RIZVI COLLEGE OF ARTS SCIENCE AND COMMERCE

Chap 14 – Ecosystem and Energy Flow

Class : SYJC Science

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ECOSYSTEM AND ENERGY FLOW

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Ecosystem

→An ecosystem is a **self regulatory** and **self sustaining** structural and **functional unit** of nature (biosphere).

→ Contains both **biotic** and **abiotic** components.

→ Biotic components interact with **each other** and also with the **surrounding** environment.

→ Ecosystem vary in size…….

Small pond ---------- **Large oceans**

small farmland …… **Village**

→ **Biosphere** can be considered as one global ecosystem.

Earth ecosystem too big and complex to study so divided into two basic categories.

Terrestrial

→Forest

→Grassland

→Dessert

Aquatic

→Lakes

→Wetlands

→Rivers

→Estuaries

The ecosystem can also be classified into….

Natural ecosystem

Do not require any human inputs, in other words they are self-sustainable.

Eg. → **Oceans**

→ **Grassland**

Artificial ecosystem

Requires constant input in terms of energy or materials.

Eg. → **A farm land**

→ **A fish tank**

→ **A large pond used for rearing fish.**

Ecosystem – Structure

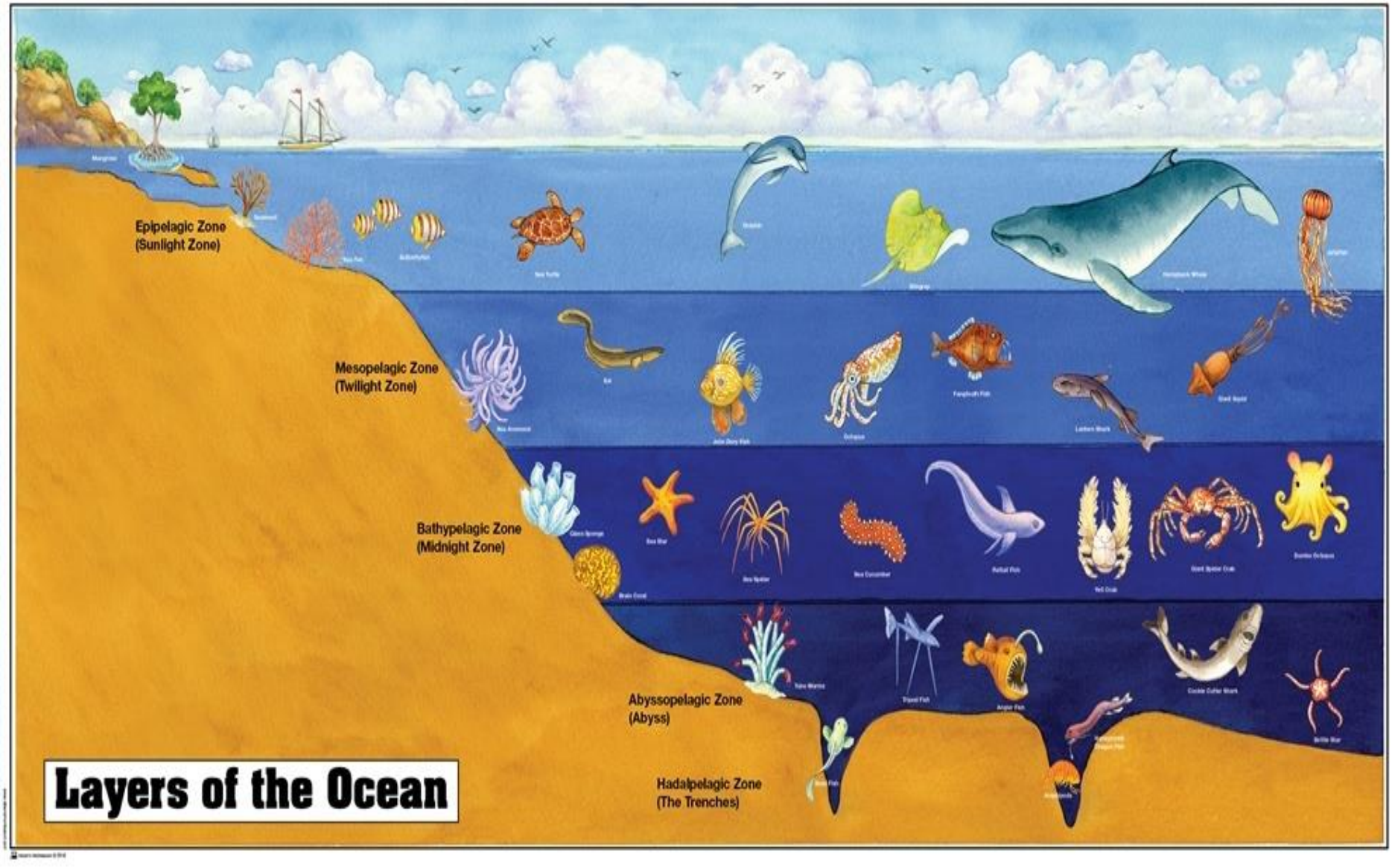
→ **Biotic** and **Abiotic** factors differ as the locations vary in space and time.

→ The variation due to **space** is results in spatial pattern.

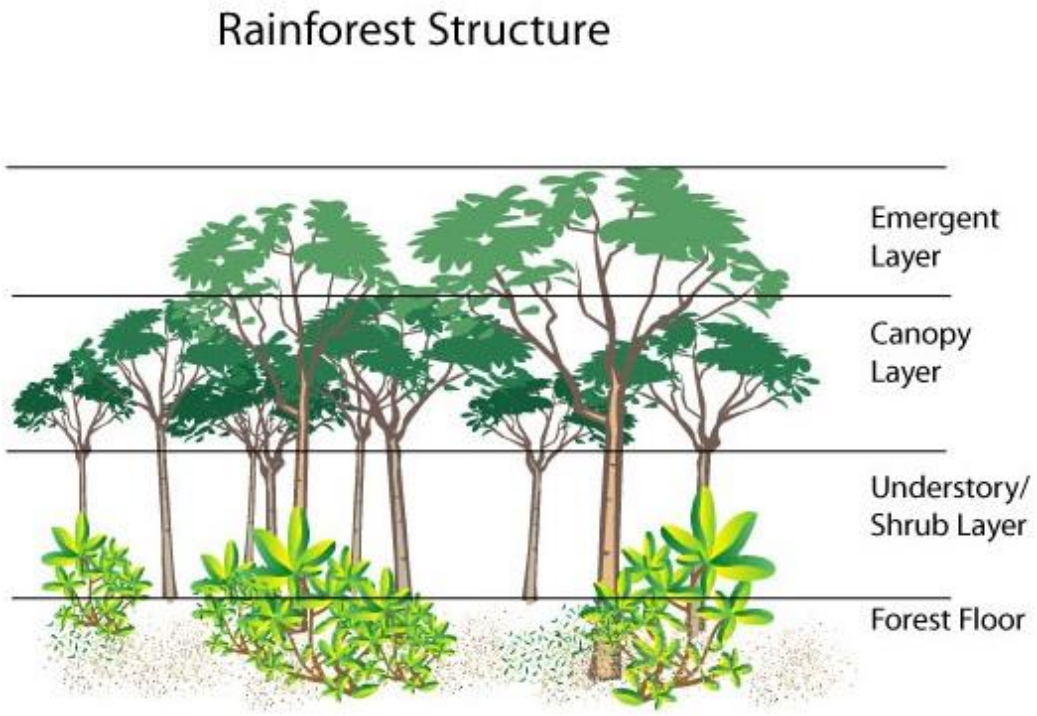
→ Two types of spatial pattern are…

- **Stratification**
- **Zonation**.

