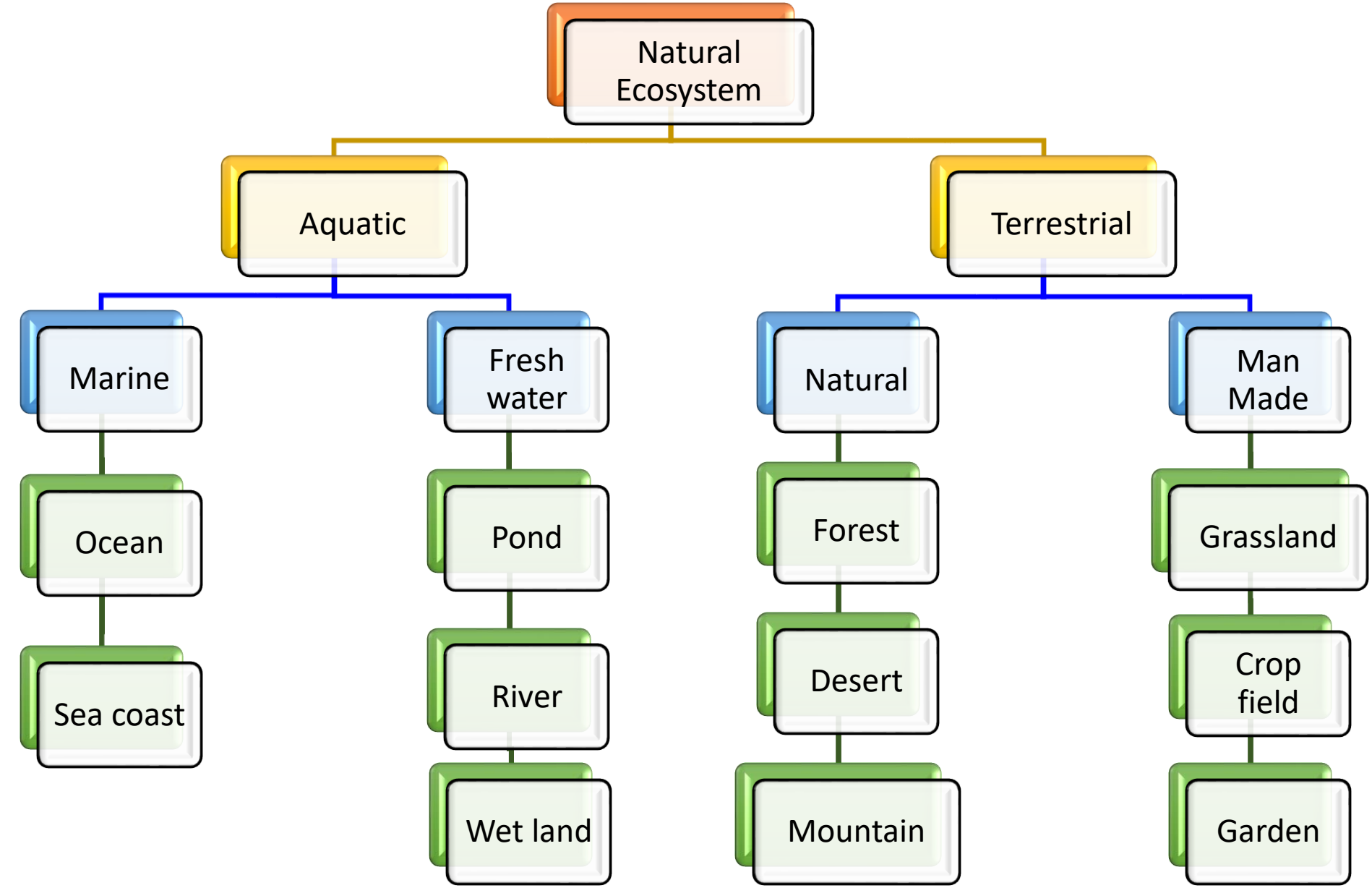
Double channeled (Y shaped) Energy Flow Model

- In this model, the passage of energy happens via two food chains.
- Decomposers are placed in separate box to partially separate the grazing food chain and detritus food chain. In terms of energy levels, decomposers are a mixed group.

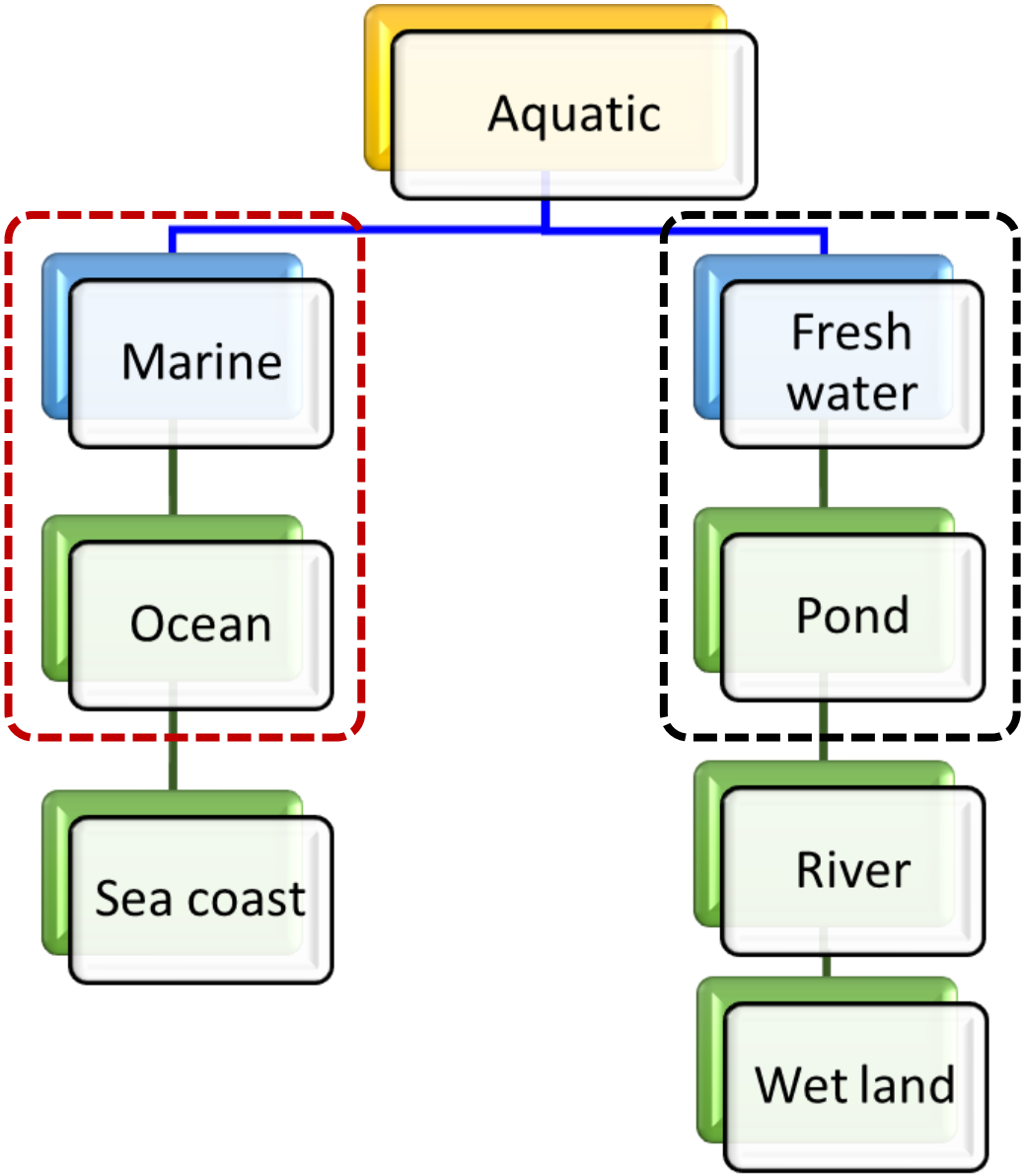


Types of Ecosystem

Types of Ecosystem

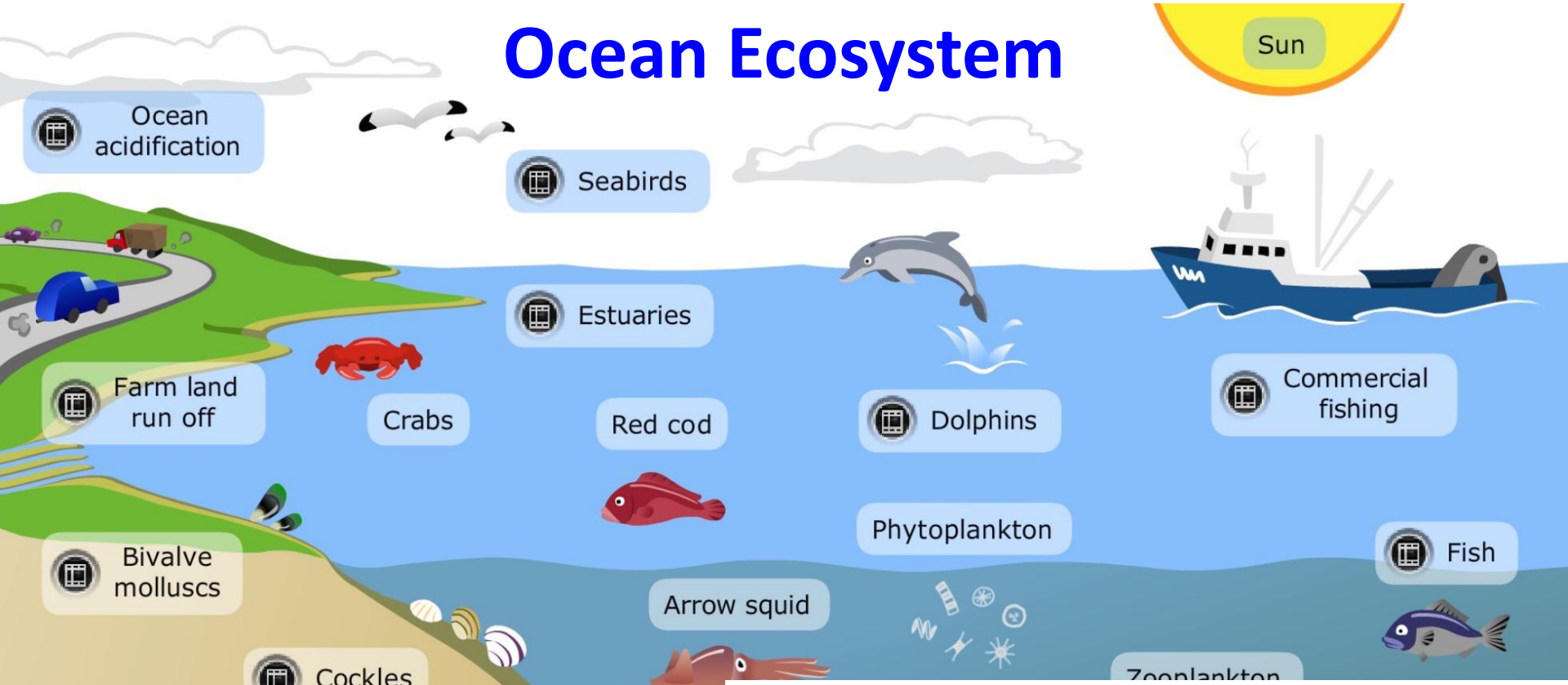


Aquatic Ecosystem



Marine Ecosystem

Ocean Ecosystem



Structure of Marine Ecosystem

Abiotic components	Biotic components		
	Producers	Consumers	Decomposers
About 27 % of 0.5M NaCl, remaining Mg, Ca & K salts, temperature, light.	Diatoms, microscopic algae.	1°- Crustaceans, mollusks, fish. 2° - Herrings, shad. 3°- Cod, Haddocks.	Fungi, bacteria, etc.

Ocean Ecosystem

Oceans in the world covers about 71 % of the earth's surface (Atlantic, Pacific, Indian, Artic & Antarctic oceans). Represents a very large saline ecosystem.

- Characteristics
  - It is a saline water ecosystem.
  - Occupies a large surface area.
  - Vessels like ships & submarines can sail.
  - It is rich in biodiversity.
- Functions
  - Serves food for many marine and terrestrial species.
  - Provides many products like drugs, stones, pearl, etc.
  - Reservoir for NaCl and many other minerals.
  - Plays a major role in climate change and biogeochemical cycle

Fresh water Ecosystem

Pond Ecosystem

Structure of Pond Ecosystem

Abiotic components	Biotic components		
	Producers	Consumers	Decomposers
Temperature, light, pH, H_2O, Organic and Inorganic compounds.	Rooted plants (macrophytes)& floating plants (phytoplankton)	1°- Animals feeding macrophytes, birds feeding phytoplankton & zoo planktons. 2° - Insects, fishes 3°- Large fishes	Microbes like Fungi, bacteria, Actinomycetes etc.

