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Notes

By

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Ernst Haeckel in 1886 "Ecology" " the knowlegde of the sum of the relations of organism to the surrounding outer world, to organic and inorganic conditions of existence.

ethology (animal behaviour) (Biologist)

Coined by Isodore Geoffroy st. Hilaire (1859) for the study of reations of organism within the family & society in the collectively & in the communit

Elton "1933" ecology is nothing but the application of scientific method to natural history. As a science

According to Elton ecology depended on 3 methods of approach : Field observation

Systematic techniques

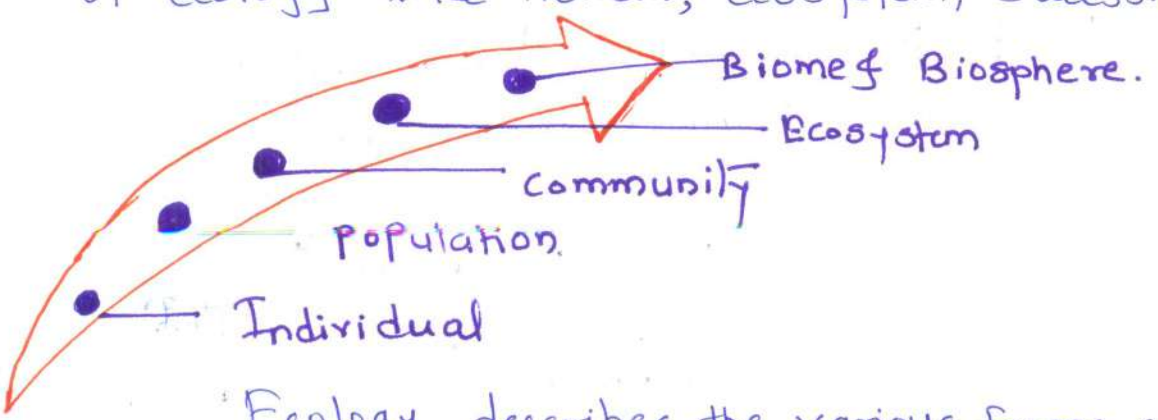
experimental work in lab/ in the field.

Defination of Ecology "Study of the interaction between organisms & their environment. living things and their physical, chemical & biological

Ecology is study of the dynamic relationship of organism with their physical environment & with their environment.

Basic Concept of Ecology :-

According to Mishra in 1991 there are four basic concept of ecology like holism, ecosystem, succession, & conservation



Ecology describes the various forms of interaction within and among the organism at each level of organization eractions are studied at peculiar hierarchial level are follows.

onment < individual < Population < community < Ecosystem < Biome < Biosphere.

me is an area classified according to the sps that live in that location. temp range, soil type, amt of light & water Ex. desert | heat no or little rainfall.

ecological levels of organization → Population
Community
ecosystem

opulation → group of people
↓
group of individual of any kind of os.

A population is group of interacting individual, organisms belong to same species inhabiting in any specific physical area. Population belong to same taxonomic group.

Community → is next level of e. organization after the population.

Community is any size group of populations of taxonomically different species in any given areas. ex. plants, animals microbes inhabiting together in the given area showing sps diversification.

Diversity → Combination of no. of sps & no. of individual of each sps.

Definition of Ecosystem

A. G. Transley :— " Ecosystem is the System resulting from the integration of all the living & non-living factors of the environment.

) **Odum** "Ecosystem is any unit that includes all the organism in a given areas interacting with the physical environment so that a flow of energy leads to clearly defined tropic structure, biotic diversity and material cycles within the system."

) **F. R. fosberg:**

" Ecosystem is a functioning interacting system composed of one or more living O^s & their effective environment both physical and biological."

4) **H. L. Lindeman:**

" The term ecosystem applies to any system composed of physical chemical biological processes within a space-time unit of any magnitude."

Characteristics of Ecosystem

① structural & functional unit of ecology.

② Function of ecosystem are related to its trophic level & there is flow of energy from lower trophic level to higher level.