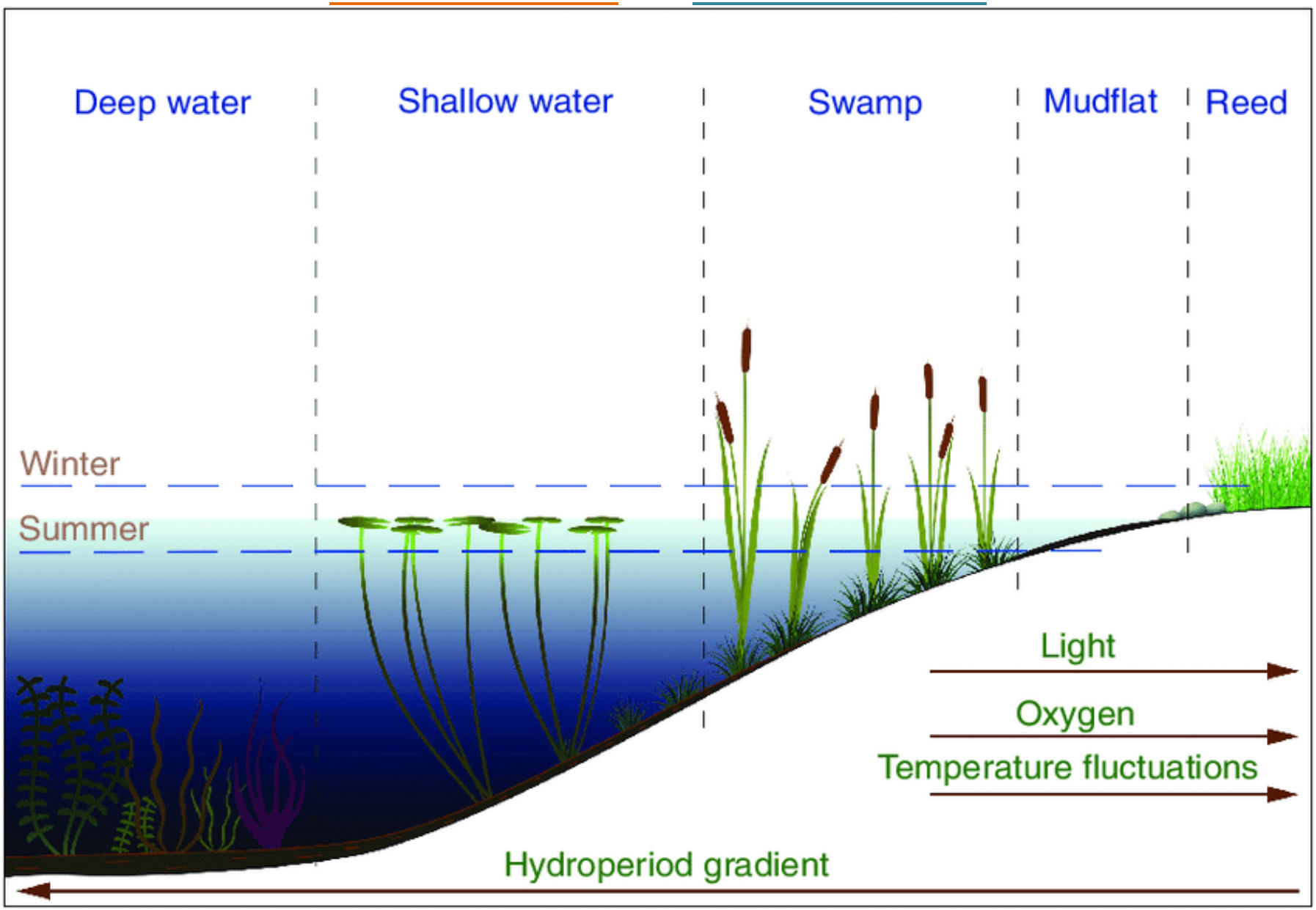
Stratification -- Ocean



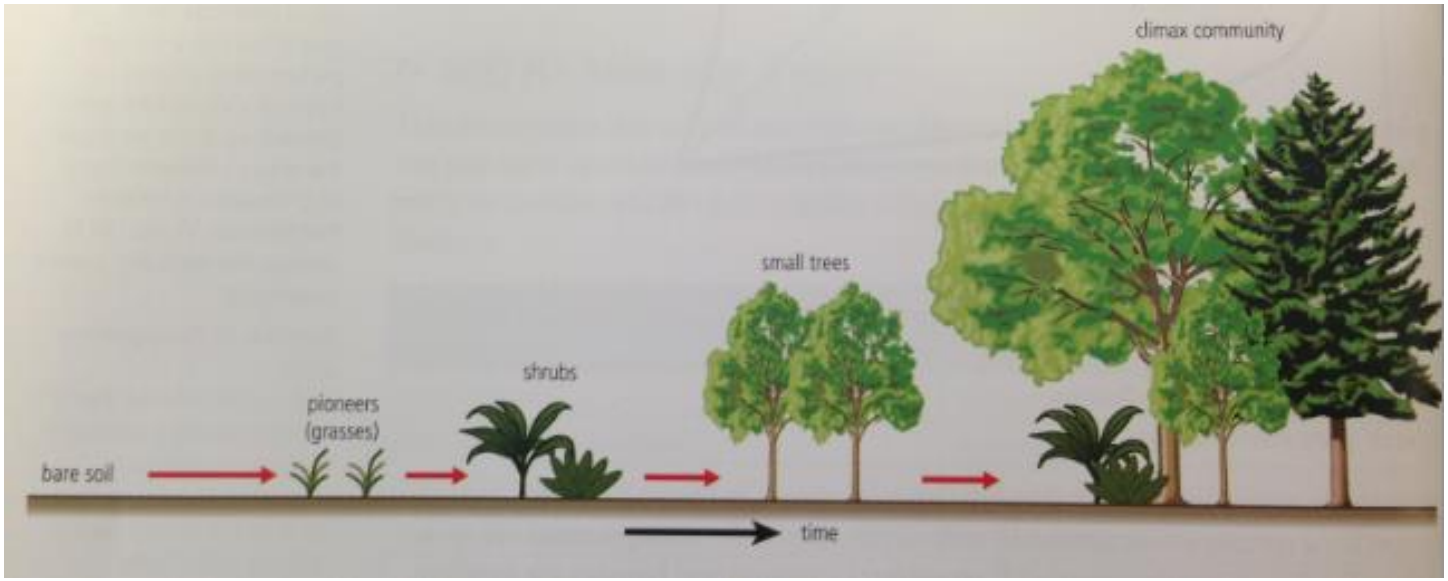
Stratification -- forest



Zonation – Wet land



Zonation – Terrestriral land



Spatial pattern

Stratification

→Vertical distribution of different species of plants and animals occupying different levels.

→Observed in both aquatic and terrestrial ecosystem.

→**Eg**

***Tress occupy top vertical strata or layer of a forest,**

***Second Shrubs**

***Herbs and**

***Grasses occupy bottom layer.**

Zonation

→Horizontal distribution of plants and animals on land and in water.

→Observed in both aquatic and terrestrial ecosystem.

→**Eg**

***Edges of lake or beach in the form of Inter-tidal, Littoral, Sub-littoral zones**

Ecosystem -- function

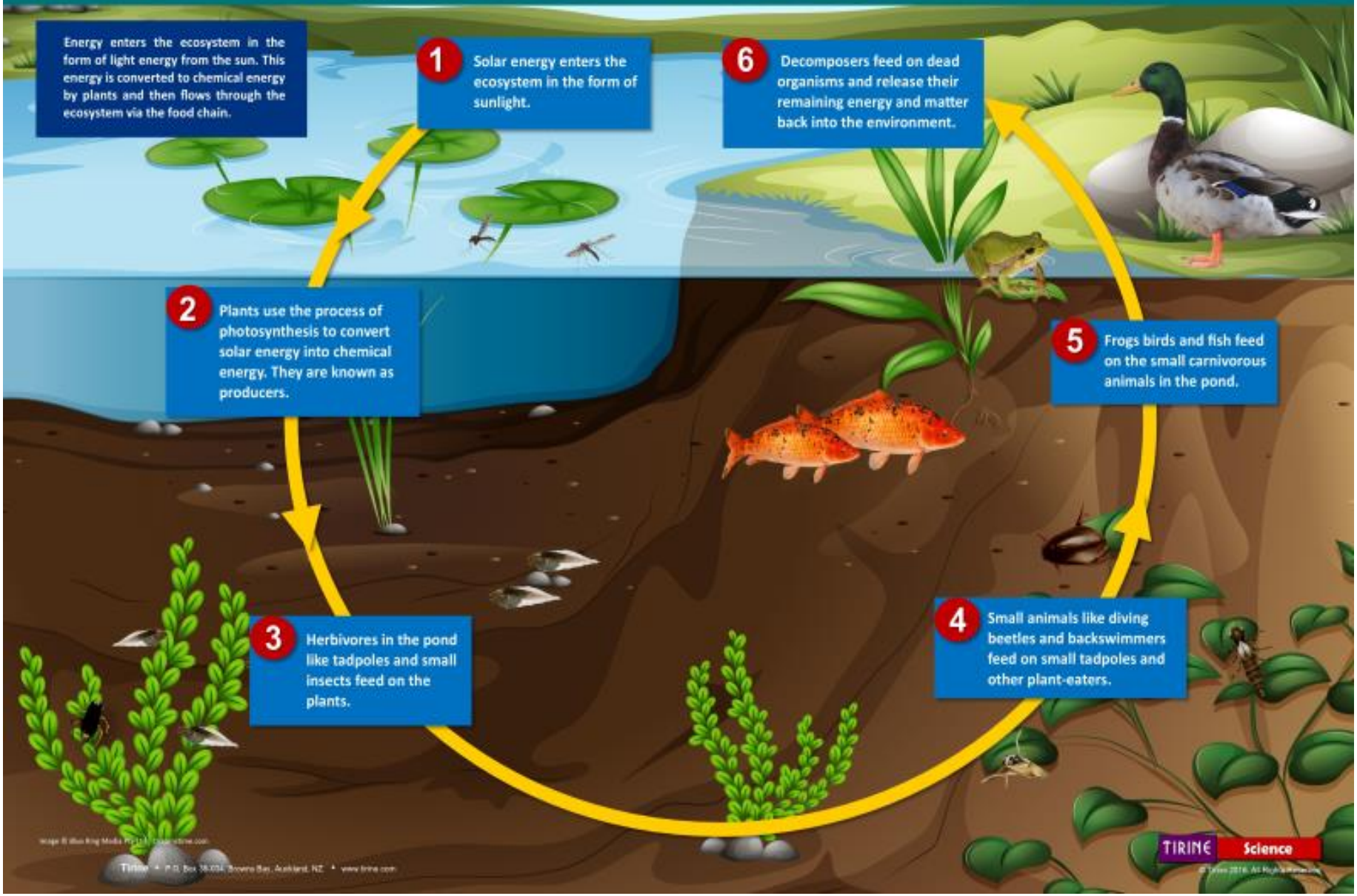
The biotic and abiotic components of an ecosystem are all linked together to function as an "Ecosystem unit" through various processes like ....

- Productivity – Conversion of inorganic chemicals into organic material with the help of the radiant energy of the sun by the autotrophs and consumption of autotrophs by heterotrophs.
- Decomposotion – Breakdown of dead organic material and mineralization of the dead matter.
- Nutrient cycling – Storage and transport of nutrients.
- Energy flow – Unidirectional flow of energy from producers to consumers and finally dissipation and loss as heat.

Biological Sciences

Ecosystems

Energy Flow in an Ecosystem



Eg. POND

→Pond is **shallow water body** in which all the above four basic processes of an ecosystem are observed.

→A **biotic component** in water with all the **dissolved inorganic** and **organic substances** and **rich soil** deposit at bottom of pond.

→**Solar input**, **cycles of temperature**, **day-length** and other climatic conditions regulate the rate of function of the entire pond.

→**Producers** – **Phytoplankton algae** and other **aquatic plants**.

→**Consumers** – **zooplankton**, aquatic **insects** and **fish.**

→**Decomposers** – **fungi, bacteria** located at the bottom of the pond.

A -- Productivity

→Productivity refers to the **rate of generation of biomass** in an ecosystem.

→It is expressed in units of **mass/ unit surface/volume unit time.**

→Divided into **Gross primary productivity** (GPP)
Net primary productivity (NPP)

GROSS PRIMARY PRODUCTIVITY (GPP)

→*Rate of production of organic matter during photosynthesis.*

→*Plants themselves use a considerable proportion of this GPP for their respiration.*

→*Hence, gross primary productivity minus respiratory losses (R) constitute the net primary productivity (NPP).*

NET PRIMARY PRODUCTIVITY (NPP)

→ Available biomass for the consumption, to heterotrophs (herbivores, carnivores and decomposers).

→ The annual net primary productivity of the whole biosphere is approximately 170 billion tons (dry weight) of organic matter.