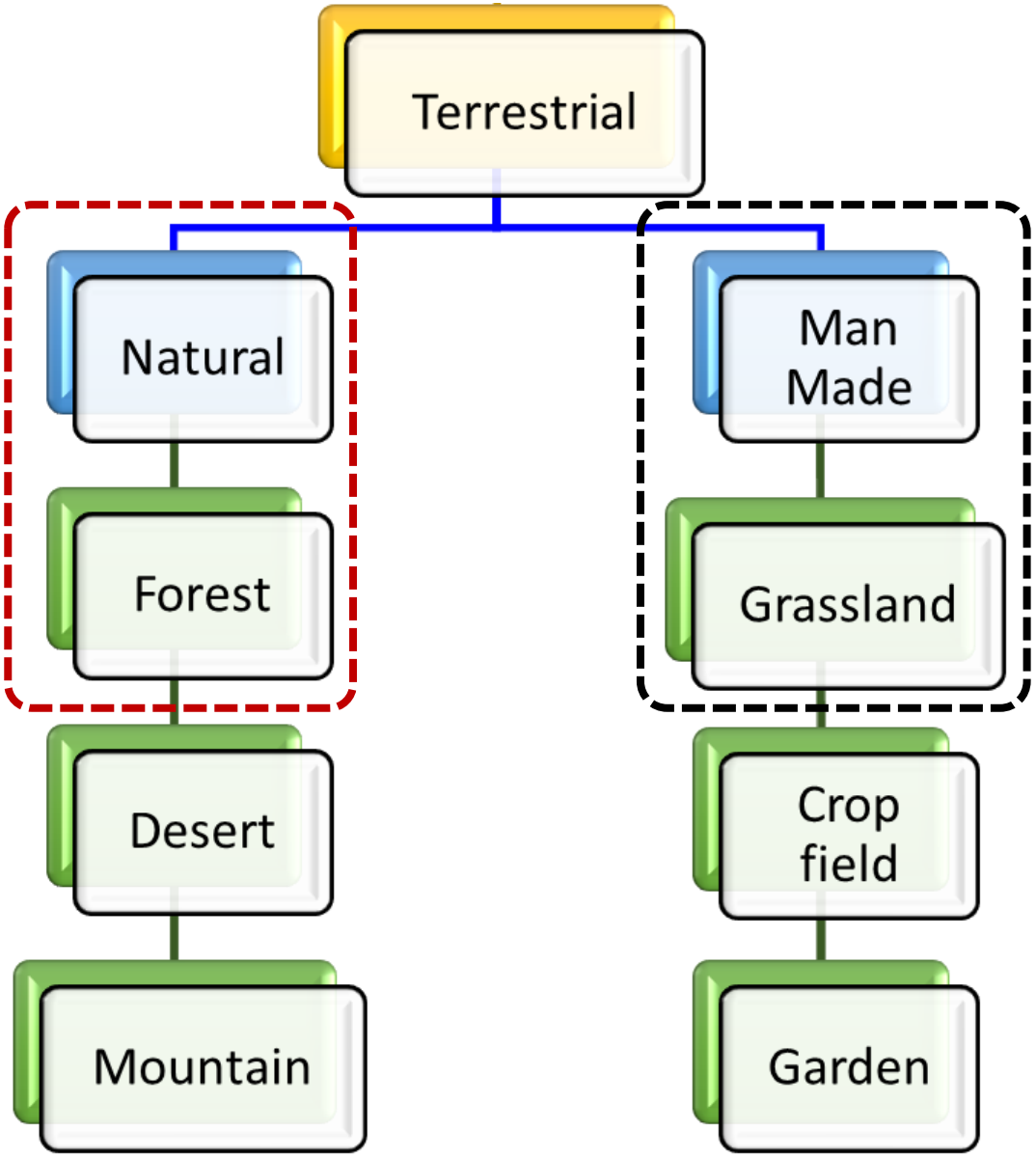
Pond Ecosystem

- Pond is a fresh water ecosystem, and is self sufficient & self-regulating.

- Characteristics
  - Stagnant fresh water .
  - May be temporary, only seasonal.
  - More polluted due to over utilization by community.

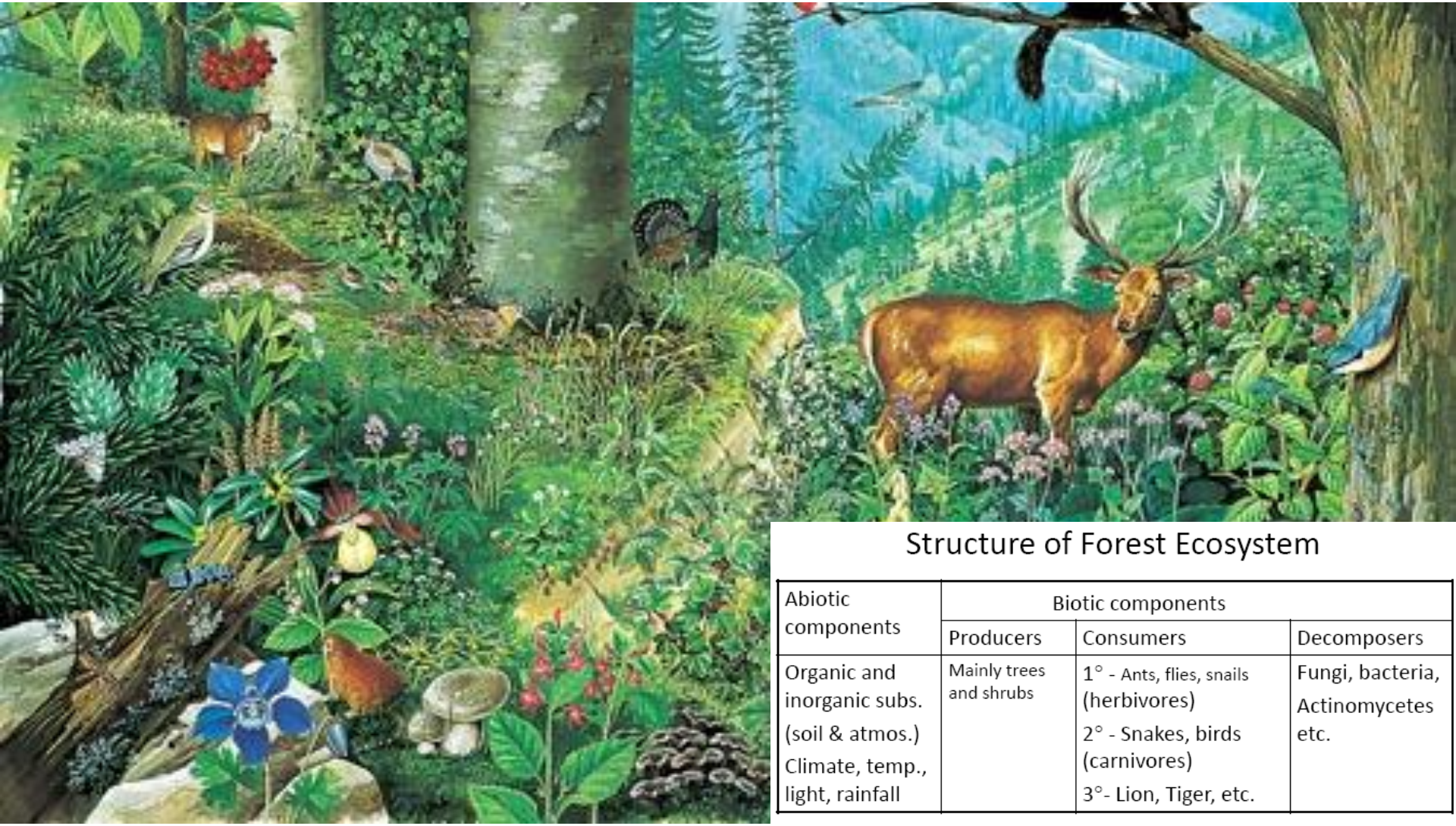
- Functions
  - Serves as resource for small water requirements.
  - Contains small algae, plants and animals.
  - Place for human activity like drinking, swimming, washing cloths.

Terrestrial Ecosystem



Natural Ecosystem

Forest Ecosystem



Structure of Forest Ecosystem

Abiotic components	Biotic components		
	Producers	Consumers	Decomposers
Organic and inorganic subs. (soil & atmos.) Climate, temp., light, rainfall	Mainly trees and shrubs	1° - Ants, flies, snails (herbivores) 2° - Snakes, birds (carnivores) 3°- Lion, Tiger, etc.	Fungi, bacteria, Actinomycetes etc.

Forest Ecosystem

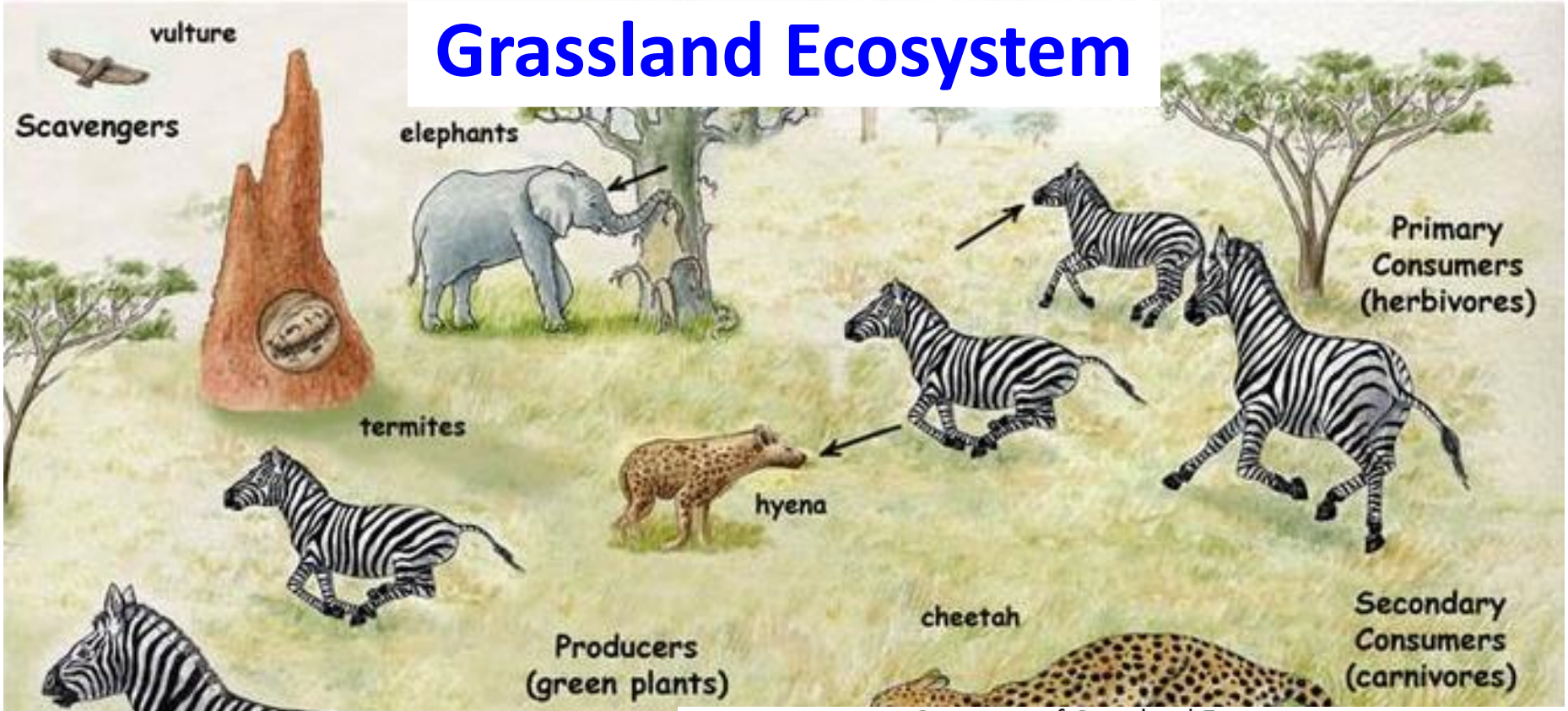
- Forest: Collection of biological organisms & non-biological factors.
- From trees to the bacteria, and the soil type to the micro-climates.
- Natural forces - wind and fire - shape the forest structure.

- Characteristics: Types of Forest
  - Tropical forest: Surrounding the equator (India, Africa, Sourth America)
  - Mountain forest: Mountain areas up to 1500 m altitude.
  - Temperate forest: Forests that exist above 1600 m altitude.
  - Alpine forest: High mountain forests that exist above 3000 m altitude.

- Functions of the Forest
  - Protects biodiversity.
  - Maintains climate & rainfall.

Man made Ecosystem

Grassland Ecosystem



Structure of Grassland Ecosystem

Abiotic components	Biotic components		
	Producers	Consumers	Decomposers
Nutrients in soil and aerial environment(C, H, O, N, P,S, H_2O, CO_2)	Mainly grasses and few shrubs	1° - Cows, buffaloes, rabbits, sheep. 2° - Snakes, birds lizards. 3°- Hawks	Microbes like Fungi, bacteria, actinomycetesetc.

Grassland Ecosystem

- Grassland occupies about 19% of earth's surface.
- Dominated by grass along with few trees and shrubs.
- Characteristics:
  - Average and erratic rainfall.
  - Primary production of food.
- Functions
  - Traps solar energy and biomass is consumed by producers.
  - Serves as a pool of energy for grassing animals.
  - Prevent soil erosion.
  - Insects living and breeding takes place.