③ E. structure is related to its unique diversity

④ amt of energy require to maintain an Ecosystem is depend on structure of ecosystem
Ex. less energy is require to maintain complex ecosystem than simple one.

Characteristics of Ecosystem

⑤ Green plt (producer) → Convert radiant energy of sun into Chemical form (CHO) in biomass → utilize by Consumers.

(7) Change in Environment —represent→ Selective Pressure up on population to which ——→ population must adjust to Survive in ecosystem.

(8) Ecosystem allows flow of energy & cycling of materials which ensures the stability of system & Continuation of life of organisms.

Biosphere :→ The biosphere is that part of earth inhabited by living os including land, oceans & the atmosphere in which life can exist.

- It is global ecosystem
- Sum total of all ecosystem.
- Place on earth where life exist.

lithosphere
- Hydosphere
- Atmosphere.

The term 'biosphere' was coined by geologist Eduard Suess in 1875, which he defined as. The place on Earth's surface life dwells.

Thermo - 90 km
meso - 50 km
stratosphere 20 km
Trophosphere - 10 km

Ecosystem

A. G. Tansley in 1935, who defined

"Ecosystem is system resulting from the integration of all the living and non-living factors of the environment"

E. P. odum (1971)

"Ecosystem is basic functional unit of organism & their environment, interacting with each other & within their own components."

Ecosystem

- Natural
  - Terrestrial (forest, Grassland, Desert)
  - Aquatic
    - freshwater
      - lentic (Standing H_2O) lakes, Ponds, Ditch, swamp
      - lotic (Running H_2O) (River, spring, streams)
    - Marine (Ocean/sea)
- Artificial
  - Man-engineered ecosystem eg. Urban, Industrial Laboratory space

The major ecosystem with their groups of climax plants & associated animals are called "biomes"

Ecosystem is basic functional unit of ecology

Structure of Ecosystem

Biotic + Abiotic Components.

- depend on eachother & interact with eachother.

eg. Plant get CO_2 for photosynthesis. ② plt & animal → O_2 for respiration

living (biotic) (Abiotic) ③ H_2O → metabolism

④ Soil → support plant/animals

Abiotic Components

① Inorganic ② Organic ③ Climates

① includes nutrients
such as Ca
N
CO_2
H_2O
O_2
P
sulphur

Circulat - through trophic levels

Utilized by Producers
↓ to form
organic substance
↓ pass on to
Consumers
↓ released in
Evs.
in the form of
- undigested food
- dead protoplasm
then decomposed by decomposers
↓
made available for recycling.