→ Productivity of the oceans is only 55 billion tons.

-- GPP depends on the plant species inhabiting a particular area, variety of environmental factors, availability of nutrients and photosynthetic capacity of plants.

-- It varies in different types of ecosystem.

Secondary productivity

→Rate of formation of organic matter by consumers.

→It is rate of assimilation of food energy at the level of consumers.

→It is amount of energy available to consumer for the next trophic level.

DECOMPOSITION

Definition

Decomposers break down complex organic matter into inorganic substances like carbon dioxide, water and nutrients, and the process is called decomposition.

Dead remains of plants and *animals*, including *fecal matter*, constitute *detritus*, which is the *raw material* of decomposition.

Important steps in the process of decomposition are …….

1. **Fragmentation**:
   →Detrivores (eg. **earthworm**) **break down** detritus into **smaller fragments** or **particles**.

2. Leaching:

→**Water soluble inorganic nutrients** go down into the soil horizon and **get precipitated** as unavailable **salts**.

3. Catabolism:

→**Bacterial** and **fungal enzymes** degrade detritus into **simpler inorganic substances**.

4. Humification:

→Humification leads to **accumulation** of **partially decomposed**, a **dark coloured**, **amorphous**, **colloidal organic** substance, called **humus**.

It is **resistant to microbial action** and undergo decomposition at an extremely slow rate.

5. Mineralization

→Humus is further degraded by **some microbes** and **release of inorganic nutrients** occur by the process known as mineralization.

- Warm, moist environment and presence of oxygen favours decomposition.

- Low temperature and anaerobic conditions inhibit decomposition.

Energy flow

→ Sun is the only source of energy for all ecosystems on the earth except for the deep-sea ecosystems.

→ Of the total incident solar radiations, less than 50% of it is photo-synthetically active radiations (PAR).

→ Plants and photosynthetic bacteria fix energy to prepare food from simple inorganic materials.

→ Plants capture only 2-10% of the PAR and this small amount of energy sustains the entire living world.

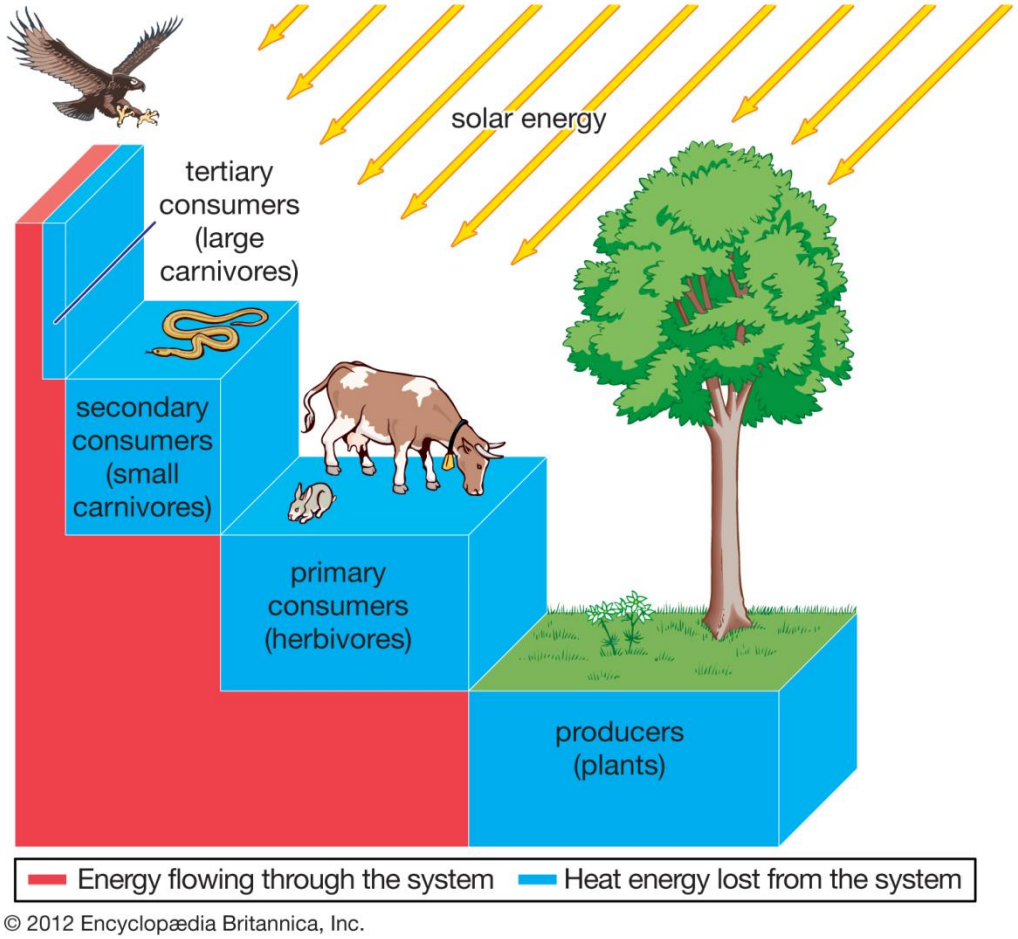
→ There is unidirectional flow of energy from

SUN ⟶ PRODUCER ⟶ CONSUMERS

→ Direction can never be reversed.

→ Energy can be used only once in the ecosystem.

Energy Flow in Ecosystem



Energy flow in ecosystem

→**Autotrophs** need **constant supply of energy** to synthesize the molecules they require.

→ Autotrophs are called **producers.**

→ ***Terrestrial producers*** – herbaceous and woody plants.

Aquatic producers – Phytoplankton and algae.

❖ All **animals** depend directly or indirectly on plants for their food.

❖ They are called **consumers.**

Consumers (Heterotrophs)		
Primary consumers	**Secondary consumers**	**Tertiary consumers**
→ They feed directly on plants. (Producers)	→ They eat primary consumer	→ They eat secondary consumers
→ They are also called **Herbivores.**	→ They are also called Primary **Carnivores**.	→ They are also called as **Secondary Carnivores.**

There are three types of food chains..

1. Grazing food chain.

2. Detritus food chain.

3. Parasitic food chain.

Grazing food chain

Grass →	Deer →	Leopad
(Producer)	(Primary Consumer)	(Sec. Consumer)

- **Plants** are eaten by primary consumer(**herbivore**) which in turn is eaten up by secondary consumer(**carnivore**)
- Energy trapped by producer is transferred from one to other consumer or remains trapped till the producer organisms dies.

Detritus Food Chain

→ **Death of an organism** is the beginning of the detritus food chain/web.

→ It begins with **dead organic matter**.

→ It is composed of decomposers which are heterotrophic organisms, mainly **fungi** and **bacteria**.

→ Decomposers meet their requirements by **degrading** the detritus.

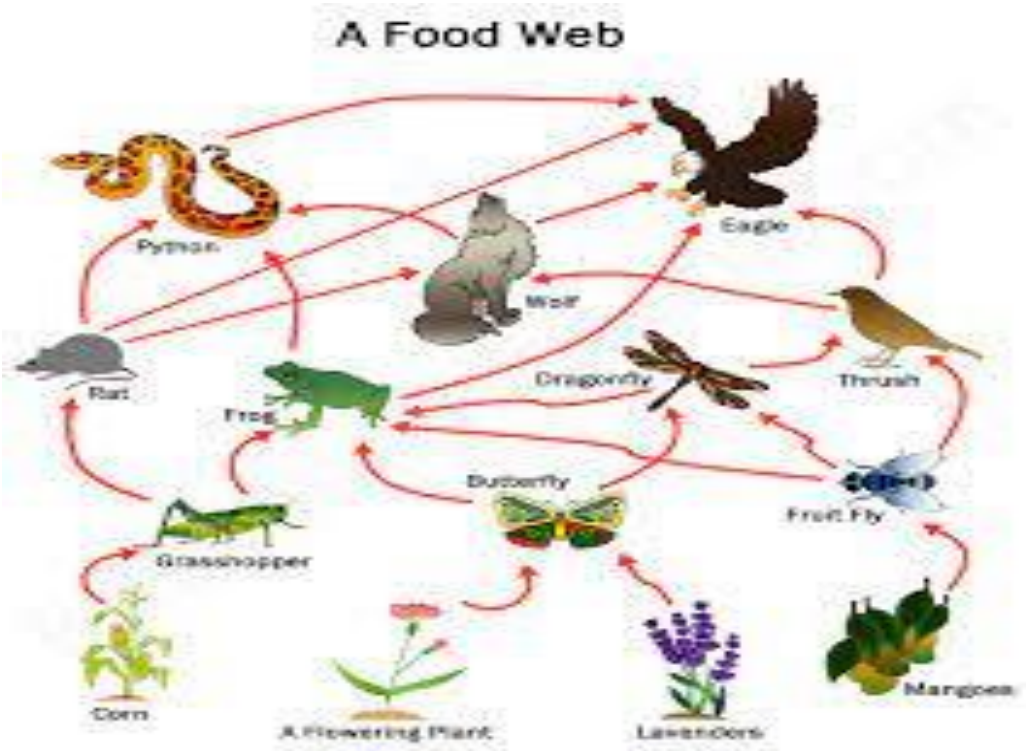
→ Such organisms are called **saprophytes**.

→ Decomposers **secrete enzymes** that breakdown dead organic materials into simple, inorganic materials, which are absorbed by them.