Functions of an Ecosystem

1. In the ecosystem, biotic components and other materials like C, N, H_2O **circulated within and outside of the ecosystem**
2. The energy is transferred from one trophic level to the other in the form of a chain called as **food chain**
3. Important source of energy is the **Sun**
4. Climatic changes
5. The major functional attributes of an ecosystems are as follows
    a. Food chain, Food webs and tropic structure
    b. Energy flow
    c. Cycling of nutrients (Biogeochemical cycles)
    d. Primary and secondary production
    e. Ecosystem development and regulation

Ecological Pyramid

Ecological Pyramid

Definition

- Graphic representation of trophic structure and function of an ecosystem, starting with producers at the base and successive trophic levels forming the apex is known as ecological pyramid

The pyramid may be constructed with respect to

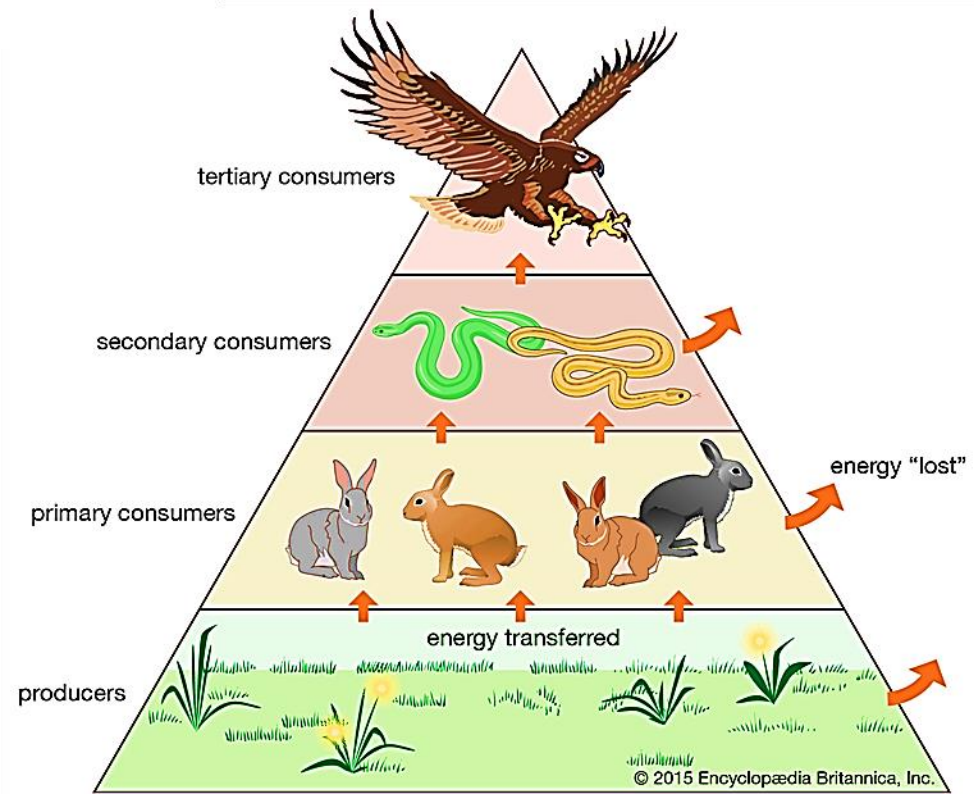
- energy flow
- number of species at each trophic level
- biomass of all species at each trophic level

Types of Ecological Pyramid

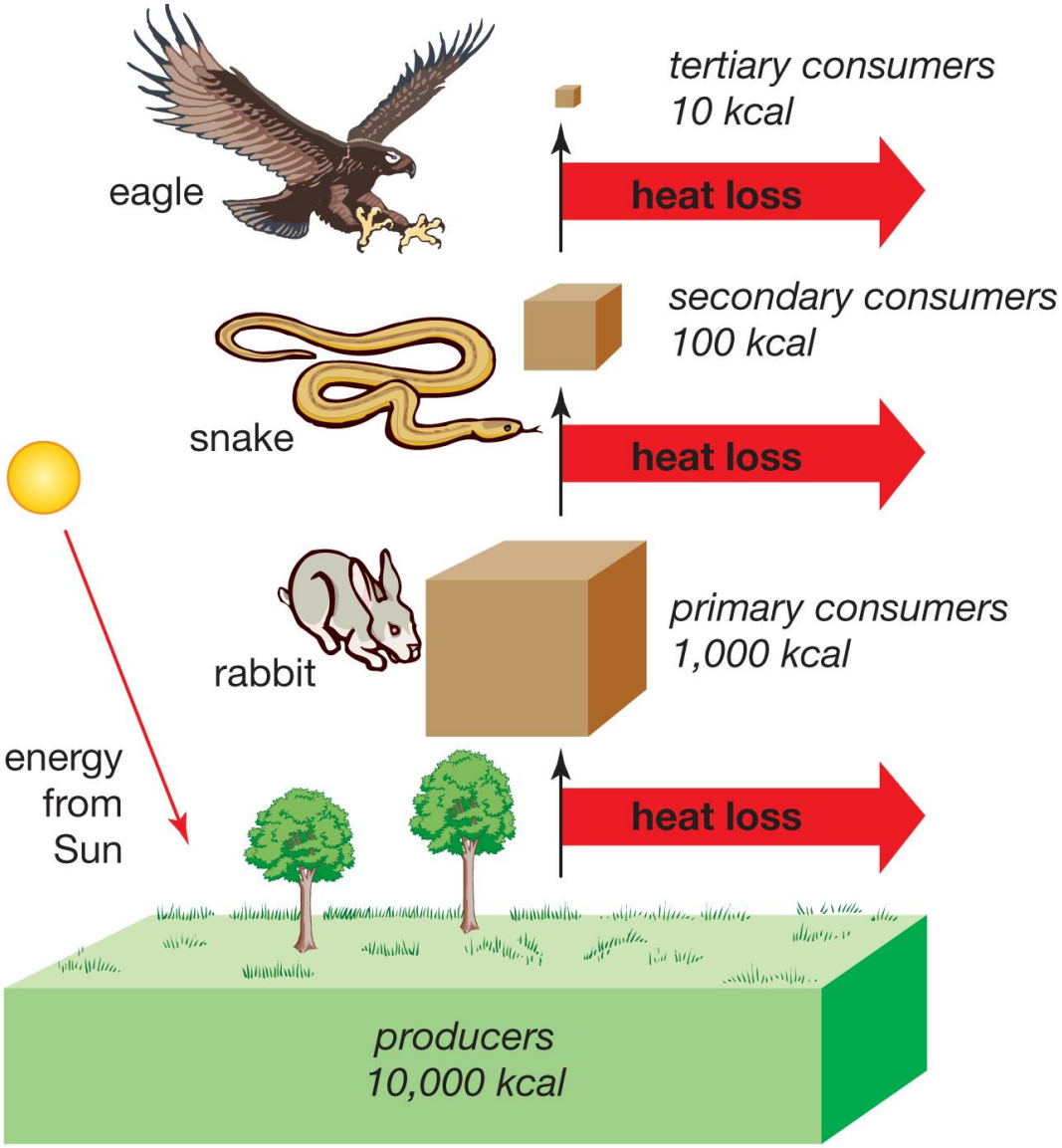
1. Pyramid of Energy
2. Pyramid of numbers
3. Pyramid of Biomass

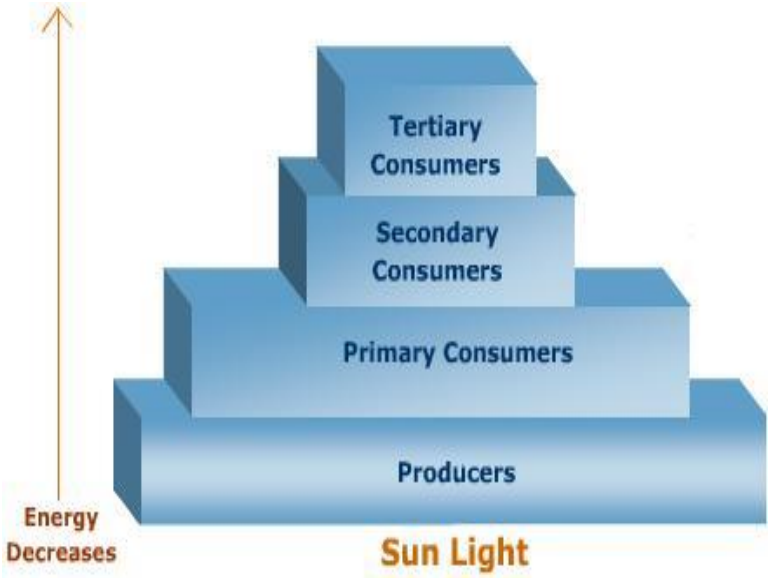
1. Pyramid of Energy

- The greatest amount of energy is found at the base of the pyramid.
- The least amount of energy is found at top of the pyramid.



1. Pyramid of Energy



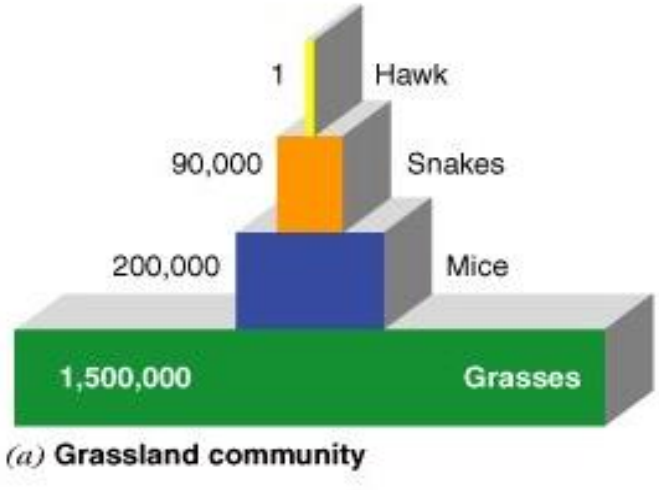


Pyramid of energy is always upright

2. Pyramid of numbers

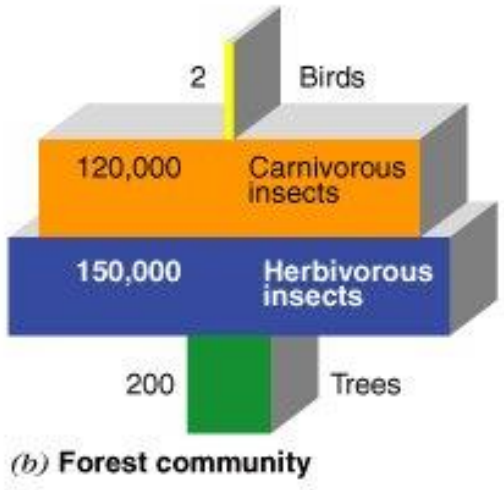
- It represents the number of individual organisms at each tropic level.
- We may have upright, spindle or inverted pyramid.

Shape depends on Type of ecosystem



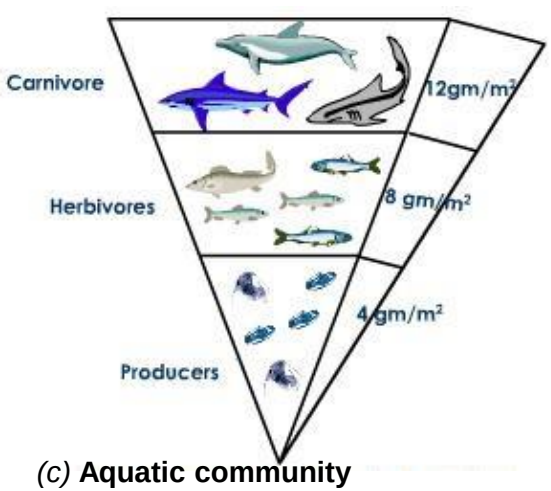
(a) Grassland community

Upright shaped for grassland ecosystem



(b) Forest community

Spindle shaped for forest ecosystems

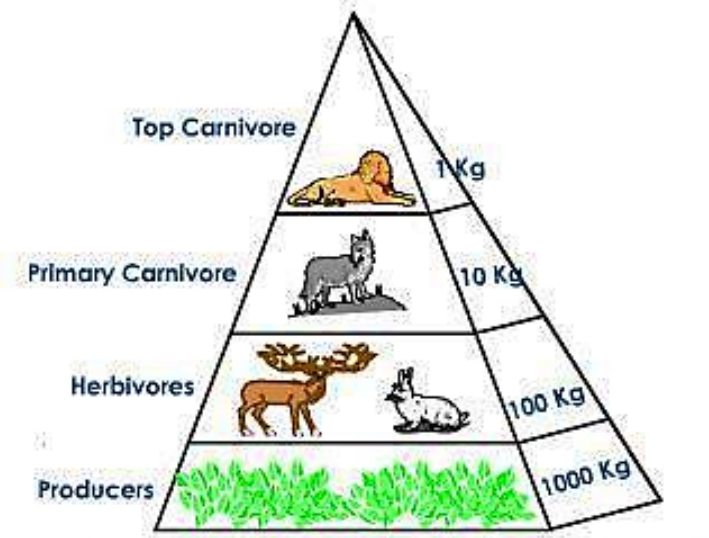


(c) Aquatic community

Inverted shaped for Aquatic ecosystem

3. Pyramid of biomass

- **Bio=life Mass=weight**
- **Bio + Mass = Weight of living things within an ecosystem.**
- Energy is sometimes considered in terms of biomass, the mass of all the organisms and organic material in an area. (Only dry mass in the species is considered as biomass)
- There is more biomass at the trophic level of producers and fewer at the trophic level of tertiary consumers. (There are more plants on Earth than there are animals.)