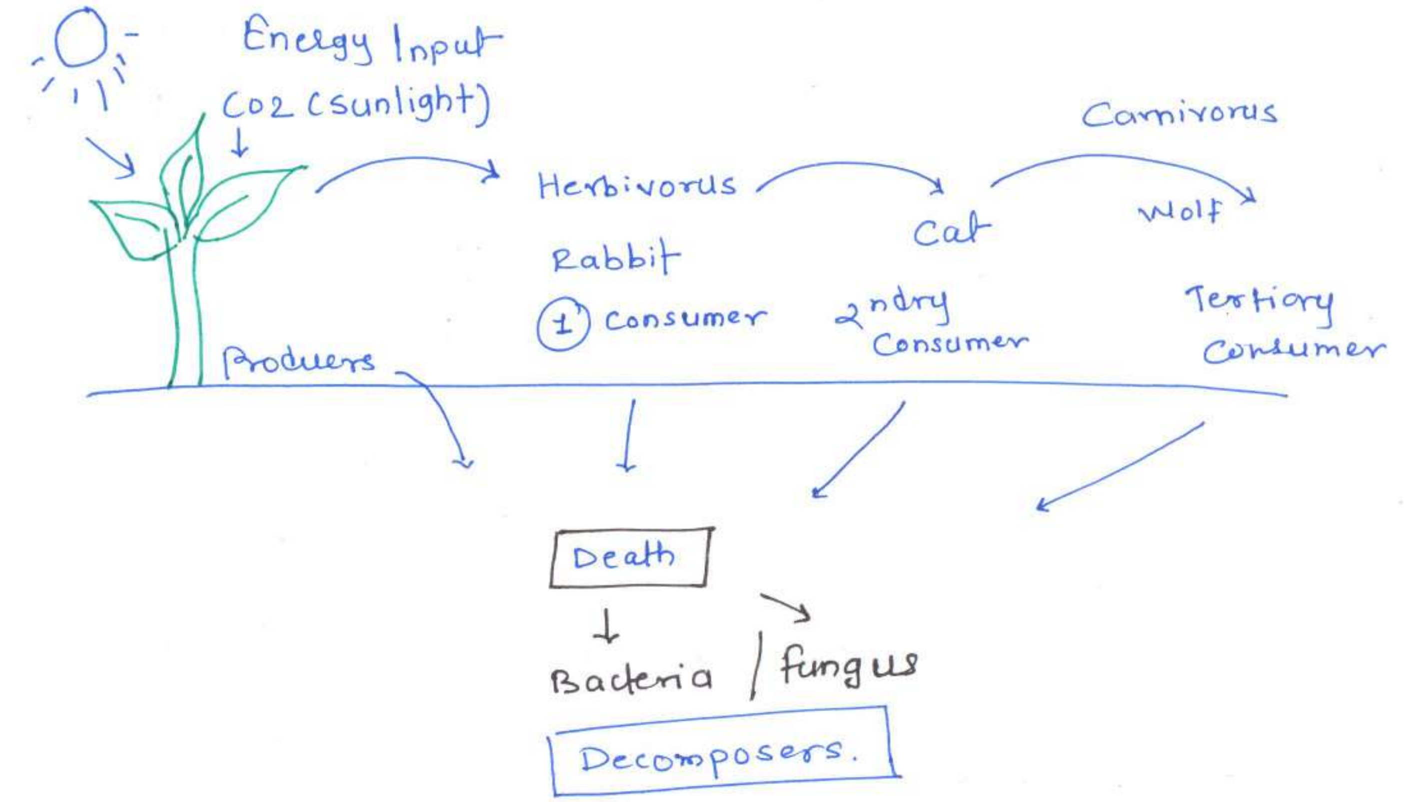
②
proteins
lipids
CHO
DNA
RNA
ATP

③ complex system involves interaction of solar radiation water, gases to produce heat, dust storm, wind rain, fog mist, snow etc.

(3) Biotic Components

living components that affects the population of another organism.

B.C → Autotrophic Component | heterotrophic Component → Classified on the basis of Nutritional relationship.



Producers: – Autotrops. | fundamentals of ~~the~~ the food chain.
↓
plant

Radient energy —plant→ chemical energy

by photosynthesis

Chlorophyll bearing green plant → phytoplankton's
algae
grass
trees

inorganic raw material
↓ sunlight
organic compound (food)

} photosynthesis → photons capture (sun ↓)
↓ split
H_2O → release O_2
reduce CO_2 release hydro.

(2) Consumers (animals)

depend on producers / other consumers kan as heterotrophs

(1) feed directly ⟶ Producers | plt | autotrophs

kn | herbivorus |. or | 1^0 Consumers |

ex: Grasshopper, rabbit, goat, deer, cow, horse etc

(2) The animals which feed on ⟶ other animal

kn as Carnivorus

ex. Frog, Snake, hawk, wolf tiger, lion etc.

or 2^0 Consumers.

(3) Animals feed on —— 2^0 Consumer kn as 30 consumer.

(4) Os feeds on plt | Animal ⟶ Omnivorus

eg Cockroaches, fox, human.