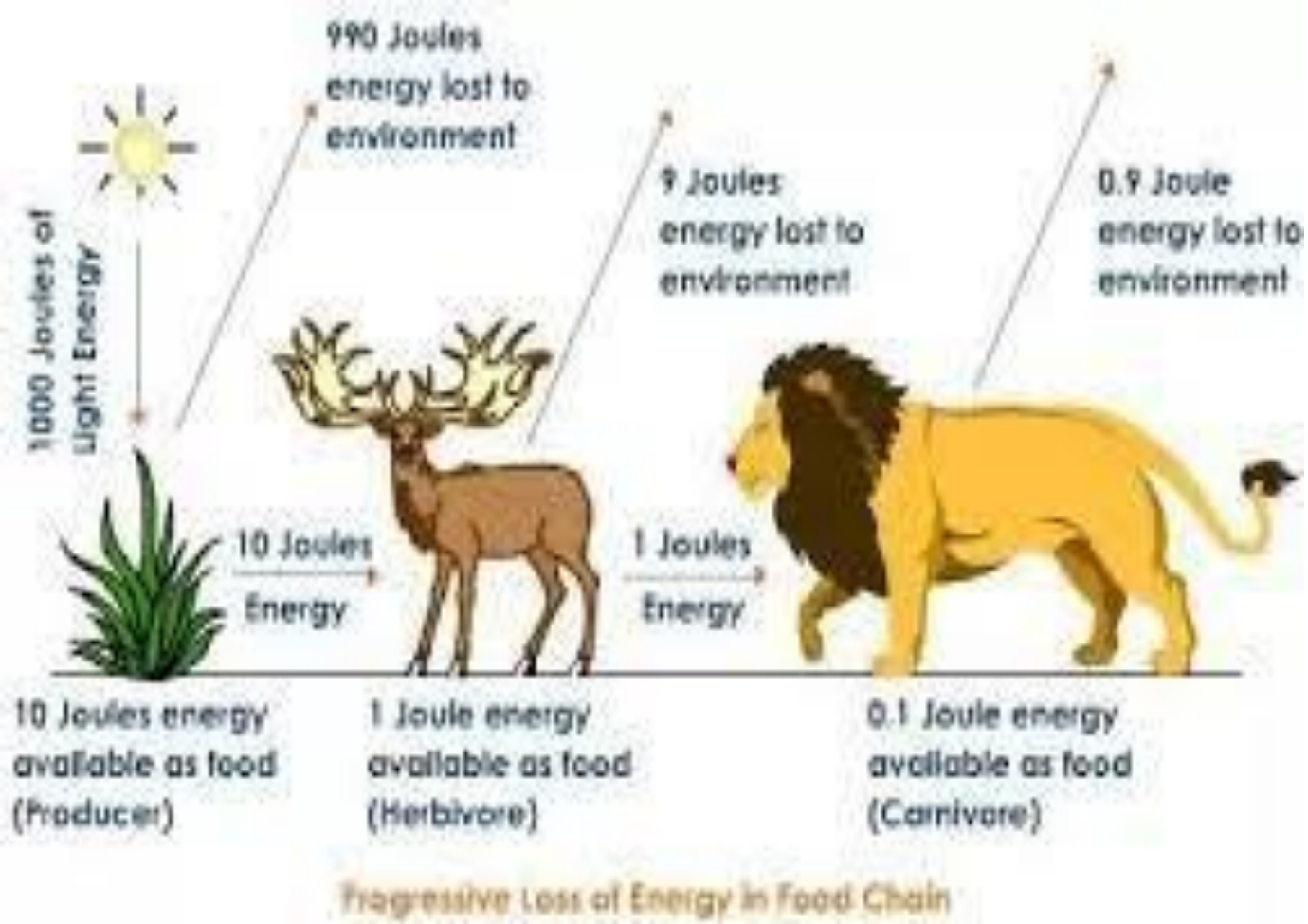
→ Detritus food chain is connected with the grazing food chain at some levels.

OMNIVORES

- Omnivores eat both producers (herbivore) and consumers (carnivore).
- These natural interconnection make it a food web.
- Eg. **Cockroaches, crows, bears, man** etc.



Loss of energy in food chain



Trophic level

→ Every **organism occupies** a place in **ecological community** according to the source and method of obtaining its food.

→ Organisms occupy a specific place in the **food cha**in that is their trophic level.

→ **Producers** belongs to **first level**.

→ **Herbivores** (Primary consumer) to the **second level**.

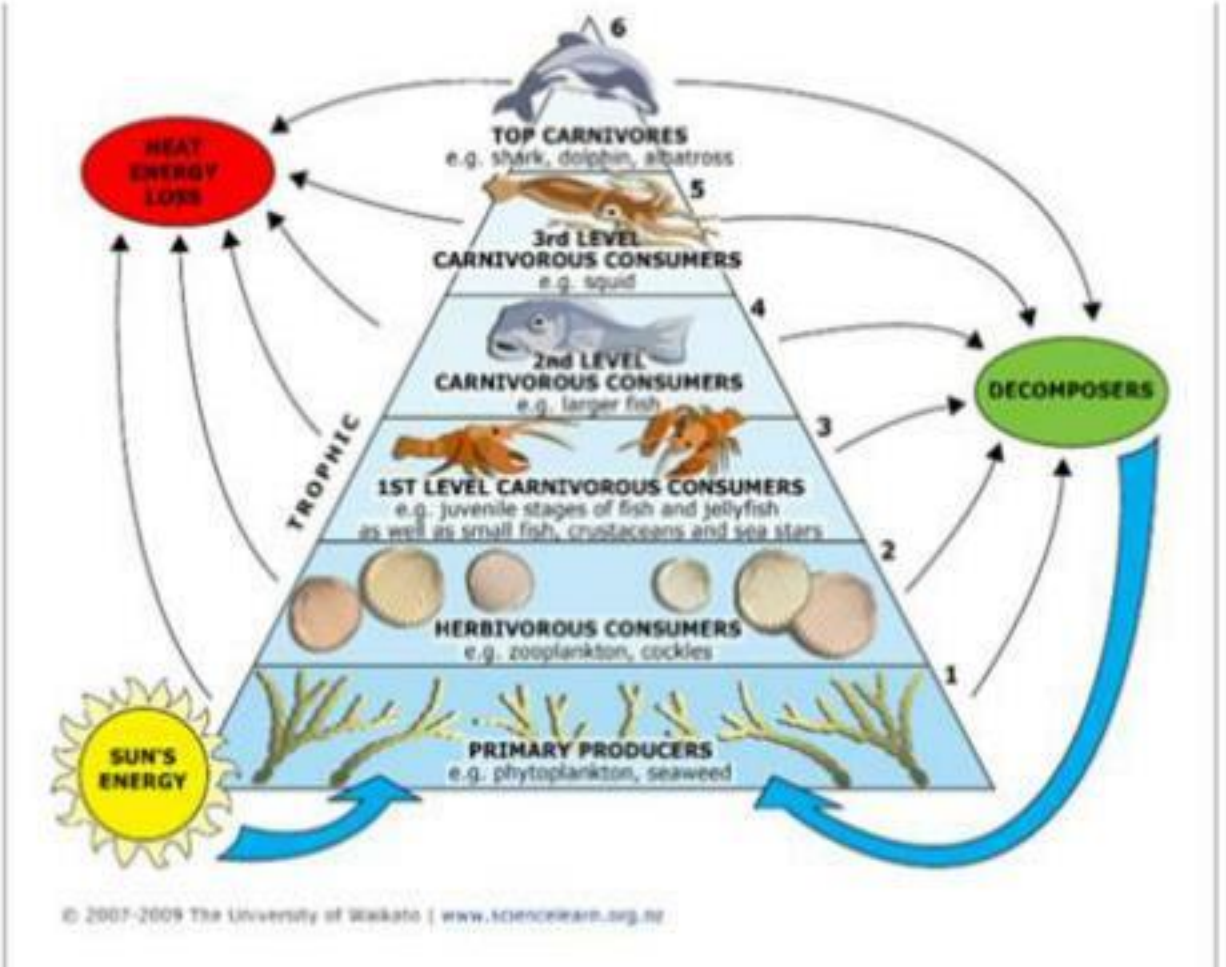
→ **Carnivores** (sec. consumer) to the **third trophic level**.

→ Amount of **energy** available **decreases** at each successive trophic level.

→ In any food chain transfer of energy follows "**10% law**".

→ Law states that '**only 10%'** of the energy is transferred to each trophic level from the previous trophic level.

Energy Flow Pyramids and Trophic Levels



Trophic level – **Producer** → **Herbivore** → **Primary carnivore** → **Secondary carnivore** → **Tertiary carnivore…….**

Beyond secondary carnivore, amount energy available is too less, hence there is no tertiary consumer that feeds exclusively on secondary consumer.

This is the reason why **food chains** do not exist in isolation, but are **always interconnected** to form food web that maintains the stability of an ecosystem.

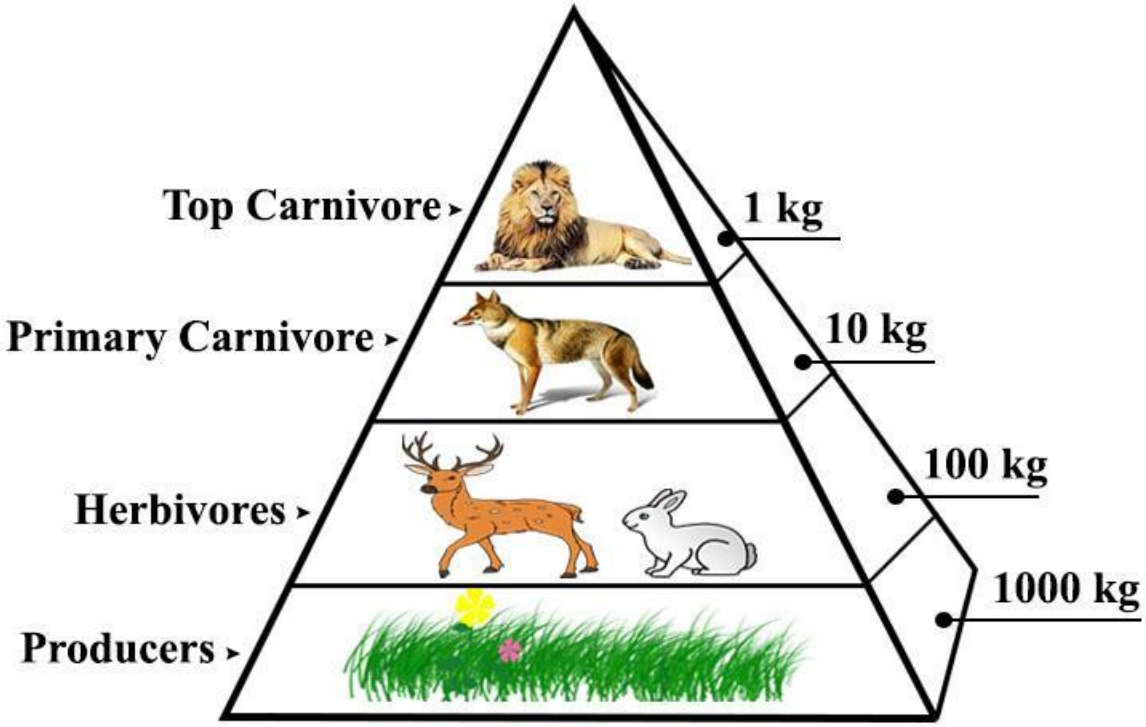
Ecological Pyramid

Ecological pyramid is a graphic representation of the relationship between the organisms of various successive trophic levels with respect to energy, biomass and number.