Upright Pyramid of biomass in a Terrestrial Ecosystem

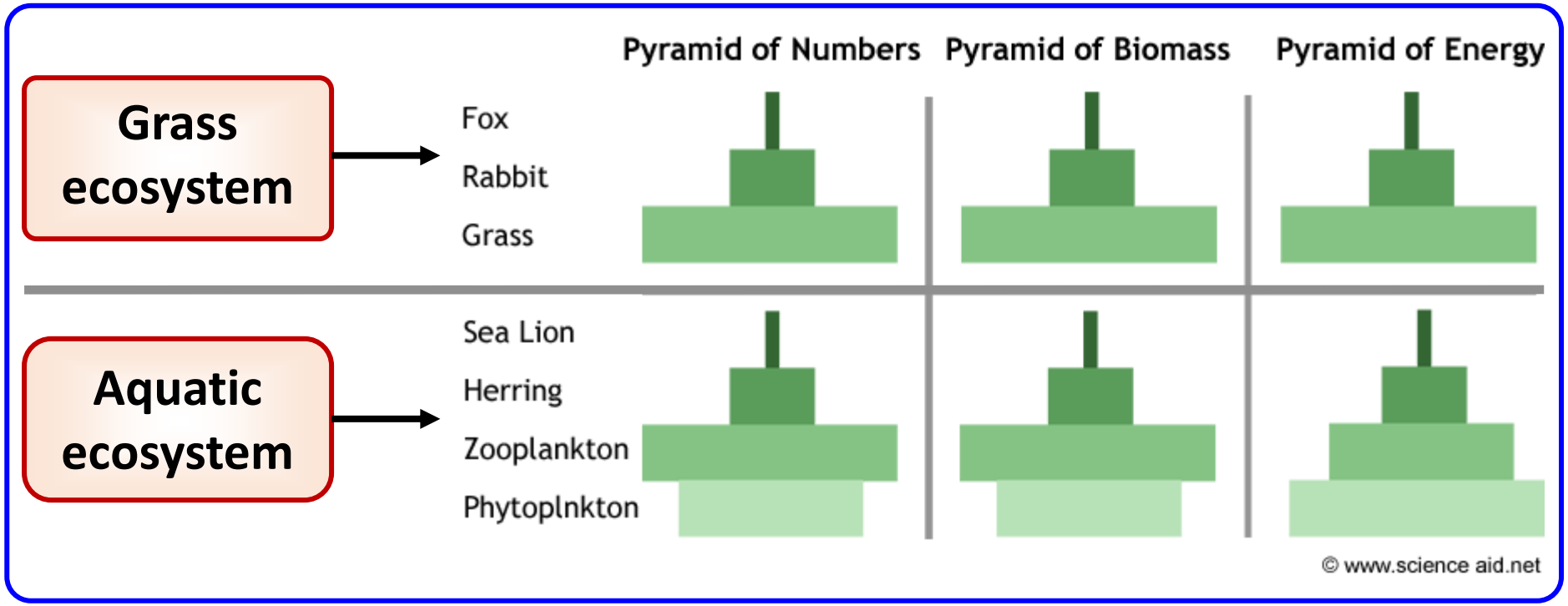
upright or inverted depends On food chain and ecosystem

Ecological Pyramid

Shapes of ecological pyramids

- The flow of energy decreases as we go from one trophic level to another and the 'energy pyramid' is always upright
- The shape of 'Pyramid of numbers' depends on the type of ecosystem and food chain. It is upright for grass systems and inverted for aquatic system
- The 'pyramid of biomass' is either upright or inverted. Inverted for pond ecosystems and upright for grassland and forest ecosystems

Shapes of ecological pyramids



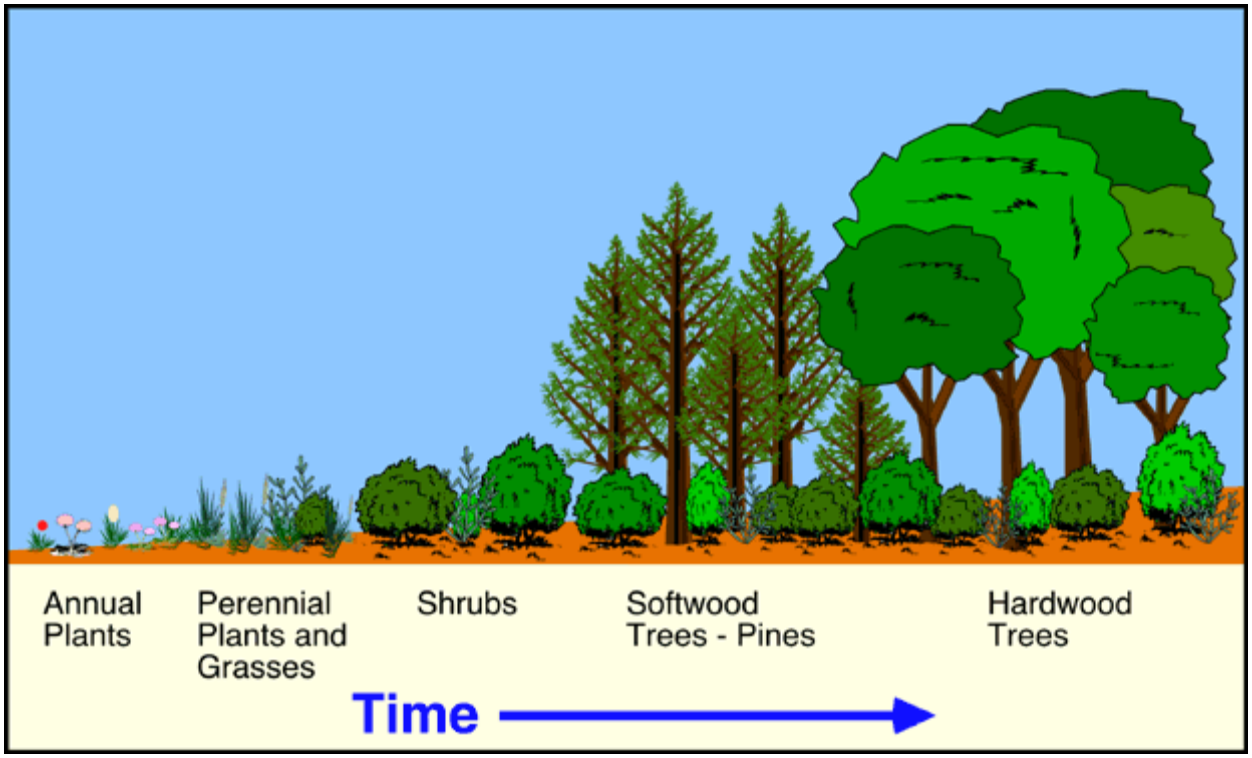
Functions and Functional attributes of an ecosystem

Ecological succession

- **Ecosystem – A dynamic system – so there will be change in Structure and Function**
- **Ecological succession** is the gradual process by which **ecosystems change and develop over time**. Nothing remains the same and habitats are constantly changing.
- The **gradual and continuous replacement of plant and animal** species by other species until eventually the **community is replaced by another type of community**.
- It occurs in stages, called **Seral stages or Seres** that can be recognized by the collection of species that dominate at that point in the succession.

Ecological succession

- Ecological Succession is defined as an orderly process of changes in the community structure and function with time mediated through modifications in the physical environment and ultimately culminating in a stabilized ecosystem known as climax.



Reasons for Succession

- Ecosystems responding/changing due to natural and human disturbances.
- In ecosystems community dynamics change as older organisms die out and new ones move in.

Reasons for ecological succession-

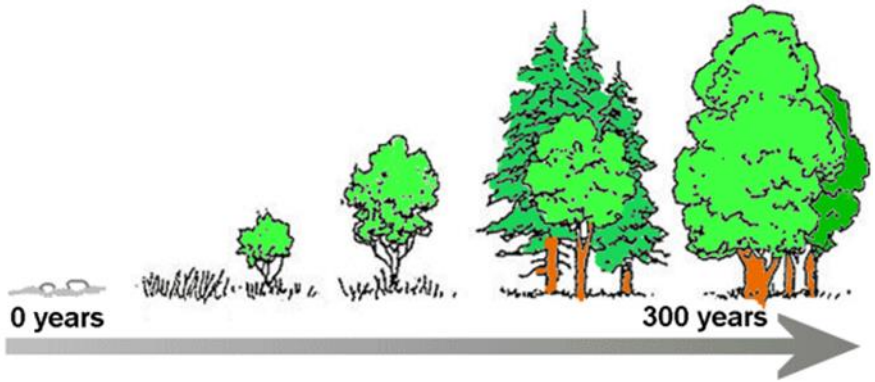
- Every species has a set of environmental conditions under which it will grow and reproduce most optimally.
- Constant temperature.
- Changed condition.
- Suddenly and drastically change.

Types of Ecological succession

Ecological succession

- **Primary succession**
- **Secondary succession**

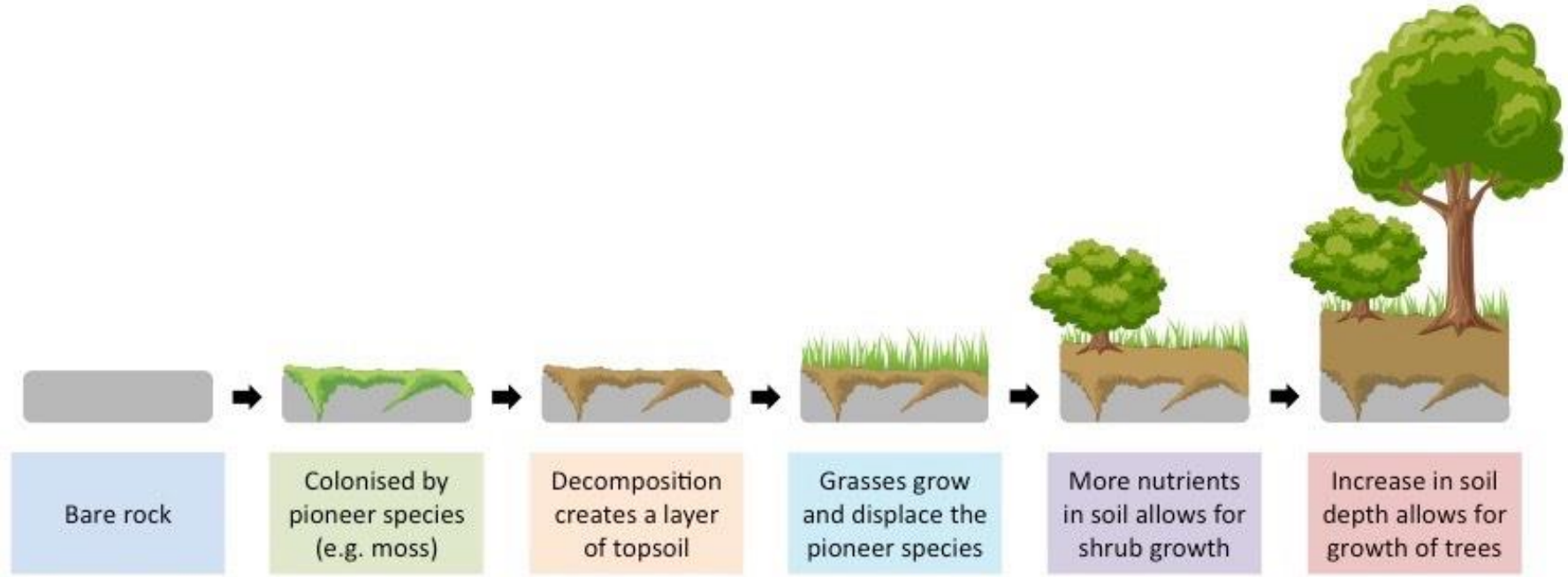
Occurs on an area of newly exposed rock or sand or lava or any area that has **not been occupied previously** by a living (biotic) community.



takes place where a community has been **removed**, e.g., in a clear cut forest

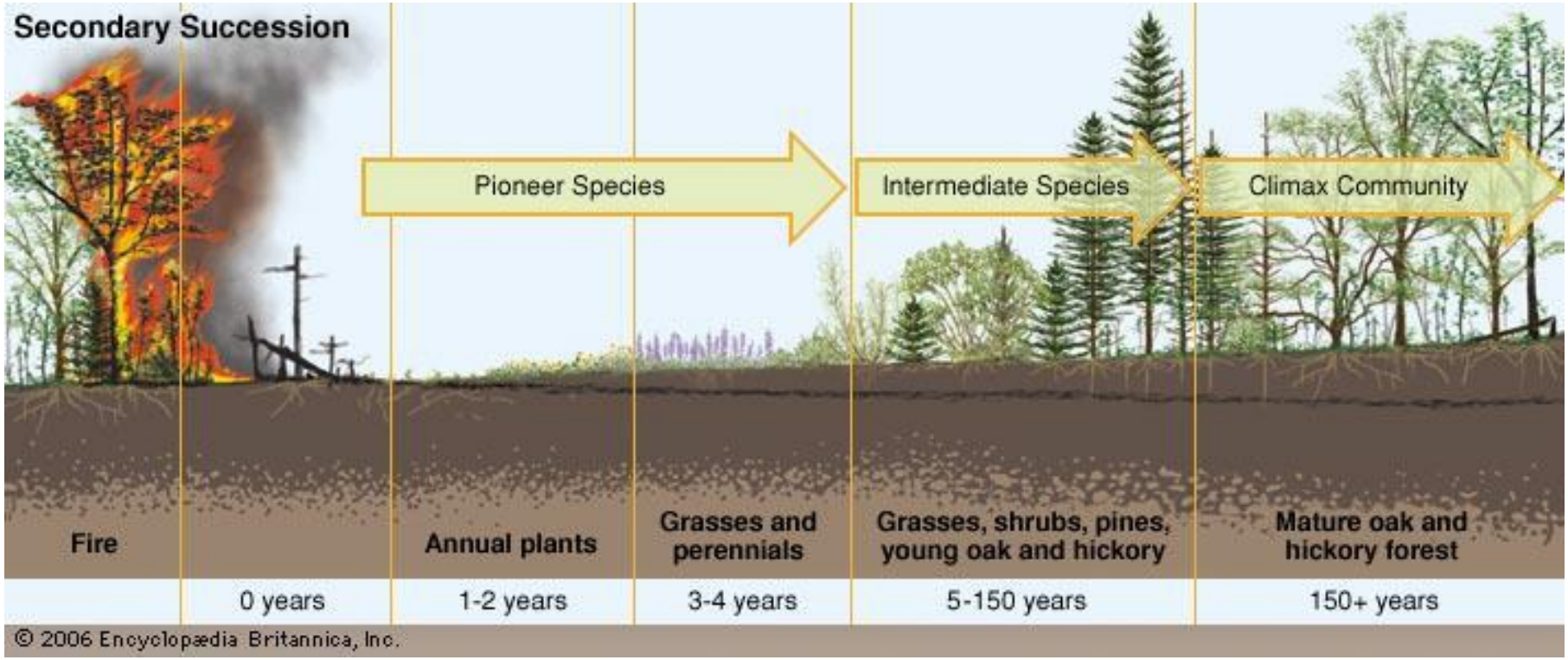
Primary Succession

- The process of creating life in an area where no life previously existed.
- For example, new land created by a volcanic eruption is colonized by various living organisms