(3) Decomposers | detrivore → break down or decompose the dead protoplasm

or chemicals nutrients of producers & consumers into simpler form which can be reused.

ex. mos. bacteria | fungi

Decomposers Secrect ⟶ Digestive Enzyme

Digest dead tissue / excretory materials of animals

Autotrophs — Heterotrophs. — Pop ↓

Producer —feed on⟶ 1^0 Consumer → 1^0 carnivo → 2^0 car → 3^0 carn

Aquatic Ecosystem

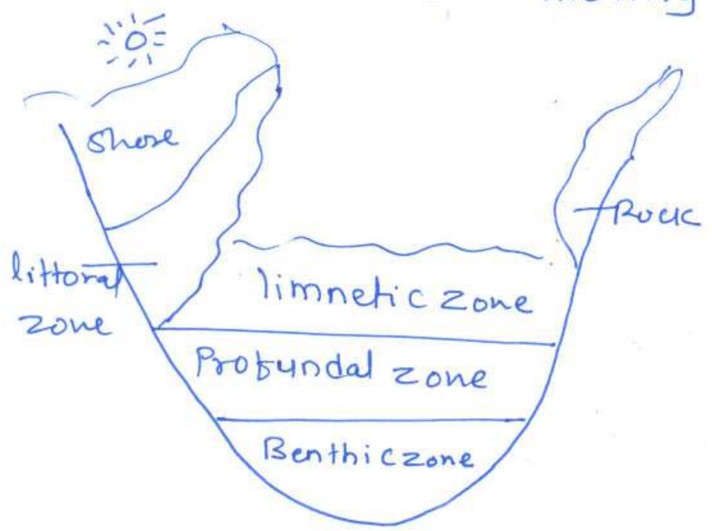
① fresh H_2O Ecosystem
- standing (lentic)
- free floating (lotic)

0.80% Earth's surface

0.009% of its total water

3% net primary pdn

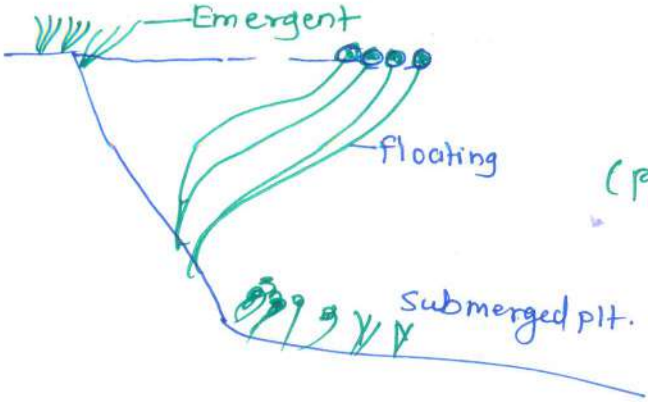
ⓐ lentic → slow moving → pools, Ponds, lakes

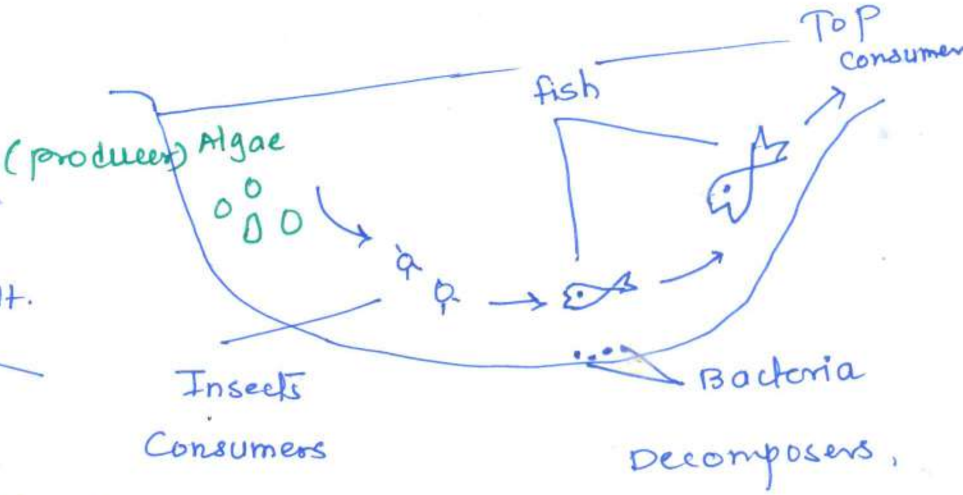


- Pelagic (open offshore waters)
- Pro-fundal (littoral)

near shore shallow water

- riparian (the area of land bordering a body water)





Pond ecosystem : → Abiotic Components

- organic
- inorganic components / material
  - Water
  - O_2
  - CO_2
  - Salt of Calcium
  - Nitrogen etc.