Types :--

1. **Pyramid of Biomass** – Bio mass/unit area
2. **Pyramid of numbers** -- The relative no. of individuals per unit area at different tropic level
3. **Pyramid of Energy** – Amount of accumulated energy per unit area.

Upright Pyramid of Biomass in a Terrestrial Ecosystem



Pyramid of Biomass

1. Pyramid is a structure which has **broader base** that gradually narrows upwards forming an **inverted cone** like structure.
2. **Base** of each pyramid represents the **producers** or the first trophic level while the **apex** represents **top level consumer**.

   ie. **More the no. of individual → more biomass**

   less the no. of indivudual →less biomass.

3. In most **well balanced ecosystem**, all the pyramids are **upright.**
4. Exception, **Oceanic ecosystem** show **inverted biomass pyramid.**

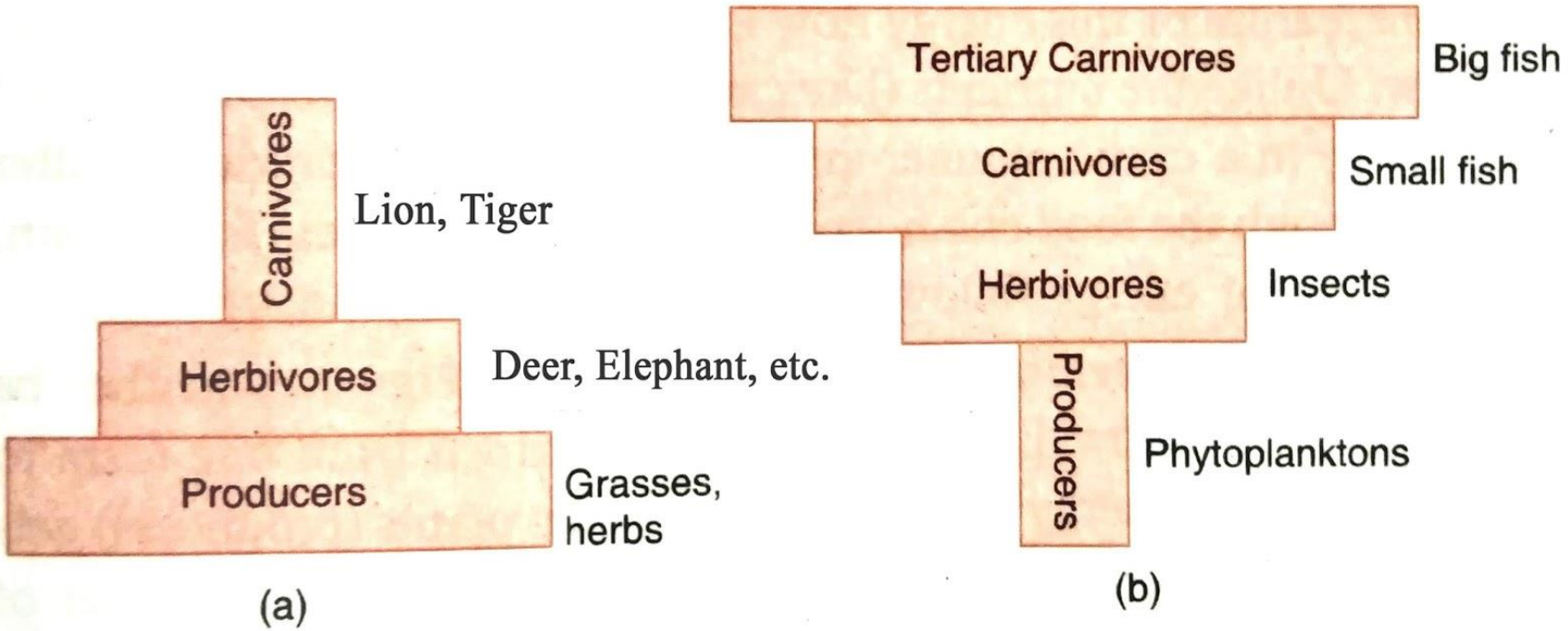
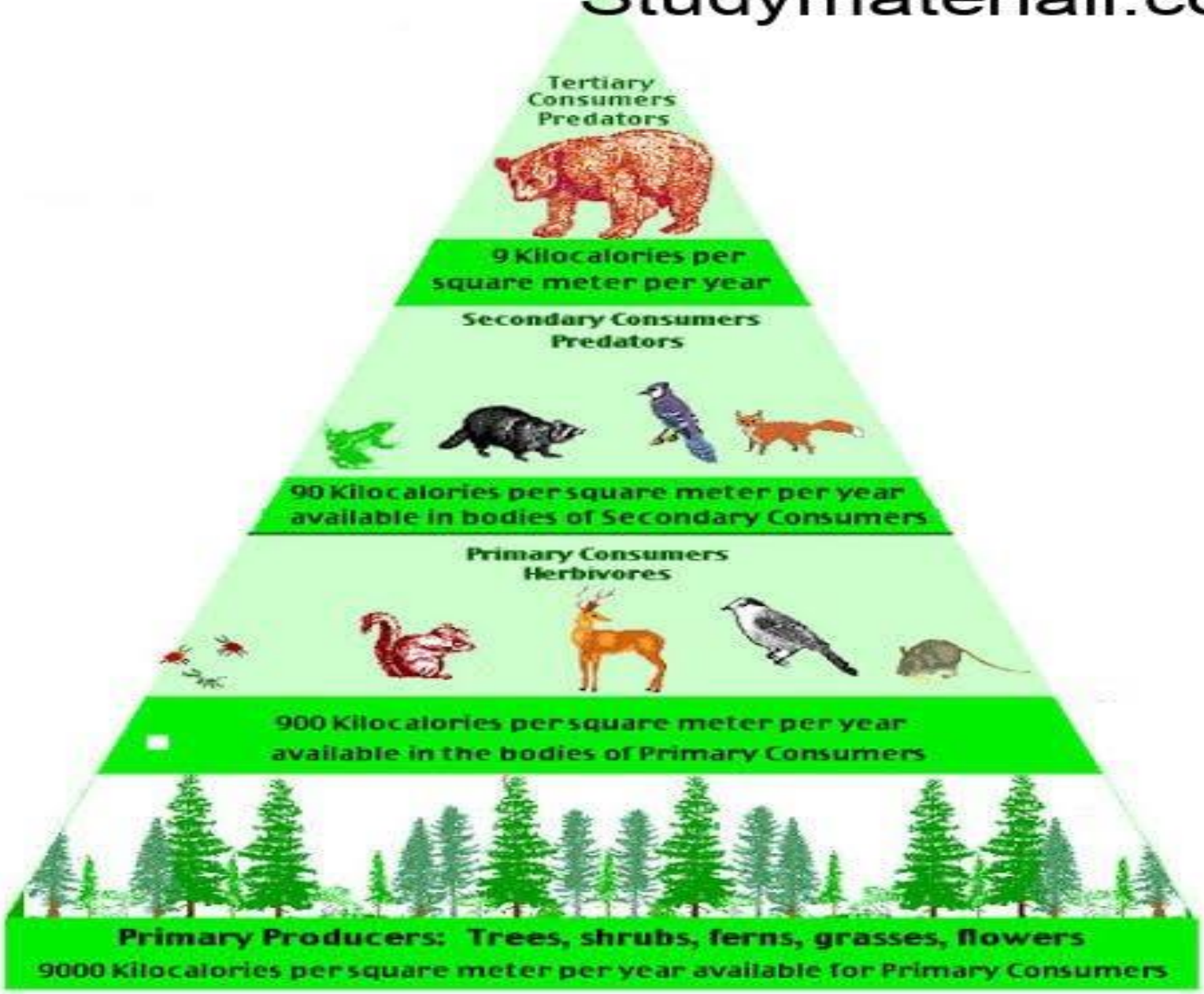
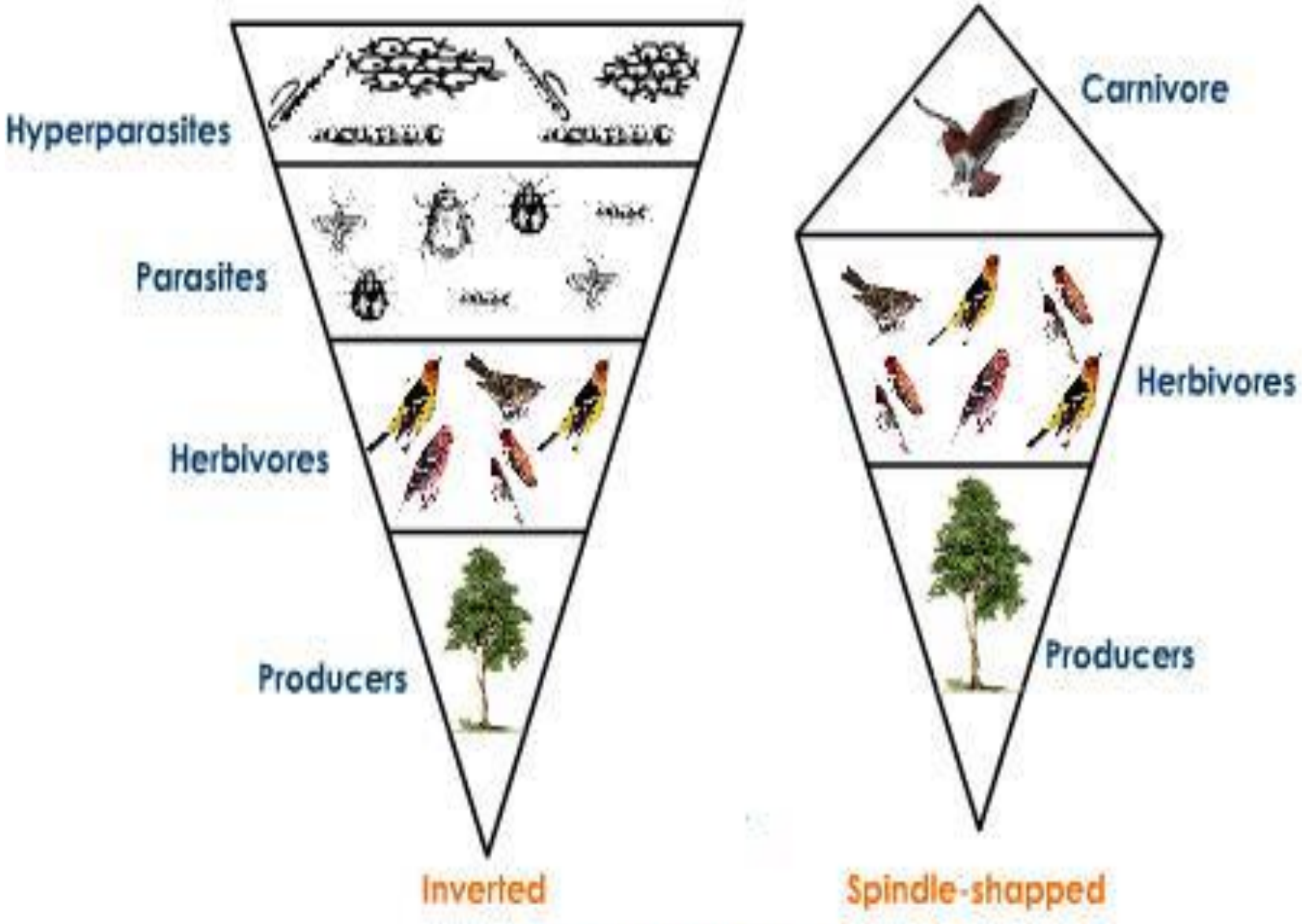