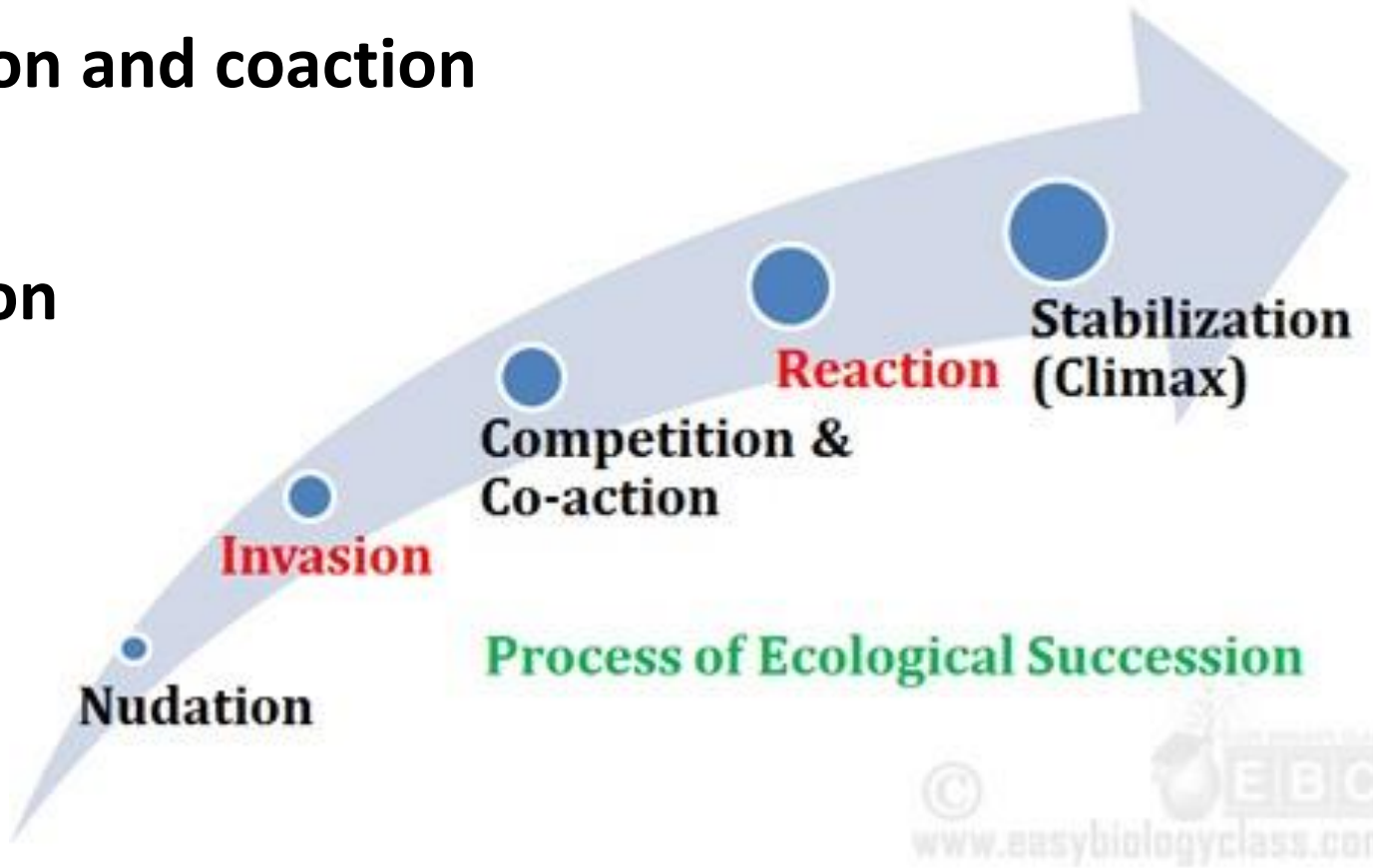
Secondary Succession

- Growth occurring after a disturbance changes a community without removing the soil



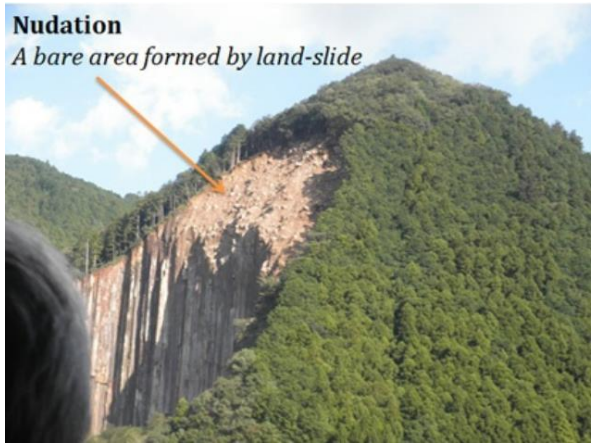
Stages in Ecological succession

1. Nudation
2. Invasion
3. Competition and coaction
4. Reaction
5. Stabilization



1. Nudation

- Development of bare area caused by land slides, volcanic eruptions, forest fires, *etc.*



2. Invasion

- Involves Establishment of one or two species on bare area.
- These first species arrived are called Pioneer species
- They do not require soil.

  e.g. Lichens

2. Invasion

- Soil starts to form as lichens and the forces of weather and erosion help break down rocks into smaller pieces

- When lichens die, they add **humus**

- This helps in growing small plants

2. Invasion

- As the plants die, they add more humus to soil
- Now bigger plants and trees can grow.

2. Invasion

3.Competition and coaction

- As the number of individual **species grow**, there is competition for space, water, nutrients etc.
- They influence each other, called **coaction**

Ecological Competitions

4. Reaction

- When vegetation grows, living organisms move in and influence the environment.
- Some species sustain, some are lost in the process
- Strong influence on the environment.

5. Stabilization

- The succession ultimately in a more or less stable community which is in equilibrium with the environment.
- This community is called climax community.

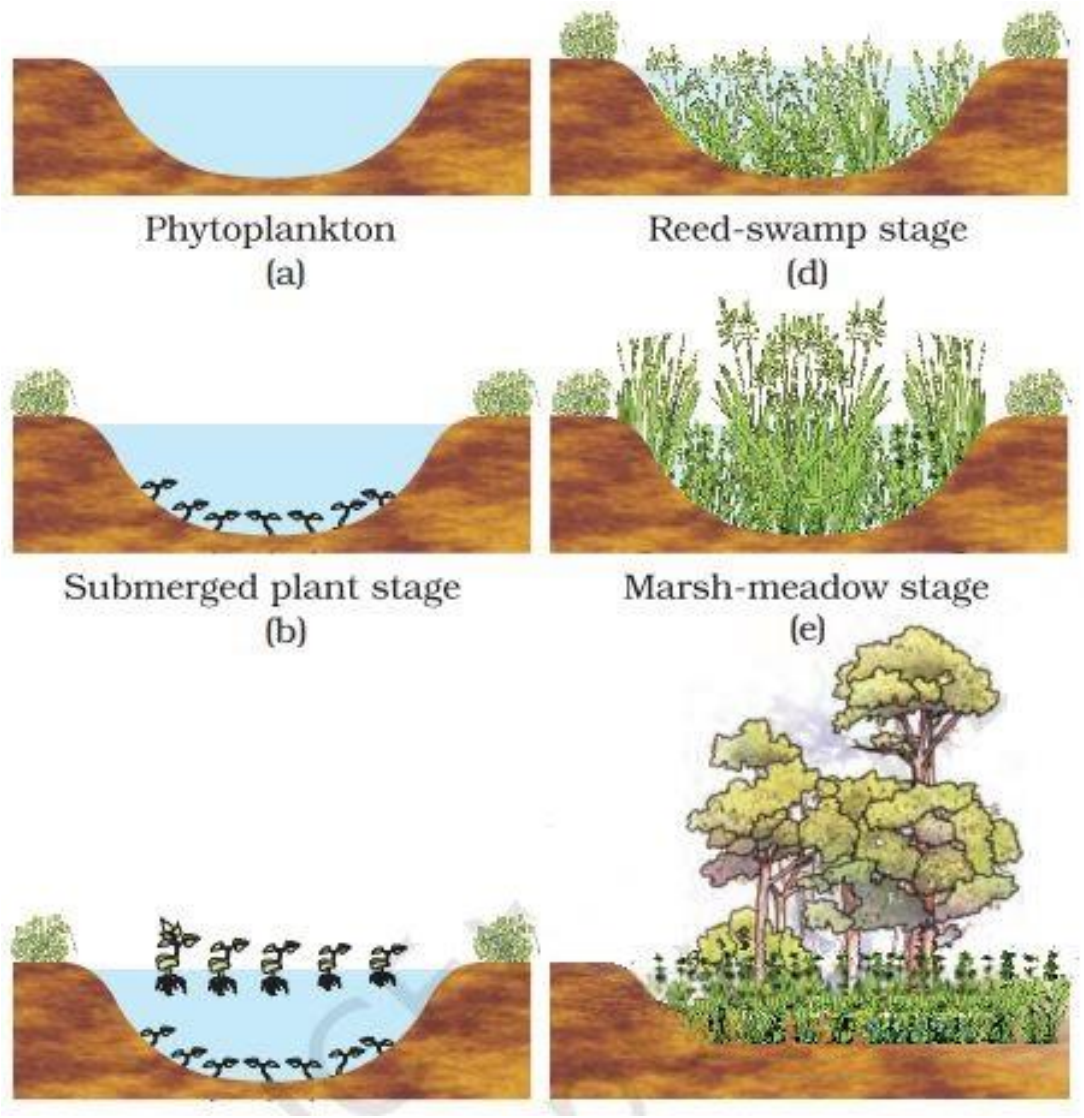
Ecological Succession – Categories

Ecological successions starting on different types of areas are named differently,

1. **Hydrarch (or) Hydrosere:** Starting in watery area like pond, lake
2. **Xerarch (or) Xerosere:** Starting in a dry area with little moisture such as bare rock, sand and saline soil
3. **Mesarch:** Starting in an area with a cool moisture condition