Climatic Conditions regulate func of ecosystem
- Reserve nutrients
- solar input
- cycle of temp.
- day length.

Biotic Components of Pond Ecosystem

Producers are of 2 types → larger rooted Floating vegetation } macrophyt

eg. Typha, Acorus, ~~Ksp~~ Ipomea.

phytoplanktons → microscopic floating algae

up to depth of ~~Ko~~. eg Ulothrix, Spirogyra, Anabena

Submerged plt → Hydrilla, Utricularia, Trapa

Surface floating plants → Pistea
Wolffia
Salvinia
Eichhornia.

Consumers: → heterotrophs (Nutrition → depend on other

1° Consumers → Zooplankton → Brachionus,
Asplanchna,
lechane → feed → phytop

Crustacean → Colops
Dilepteus
cyclopes

2° Consumer → feed on zooplankton

3° Consumer →
Benthic animals snakes, big fishes,

Decomposers → Saprophyte → act on dead & decaying organic matter of plant/anim & supply raw material to the producers.

eg. Bacteria, fungi,
Aspergilus
Cladosopra.
Rhizopus

Lotic Ecosystem (Rapidly moving water)

It has H_2O current, where H_2O is in motion.

River ecosystem is made up of 2 components → abiotic
→ biotic

Abiotic factor

1) Flow / Soil / River basin (2) light (3) Temprature.

Flow is key factor in lotic system
The speed of water flow can vary within a system.

- Flow based on variability of friction with the bottom or sides of the channel.
- The amount of H_2O input in to the system from direct participation, snow melt, ground H_2O can affect flow rate.
- Flowing H_2O can alter the shape of the streambed through erosin & deposition, creating a variety of habitats including riffles, glides & pools.

(2) light → imp — Provide energy necessary to drive Primary production via photosynthesis

(3) Temprature → H_2O can be heated or cooled through → radiation at surface

- Conduction to or from air & surroding substrates.
- Shallow H_2O are well mixed & maintain uniform temperature with an area.
- In deeper slower moving water system a strong difference betn the bottom & surface temp. may develop.

Biotic factors :→

Producers → plants → Algae, phytoplankton, periphyton
phytoplanktons float freely in H_2O column

Consumers → Herbivorus

Carnivorus eg snakes, crab,

Herbivorus → eat plants → fish, snail, limpets, clam
mussel

insects,

2° consumer → Smaller & larger fish

3° —"— → fish / human

Producers → died → attacked by decomposers chiefly
Consumers — Saprophytes, bacteria, fungi

(2) Marine or Ocean Ecosystem

2,50,000 marine living Os → Source of human food & other os.

- Sea products & drugs.

- irons, phosphorus, magnesium, Petroleum Products, oil
Natural gas, sand, etc

eg. Atlantic
Pacific
Indian
Arctic
Antarctic

Abiotic factors

- Salinity of H_2O, Temp, Pressure, water waves, tides, H_2O current & light intensity at various depth of sea are greatly affecting the life.

Biotic →

2 major life zones → Coastal, → Open

Coastal zone → warm
nutrient rich
shallow water with ample of sunlight

c̄ high primary productivity & harbor rich biodiversity

Open sea → deeper part ocean vertically differentiated into 3 zones

Euphotic → receive abundant light
high photosynthetic activity

Bathyal → receive dim light
geologically active

Abyssal zone → dark zone 2000 to 5000 meters

Producers →

green flagellates
microscopic algae → brown, red
diatoms, phytoplankton

Consumers

heterotropic micro & macro consumer

1° " —— Small fishes, molluscs, crustaceans.