Fig. Pyramid of biomass (*a*) Forest (*b*) Pond.

Pyramid of Numbers

1. Pyramid is a structure which has broader base that gradually narrows upwards forming an inverted cone like structure.
2. Base of each pyramid represents the producers or the first trophic level while the apex represents top level consumer.
3. Right from **bottom to top** number of organisms keeps decreasing .(Eg. *Producers are more in no. and as we go up at every trophic level no. of organisms keeps decreasing*)
4. In most well balanced ecosystem, all the pyramids are upright.
4. Pyramid of numbers can also be sometimes inverted.
5. **Eg.** If we plot the **number of insects** on a **single tree**, **smaller birds** feeding on insects , and parasites on those bird, we get an **inverted pyara**mid.





Pyramid of Numbers

Pyramid Of Energy

0.1% - Crocodile

(Tertiary Consumer)

1% - Bonobo

(Secondary Consumer)

10% - Insect Larvae

(Primary Consumer)

100% - Rainforest Leaves

(Producers)

10% Loss of original energy as it climbs higher up the pyramid

***Detrivores and Decomposers acquire energy from all sources*

Pyramid of Energy

1. Pyramid is a structure which has **broader base** that gradually **narrows upwards** forming an **inverted cone** like structure.
2. **Base** of each pyramid represents the **producers** or the first trophic level while the **apex** represents **top level consumer.**

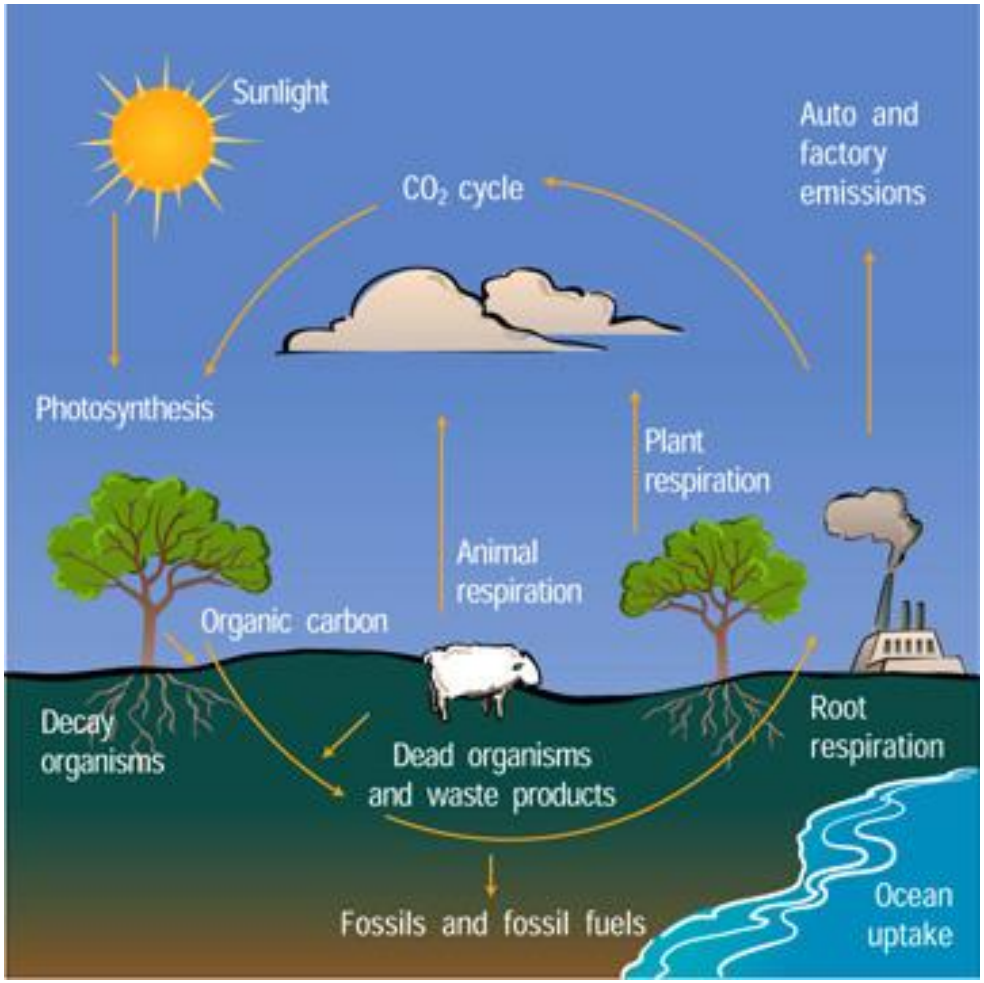
3. Pyramid of energy is always **upright.**
4. It can **never be inverted**, because when energy flows from a particular trophic level to the next trophic level, some energy is always lost as heat at each step.
5. **In smaller food chains, more energy is available than in the longer food chains**.

→**Saprophytes** are not given any place in ecological pyramids even though they play a **vital rol**e in the ecosystem.

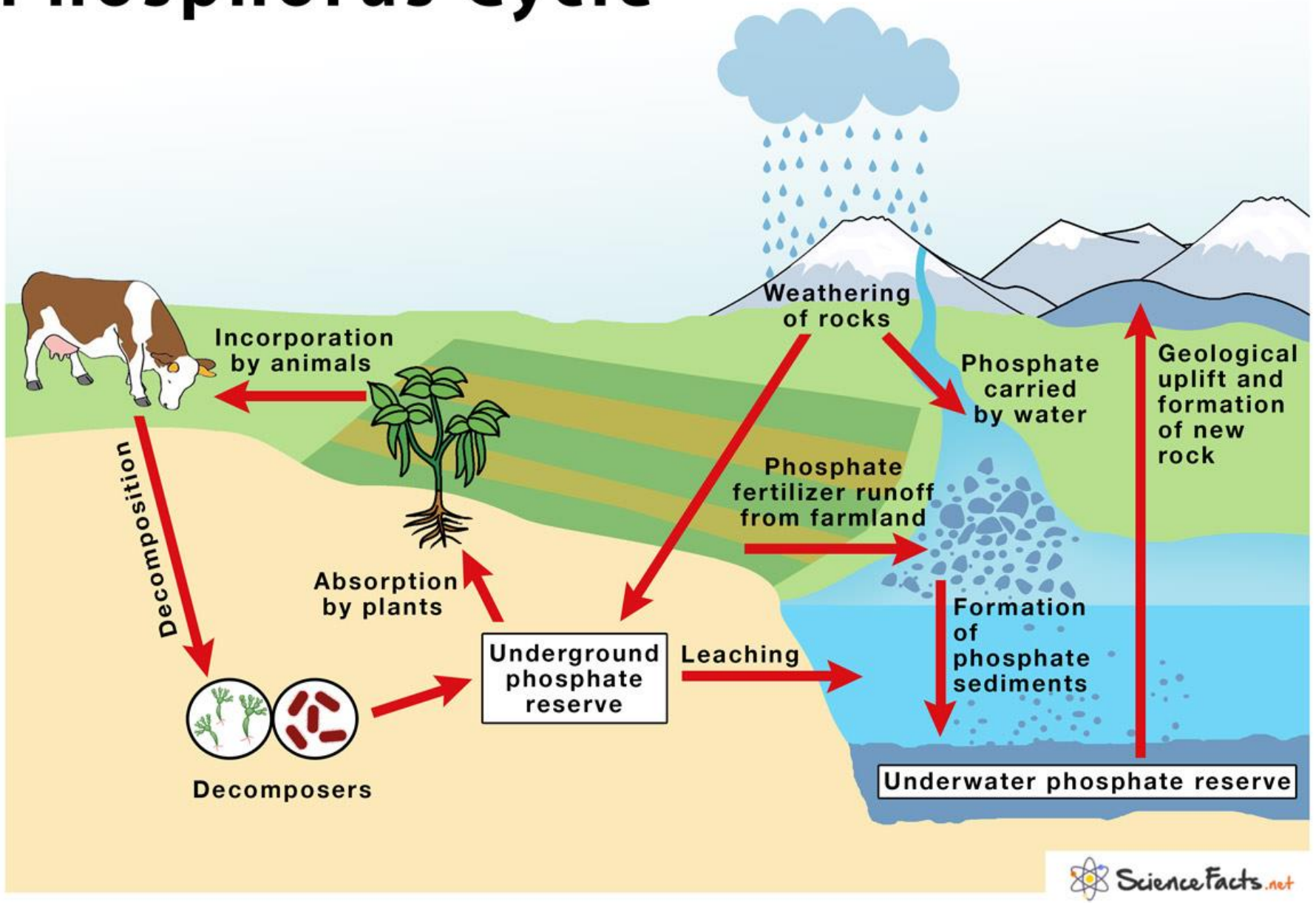
→A given **species may occupy more than one trophic levels** in the same ecosystem at a same time,

→**eg.** A sparrow is a primary consumer when it eats seeds, fruits, peas and a secondary consumer when it eats insects and worms.