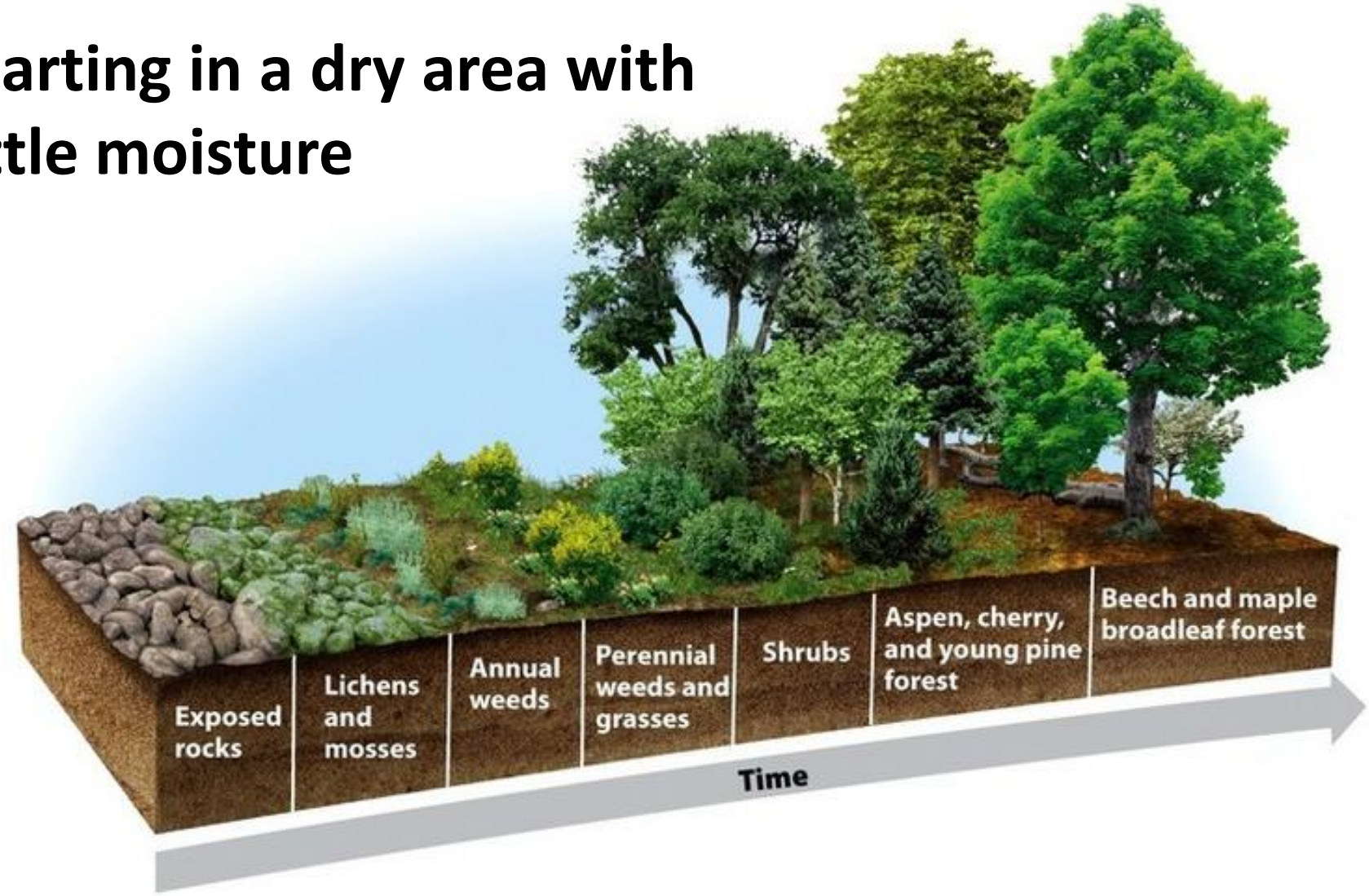
1. Hydrarch (or) Hydrosere

Starting in watery area



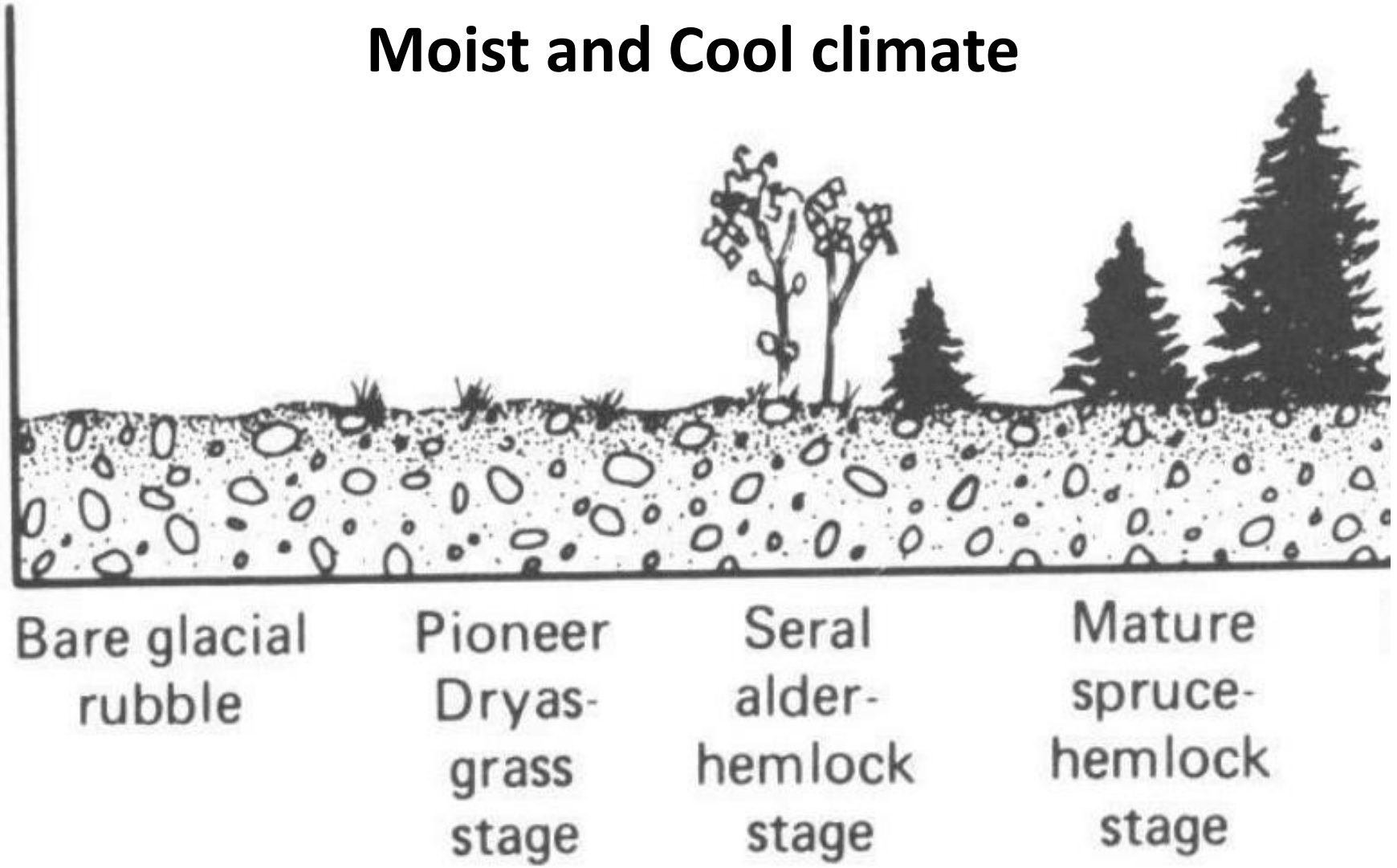
2. Xerarch (or) Xerosere

Starting in a dry area with little moisture



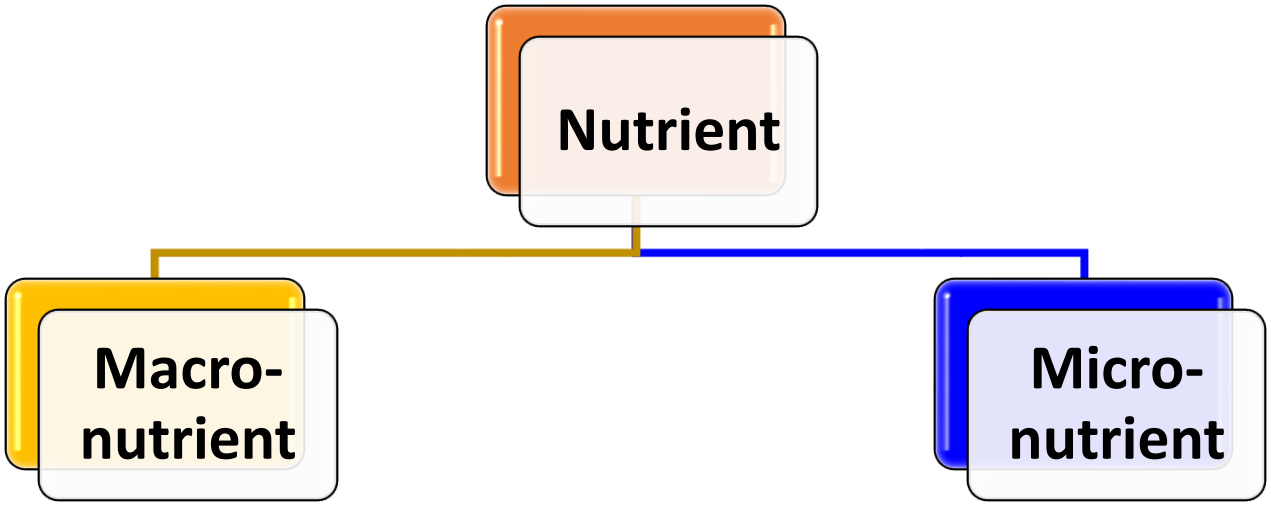
3. Mesarch

Moist and Cool climate



Nutrient

- A **nutrient** is a substance used by an organism to survive, grow, and reproduce.



The elements needed in large amounts
e.g. O_2, N_2, C, Ca, Mg & P

The elements needed in small amounts
e.g. B, Co, Sr, Zn & Cu

Both of these micronutrients and macronutrients are generally called '**Biogenic salts**'.

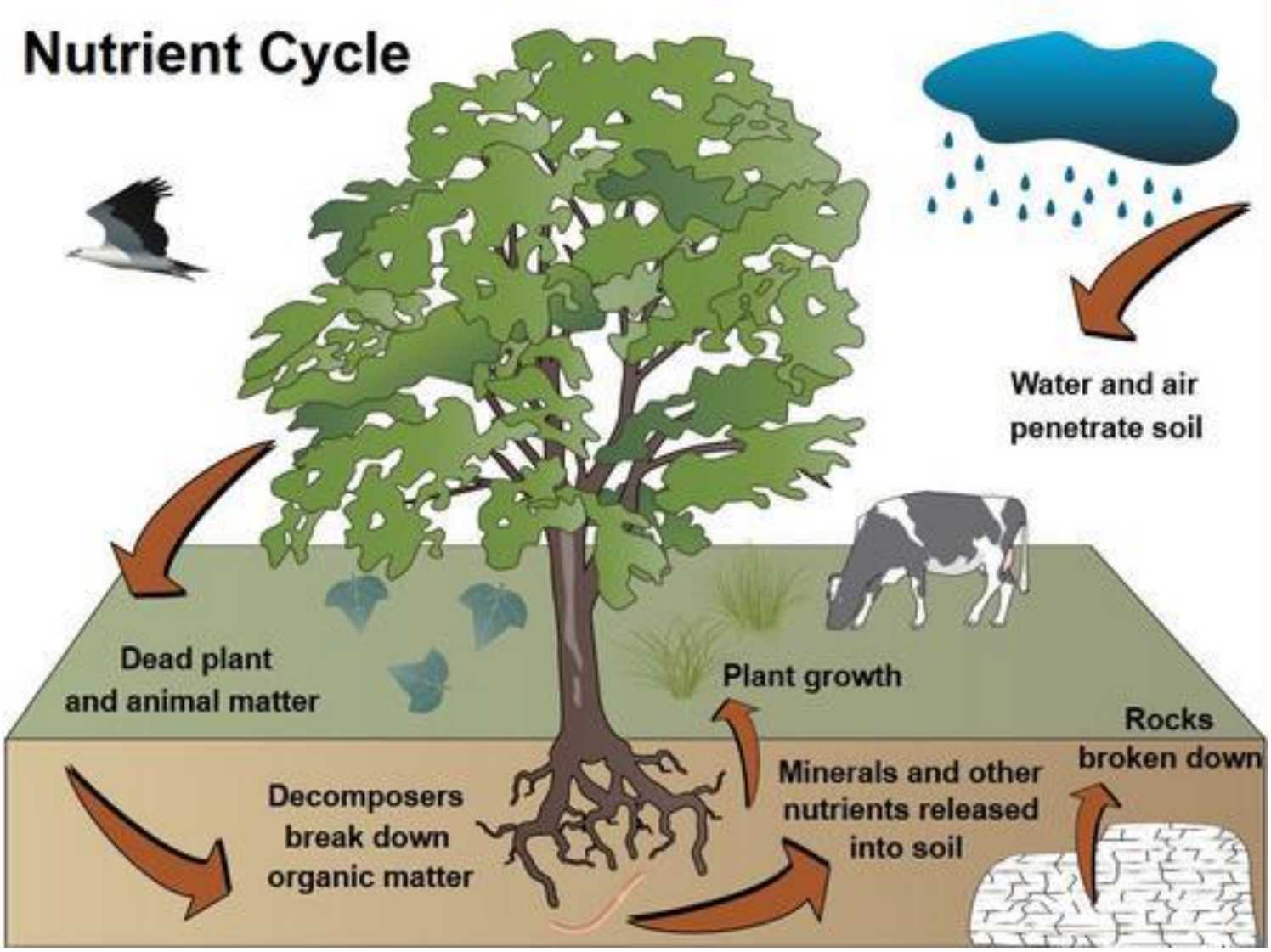
Nutrient Cycle

- The **cyclic flow of nutrients** between the biotic (living organisms within ecosystems) and abiotic (non-living matters such as air, water, soil and rock) components.
- Nutrient cycles **connect past, present and future forms of life**.
  - Some of the **carbon atom in your skin** may once have been part of a dinosaur's skin or a layer of limestone.
  - Your ancestor who lived 25,000 years ago may have inhaled some of the **nitrogen molecules** you just inhaled.

Nutrient Cycle (or) Biogeochemical Cycle

- **Nutrient cycle** are also known as **Biogeochemical cycle**
- **Biogeochemical cycle**, any of the natural pathways by which essential elements of living matter are circulated.
- The term biogeochemical is a contraction that refers to the consideration of the **biological, geological, and chemical** aspects of each cycle.
- In order for the **living components** of a major ecosystem (e.g., a lake or a forest) **to survive**, all the chemical elements that make up living cells must be recycled continuously.

Nutrient Cycle (or) Biogeochemical Cycle



Nutrient Cycle (or) Biogeochemical Cycle

Nutrient Cycle (or) Biogeochemical Cycle includes

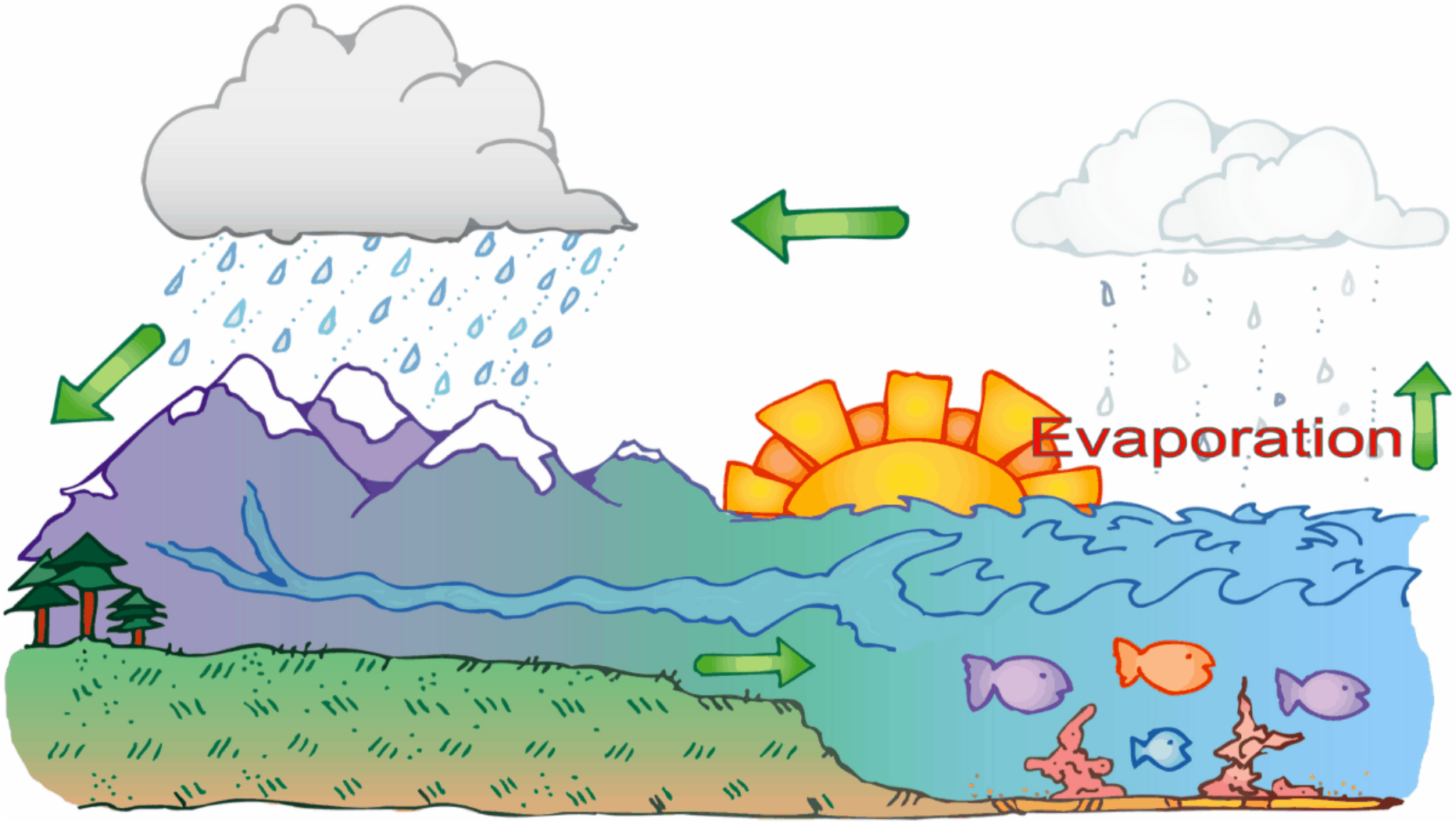
1. **Water Cycle**
2. **Carbon Cycle**
3. **Nitrogen Cycle**
4. Phosphorous Cycle
5. Sulphur Cycle