2° " —— large carnivorous fishes, molluscus, echinoderms, mammals

3° " —— (Top) shark (largefish) cod, octopus, squids

Decomposers

bacteria | fungi ⟶ decaying of dead organic matter of micro - consumers.

③ Eustarine Ecosystem : bounded by coastal area near mouth of river where freshwater meets c̄ salty water forming transitional zones severely affected by tides eg. Coastal bays & tidal marshes.

Salinity of water is ~~Constantly~~ Continuously changing in eustuaries — Os survived in this region of estuaries who have wide range of tolerance kn as "euryhaline"

eurythermal

eustaries have a rich biodiversity. migratory fishes like

- Catadromus eels : lives in freshwater enters salt wal to spawn.
- anadromous Salmons : born in fresh water - Sea-live - return to fresh water to spawn
- Sea lampray
- Striped bass

Abiotic Components → H_2O, mud, salinity, temp, light.

Biotic Components → producers → phytoplankton & algae

1° Consumers → heribrous - zooplankton

2° Carnivorus → fishes

Decomposer → plant & animal dead

Mineral & nutrients tnt in the estuary are utilized by plts

"forest Ecosystem" : Forests → 40% of total land.
India → 24% of total area

Tropical rain forest →

evergreen - located in equatorial regions of earth
ex. Congo - River basin of Africa
Central America

High Annual rain fall — 140 cm
High humidity

Avarage annual temp exceed 18°C
- Vast diversity in plant & Animal sps.
- broad leaves of tall plants, abundance of insects & invertebrates & high diversity of treesps.

(2) Tropical Savannas forest (Grassland)

Occurs near the borders of tropical rain forest
located → in Africa, South East Asia, Australia
Rainfall - 100 cm to 150 cm
- dry & wet seasons
- Wide diversity of animals including Elephant, zebra, Giraffe, antelope, kangaroo etc.

(3) Temperate forest

- found betn tropical & boreal forest

locn - temprate zone

Rainfall - 75 cm to 150 cm

Temp - 20°C (not more than)

Tending to falling off at maturity trees & shrubs shed leaves, fruits, flower.

- abundance of insect & birds, tall deciduous trees hard tree, frog, lizard, rabbits, Snakes, deers, bears etc.

Biome → naturally occurring community of flora

④ Coniferous or Taiga or Boreal forest: → pines. spruce
snow forest

forest are found across East - west band of North europe
North Asia
betn 60° or below 60°, Temp → 60C in winter   Nth - America
20°C in summer
Rainfall → 10 cm to 35 cm

Characteristics - Cold climates → high altitude & high latitude
dominated by Conifers
imp source → paper pulp & lumber

Common sps → owl, eagles, migratory birds, foxes, rabbits
deer's squirrels etc

vegetation → pines & cedars, larches etc.

⑤ Temperate shrub forest → Mediterranean

South Africa, South Australia, chile & coast of California

Rainfall — winter only / Rain is less & . Temp is moderate.
dry climate with moist air

vegetation → broad leaves & resinous plant eg Rubber

animal sps - Reptiles, Small mammals, large mammals.

* Components of a forest Ecosystem: →

Abiotic Components → minerals present in soil
Forest floor is rich in dead & decaying organic matter.

Biotic Components → Producers → Seed bearing plant

trees
shrubs
ground vegetation

(1) func → Provide initial source of food

(2) Habitat for other os

(3) Soil formation & modification of abiotic components.

1° Consumers →
Producers → Herbivorus → ants, flies, beetles, leaf-hoppers, bugs & spiders

larger → Shoots & fruits → elephants, nilgai, deer, moles, squirrels, shrews, flying foxes, fruit bats & mongooes.