Carbon Cycle



Phosphorus Cycle



ECOLOGICAL SUCCESSION

Succession

It is a **spatial pattern** which occurs over the time.

→As **time passes**, species **diversity increase** giving way to more complex organisms.

→ It leads to **climax community**.

→It does not evolve further.

Definition *--The gradual and predictable change in the species composition of a given area is called ecological succession.*

Process of Succession involves sequential steps like..

→Nudation

→Invasion

→Ecesis

→Aggregation

→Competition

→Co-action

→Reaction

→Stabilization

During succession,population of some species grow , whereas population of other species decline and even disappear.

- The entire sequence of communities that successively change in a given area, constitute what is called sere.
- Individual transitional communities are termed seral communities.
- Change in diversity of species of organisms, increase in the number of species and organisms as well as an increase in the total biomass.
- **Present day communities** are the result of **succession** occurred over **million of years**.

PRIMARY SUCCESSION

Definition

Succession is a process that starts where no living organisms were present before-like on a newly formed volcanic island.

→ **Eg.** Newly cooled lava, rocks and newly created pond or reservoir.

→ Very slow process.

→ Depending upon climate, it takes natural process, several hundred to several thousand years to produce fertile soil on bare rock.

SUCCESSION OF PLANTS

→Based on nature of habitat

Water -- Succession of plants is called **hydrach**

Dry areas – Succession of plant is called **xerarch**

Hydrarch succession

→ Takes place in **wetter areas** .

→ Successional series progress from **hydric** to the **mesic conditions.**

Xerarch succession

→ Takes place in **dry areas**.

→ Series progress form **xeric** to **mesic successions .**

Mesic condition - **Neither too dry(xeric) nor too wet (hydric)**

SECONDARY SUCCESSION

Definition

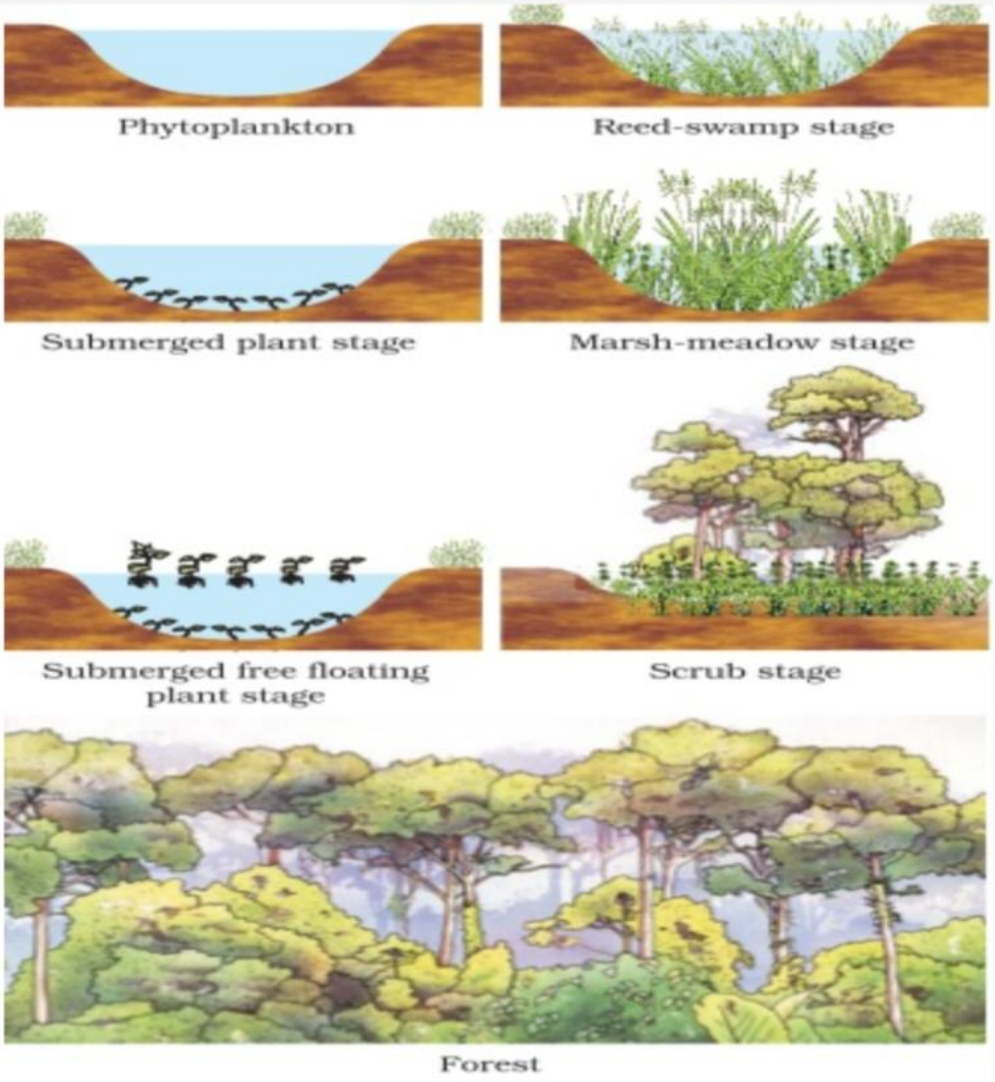
Succession process that begins in area where natural biotic communities have been destroyed.

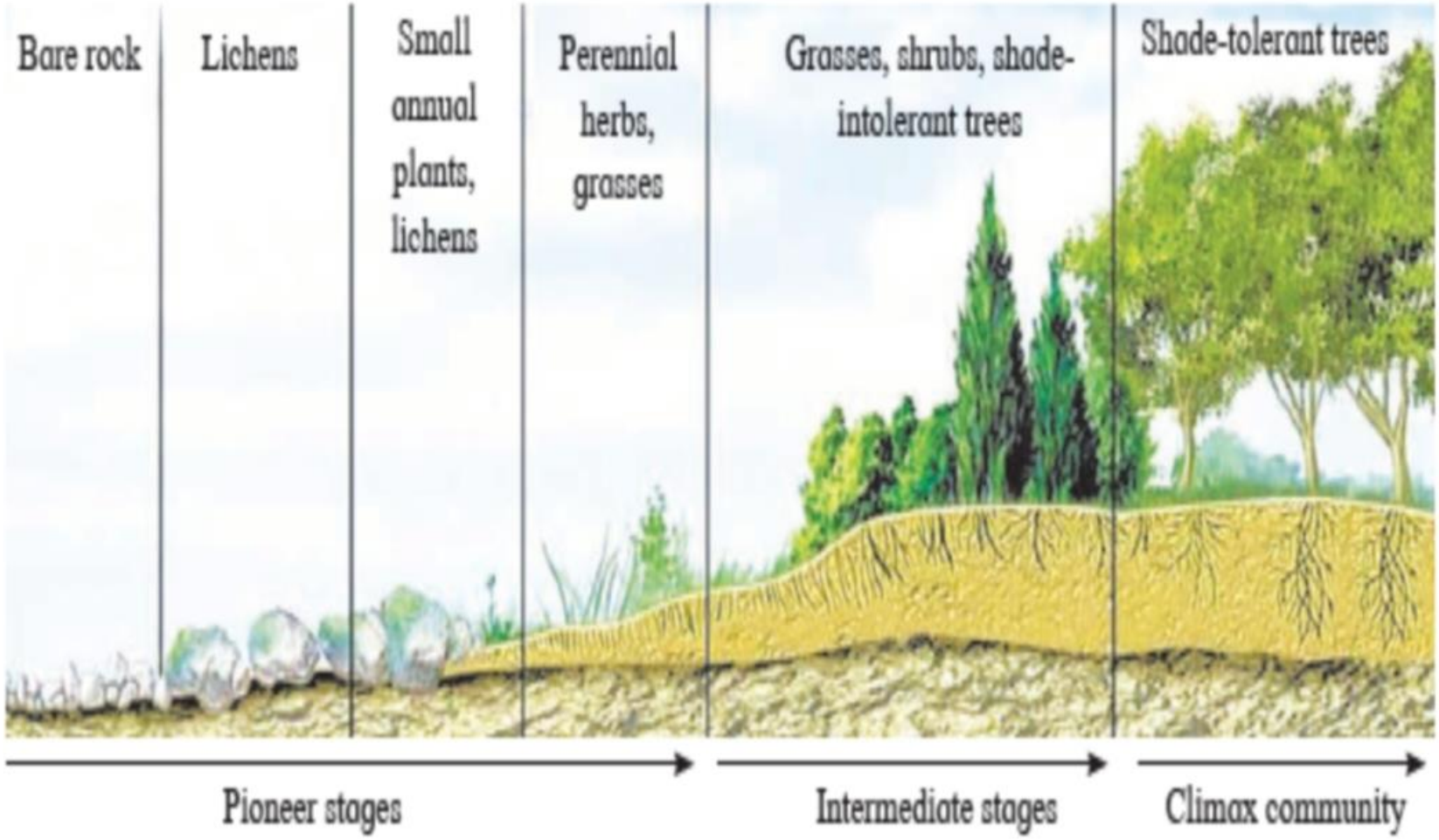
→ **Eg.** *Abandoned farm lands, burned or cut forest, lands that have been flooded, etc.*

→ *Since some soil or sediment is present succession is faster than primary succession.*