Effect of Human activities on these cycles

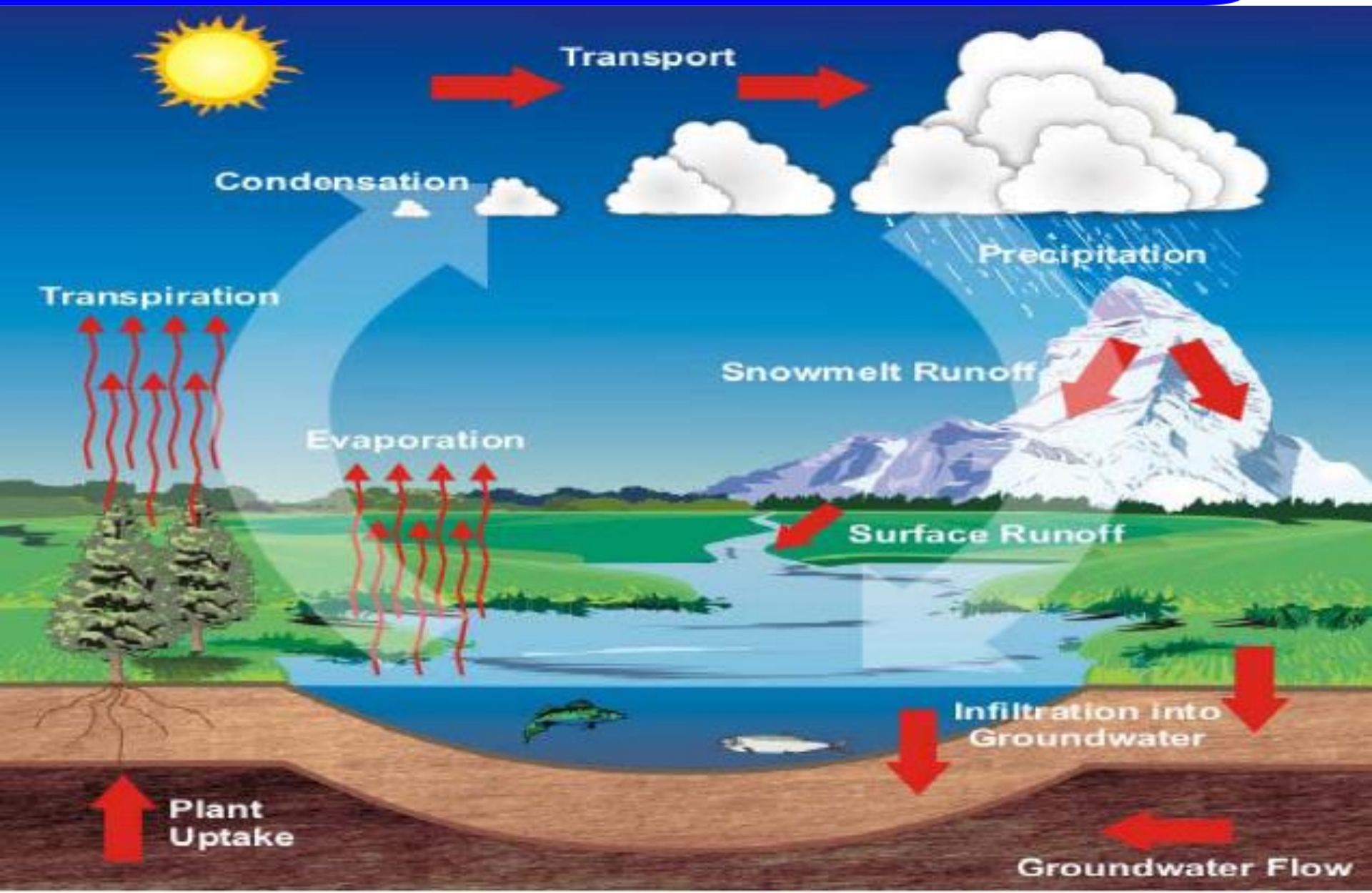
1. Water cycle (or) hydrological cycle

- The hydrological/water cycle collects, purifies and distributes the earth's fixed supply of water.
- Powered by energy from the sun and involves **3 major processes**
  - **Evaporation**: Incoming solar energy causes evaporation of water from the Earth's oceans, lakes, rivers and soil.
  - **Precipitation**: Gravity draws the water back to the earth's surface as precipitation (rain, snow)
  - **Transpiration**: 90 % of the water that is precipitated evaporates back into the atmosphere from the surfaces of plants (through a process called transpiration) and from the soil.

1. Water cycle (or) hydrological cycle



1. Water cycle (or) hydrological cycle



Effect of human activities on Water cycle

- One human activity that can impact the water cycle is **deforestation**.
- A primary way that **fresh water returns to the atmosphere is transpiration** from dense tropical forests.

- As a result of tropical deforestation, the amount of water vapour added to the atmosphere is **greatly reduced**.
- This changes **precipitation patterns** and **affects ecosystems**.

2. Carbon Cycle

- Carbon is the basic building block of the carbohydrates, fats, proteins, DNA and other organic compounds necessary for life.
- The carbon cycle is based on CO_2 gas (0.039 % of volume of the earth's atmosphere), and it is dissolved in water.

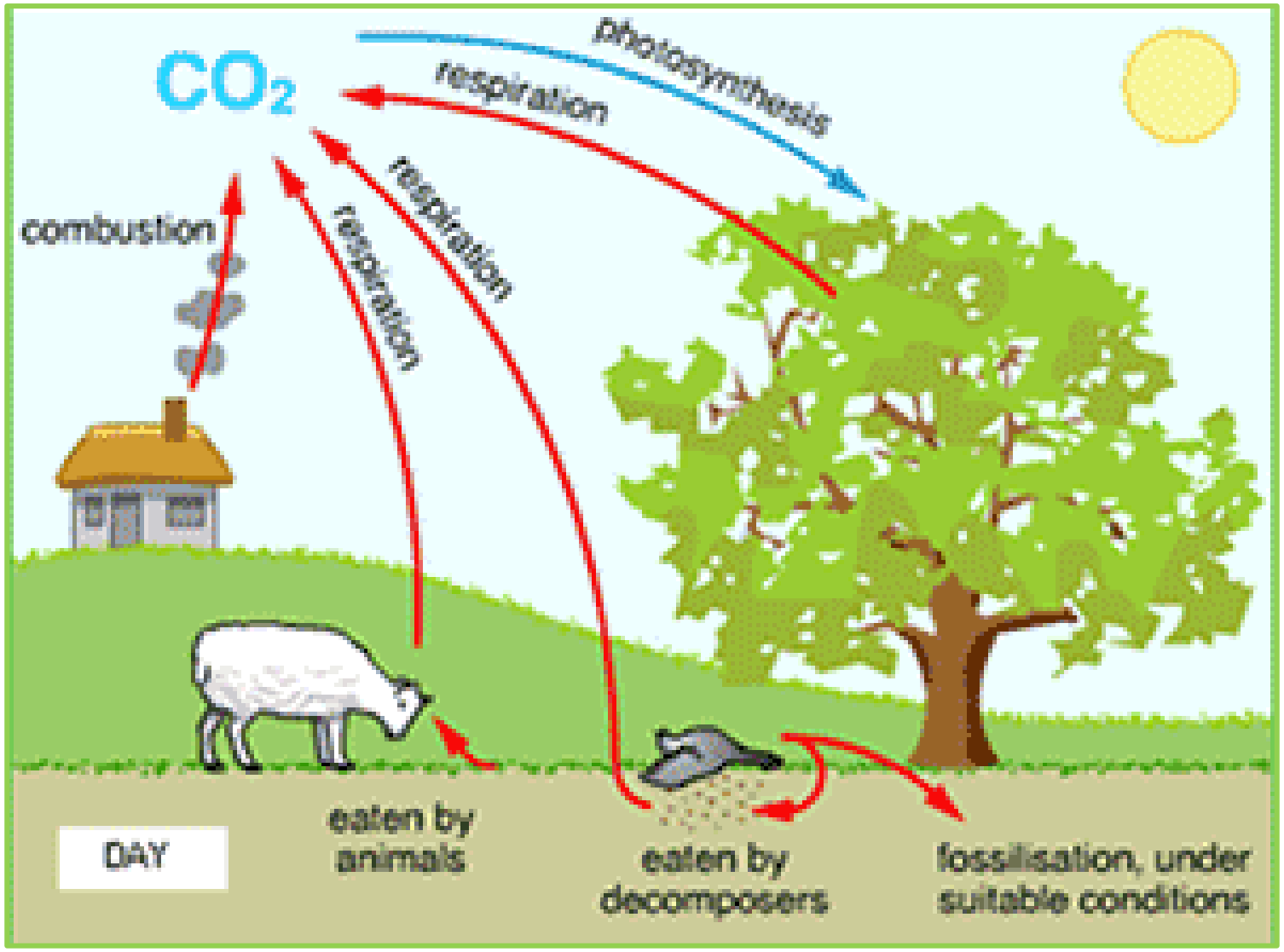
CO_2 is a key component of the atmosphere's thermostat.

- If the carbon cycle removes too much CO_2 from the atmosphere, the atmosphere will cool.
- If the carbon cycle generates too much CO_2, the atmosphere will get warmer.

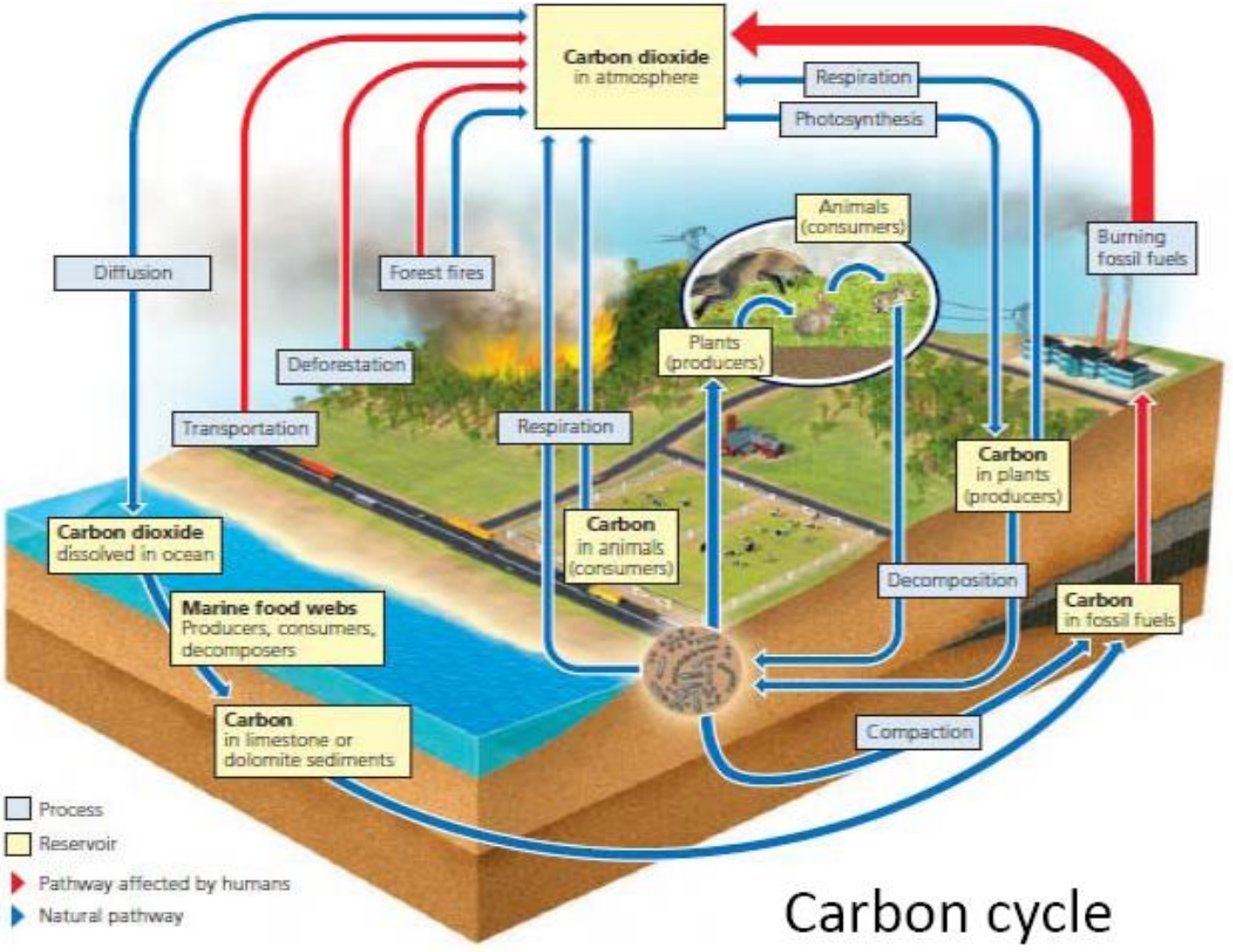
2. Carbon Cycle

- **Terrestrial Producers** remove CO_2 from the atmosphere.
- **Aquatic Producers** remove CO_2 from the water.
- **Consumers and decomposers** carry out aerobic respiration. This process breaks down glucose, and other complex organic compounds to produce CO_2 in the atmosphere and water for reuse by **producers**.
- Linkage between photosynthesis in producers and aerobic respiration in consumers and decomposers circulates carbon in the biosphere.

2. Carbon Cycle



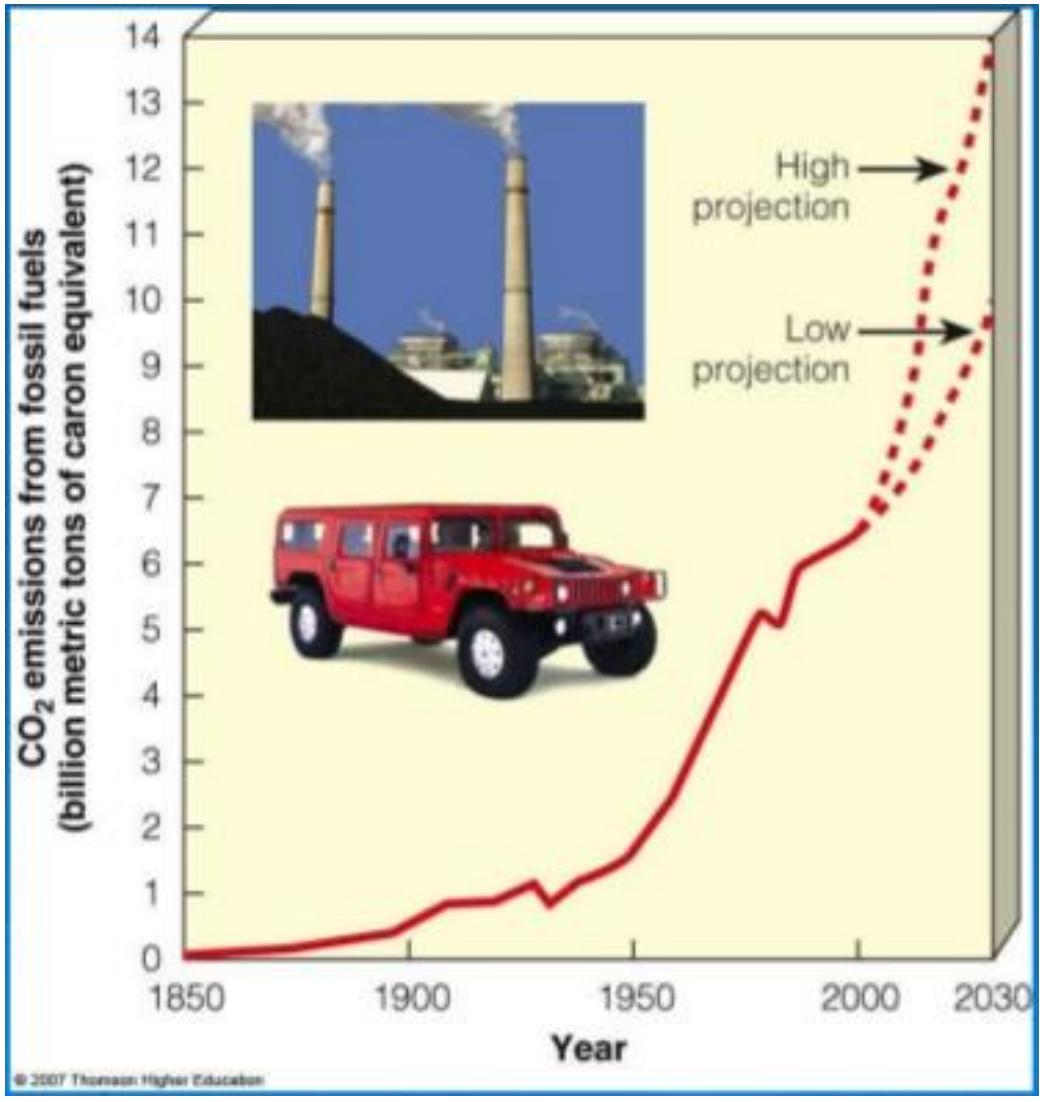
2. Carbon Cycle



Carbon cycle

Effect of Human Activities on Carbon Cycle

- We alter the carbon cycle by adding excess CO_2 to the atmosphere through
  - ➢ Burning fossil fuels.
  - ➢ Clearing vegetation faster than it is replaces



3. Nitrogen cycle

- N_2 gas makes up 78 % volume of the atmosphere.
- Nitrogen - is a crucial component of proteins, many vitamins and nucleic acids such as DNA.
- N_2 cannot be absorbed and used directly as a nutrient by multicellular plants/animals.
- **Two natural processes convert/fix N_2** into nutrients which can be used by plants and animals.
    1. **Electrical discharge/lightning** taking place in the atmosphere.
    2. In aquatic systems, in soil, and in the roots of some plants, nitrogen fixing bacteria completes this conversion as part of nitrogen cycle.

3. Nitrogen cycle – Steps

Nitrogen fixation

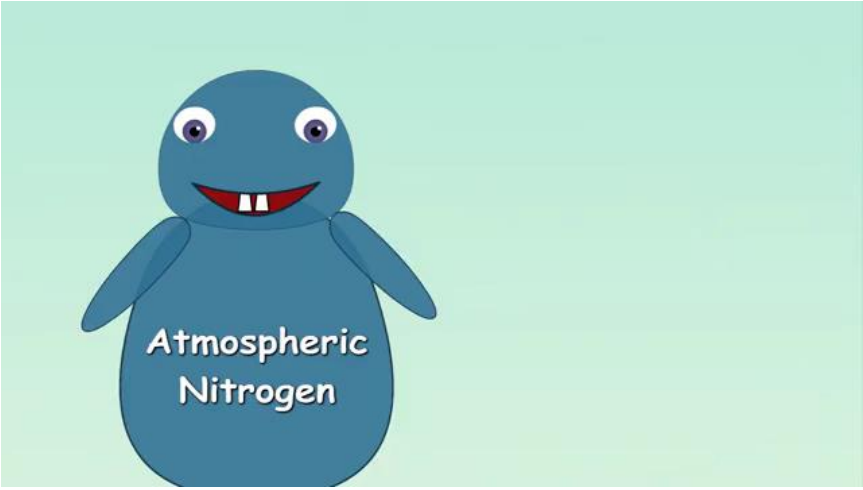
Nitrogen cycle consists of several major steps

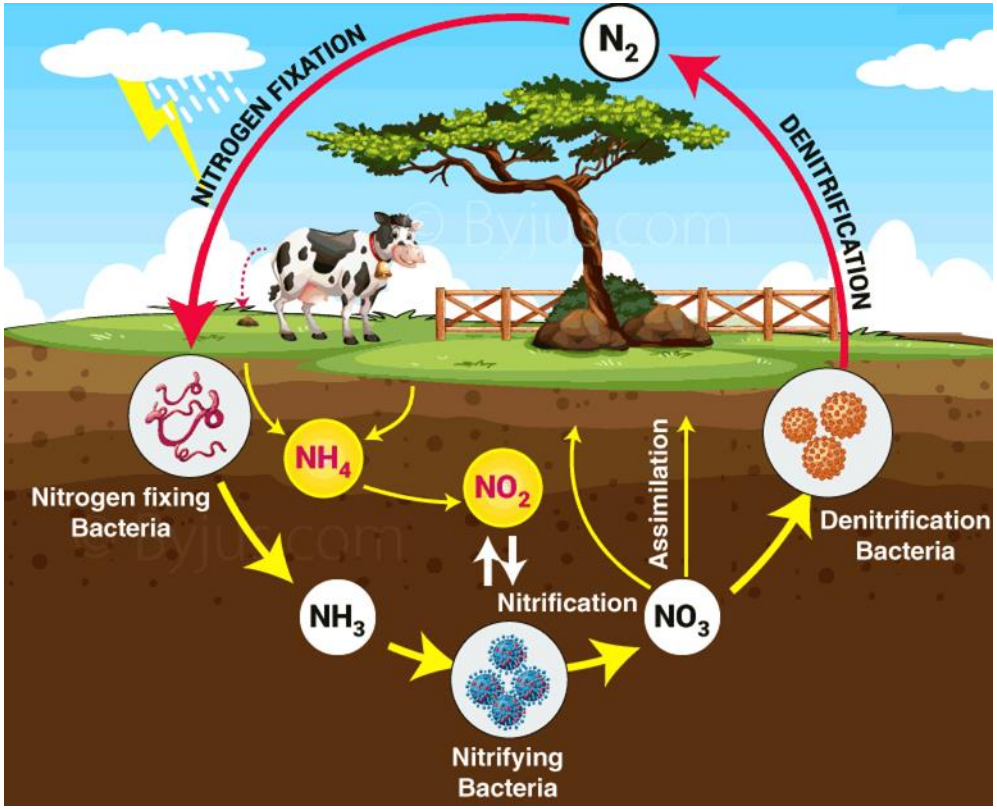
1. Specialized bacteria in soil as well as blue green algae (cyanobacteria) in aquatic environment combine gaseous N_2 with hydrogen to make ammonia (NH_3).
2. The bacteria use some of the NH_3 as nutrient and excrete the rest into the soil / water.
3. Some of the NH_3 is converted to ammonium ions (NH_4^+) – plants can use as a nutrient.
4. These gases released to the atmosphere to begin the nitrogen cycle again.

3. Nitrogen cycle – Steps

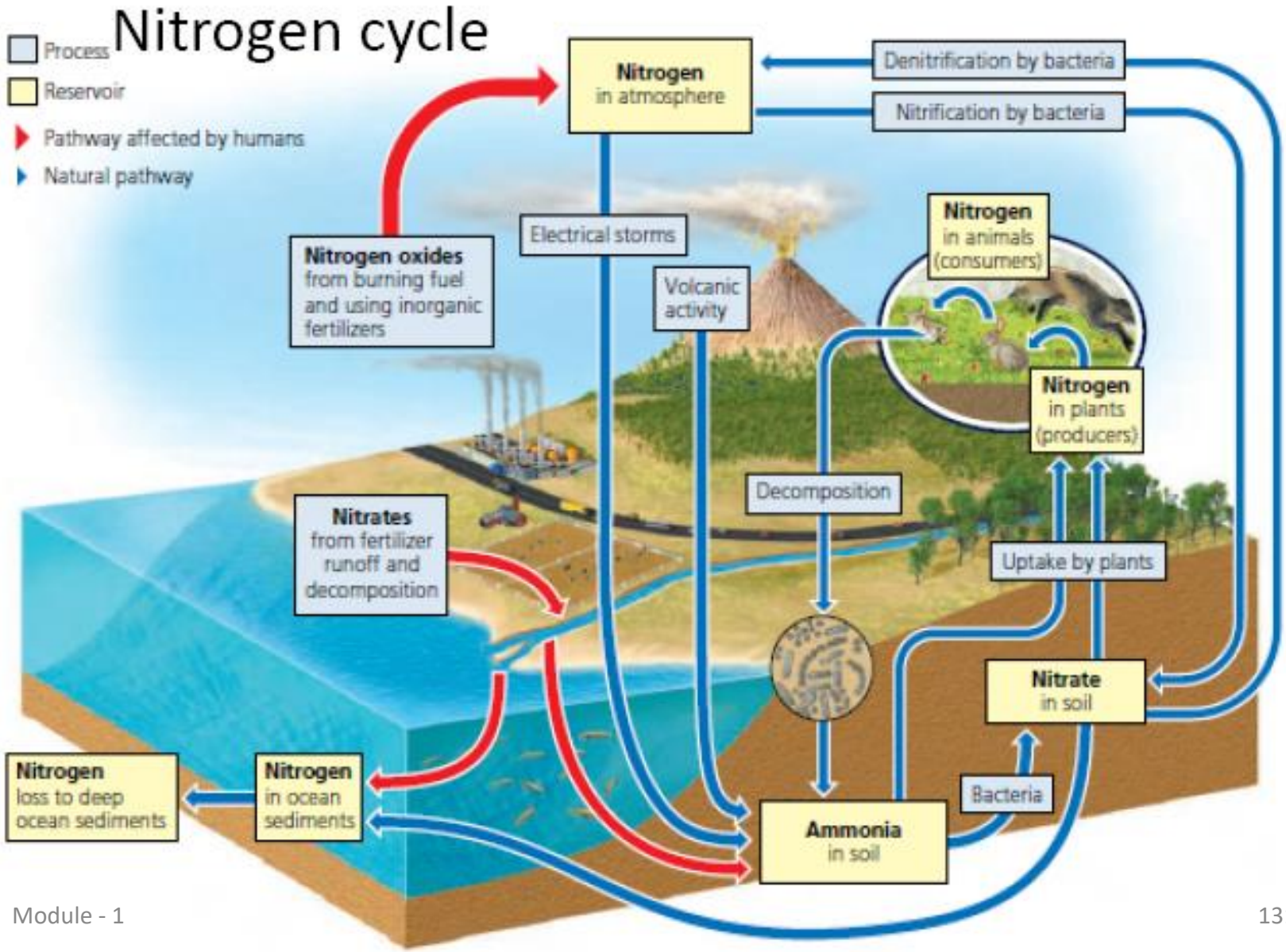
5. Plants and animals return nitrogen – rich organic compounds to the environments through wastes and cast-off particles of tissues such as leaves, skin or hair and through their bodies when they die. and are decomposed or eaten by detritus feeders.
6. In ammonification, specialized decomposing bacteria converts this detritus into simpler nitrogen containing inorganic compounds such as NH_3 and water soluble salts containing ammonium ions NH_4^+.
7. In de-nitrification, specialized bacteria in waterlogged soil and in the bottom sediments of lakes, oceans convert NH_3 and NH_4^+ back into nitrate ions (NO_3^-), and then into N_2 gas.
8. These gases released to the atmosphere to begin the nitrogen cycle again.

3. Nitrogen cycle





3. Nitrogen cycle



Effect of Human Activities on Nitrogen Cycle

- Human activities such as production of fertilizers now fix more nitrogen than all natural sources combined