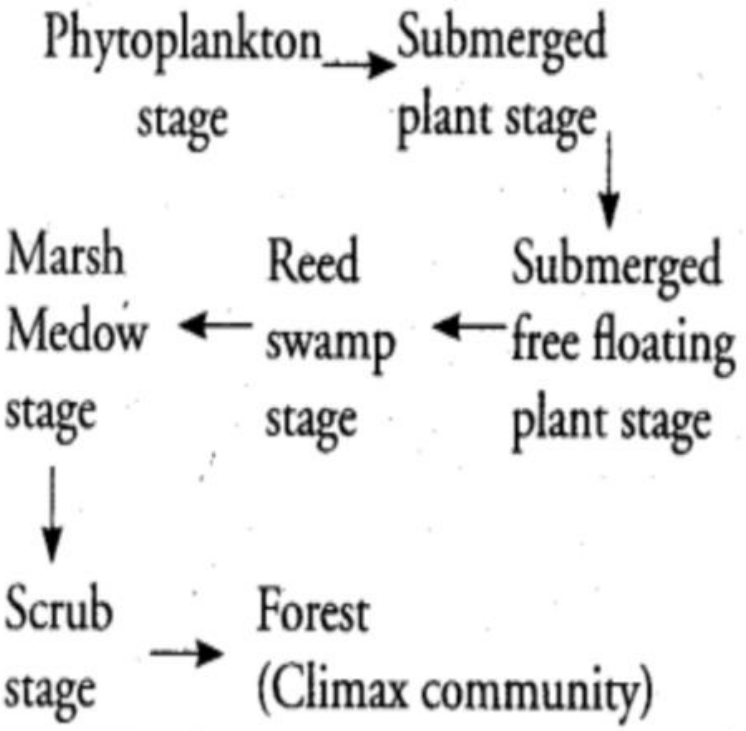
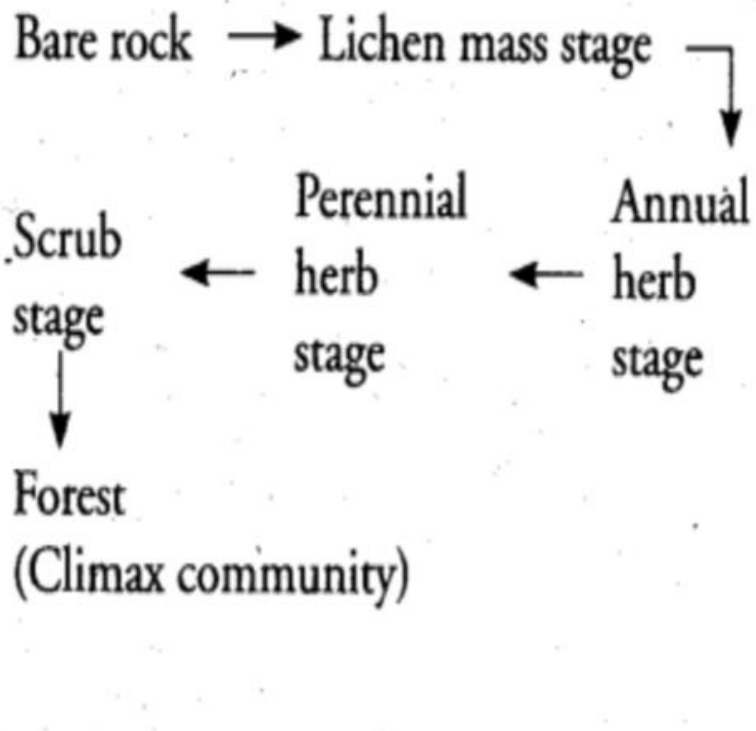
- As succession proceeds vegetation, food and shelter of animals, types of animals and decomposers also change.
- Human induced disturbances (fire, deforestation etc.) can convert a particular seral stage of succession to an earlier previous stage.
- Disturbances create new conditions that encourage some species and discourage or eliminate other species.

Hydrarch Succession of Plants





Xerarch Succession of Plants

	Hydrarch Succession	Xerarch Succession
(i)	Ecological succession that starts in water bodies and proceeds to mesic condition called hydrarch succession	Ecological succession that starts with bansen rocks xeric condition and proceeds to mesic conditions, called xerarch succession.
(ii)		

PIONEER SPECIES

The species that invade a bare area, are called pioneer species.

Primary succession of land

→Crustose lichens secrete acids to dissolve rock, helping in weathering of rocks and soil formation.

→They pave the way for bryophytes, mosses that are able to take hold in the small amount of soil.

→Succeeded by herbaceous plants.

→After several more stages , ultimately a stable climax forest community is formed.

→Climax community remains stable as long as the environment remains unchanged.

Primary succession of aquatic habitat

→Pioneers are the small phytoplankton.

→They are replaced with time by rooted-submerged plants. (eg. Hydrilla).

→Then rooted floating-angiosperms. (eg. Lotus)

→Followed by free-floating plants. (eg. Pistia)

→Then reed swamp. (eg. Typha)

→Followed by marsh-meadow. (eg. cyperus)

→Finally trees.

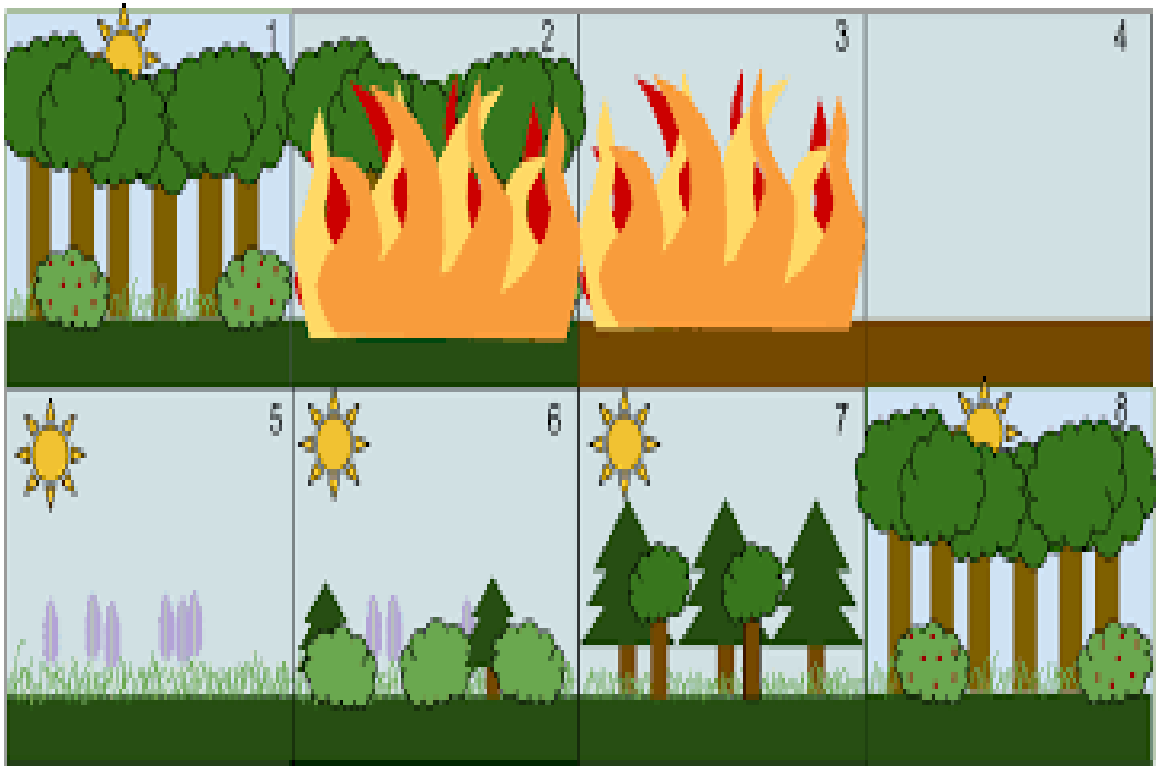
→The climax again would be a forest

→With passage of time the water body is converted into land.

SECONDARY SUCCESSION

→The species that invade depend on the conditions of the soil, availability of water, the environment as also the seeds or other propagules present.

→Soil is already there, so rate of succession is much faster and hence , climax is also reached more quickly.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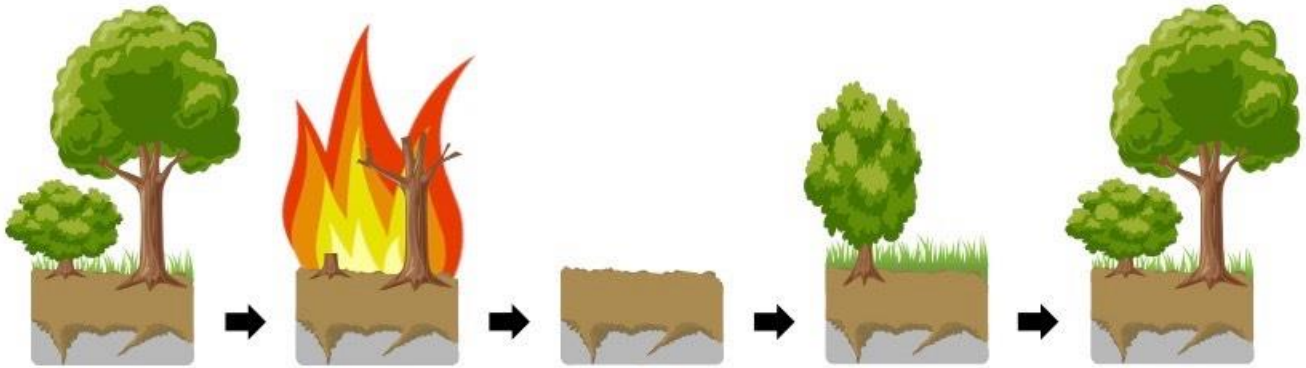
Established climax community
Disturbance destroys the community
Biota removed but the soil *remains*
Fast growing plants initially dominant
Eventually climax community is re-established

Primary succession is very slow process, may be requiring thousands of years for the climax to be reached.

Another important fact to understand is that all the successions whether taking place in water or on land, proceed to a similar climax community--mesic

ECOSYSTEM SERVICES

The products of ecosystem processes are named as ecosystem services.

For eg. Healthy forest ecosystem purity air and water, mitigate droughts and floods.

Four categories of ecosystem services are as follows.

1. Supporting services

   Includes nutrient cycle, primary productions, soil formation, habitat provision and pollination maintaing balance of ecosystem.

2. Provisioning services

   Food (sea food), raw materials (tiber, skins, fuel woo), genetic resources(crop improvement gene ans health care), medicinal resources, ornamental resources (furs, feathers, ivory, orchids, butterflies etc)

3. Regulating services

Carbon sequestration, predation regulates prey populations, waste decomposition and detoxification, purification of water and air, and pest control.

4. Cultural services

Cultural, spiritual and historical, recreational experiences, science and education, and therapeutics.

Following are the main ecological services:

1. Fixation of atmospheric CO2 and release of O2.
2. Pollination of plants brought about by wind, water or other biotic service, without which there would be no crops and no fruits.

Though the value of all such services of biodiversity is difficult to determine, it seems reasonable to think that biodiversity should carry a hefty price tag.


Thank
You