2° Consumer → Snakes, birds, lizards, foxes

3° —"— → lion, tiger,

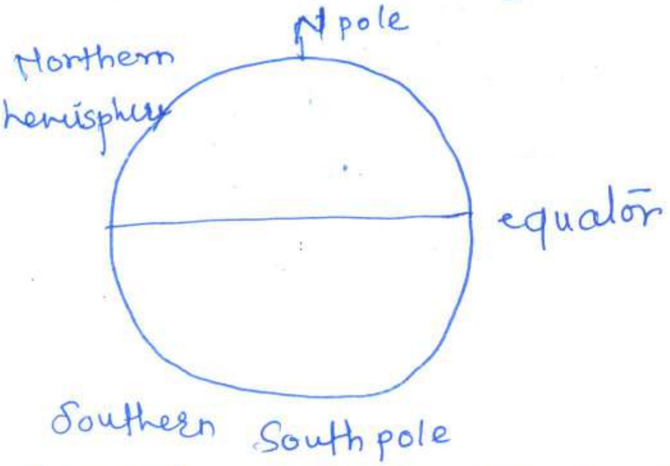
Decomposers → Bact | fungi
Breakdown the organic compounds of dead organic matter & organic waste.

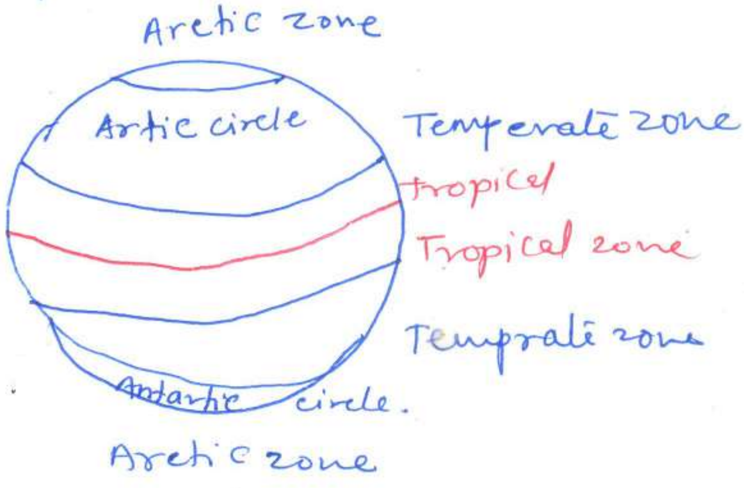
(2) Grass. land ecosystem :→

- dominated by various grass sps with scattered trees & shrub
- avarage rainfall but is highly unpredictable.
- Grazing animals is Predominating consumers. affecting Producer Community.
- Limited grazing activity tend to improve primary Productivity.
- overgrazing destruct grass community & soil surface exposed to physical factor causing degradation of grassland ecosystem.

- There are 3 kinds of grassland

(1) Tropical grassland :→ grazing animals → zebras, giraffe, antelops, buffalo, ostrich etc.
↓ dry ↓ rainy season





Predators → lions, cheetahs, lepards, wild dogs etc.

→ occur at visinity of tropical rain forest
high avarage temp & moderate to low rainfall.

Character → tall grasses with dispersed trees & shrubs

popularly kn Savannas in Africa eg. Velavadar grassland in Gujarat

* Components of a forest Ecosystem: →

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forest floor is rich in dead & decaying organic matter.

Biotic Components → Producers → Seed bearing plant

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Decomposers → Bact | fungi

Breakdown the organic compounds of dead organic matter & organic waste.

2^0 Consumers → frog, lizard, box, jackals, wild dogs
3^0 -"- → lions, hyenas, cheetahs, lepards, Vulture

Decomposers → - dung bettle, → (decomposition) of dung.
- bacteria
- antinomyceetes
- fungus → Aspargillus
  Rhizopus
  mucor
  penicillium
  Fusarium
  Cladosporium etc.

Desert Ecosystem

- arid & dry
- less than 25 cm annul rainfall
- 1/3 earths land area is Covered by deserts.
- little sps diversity & consist of drought resistant plt.
- Animal live in harsh environment.
- Desert → Poor insulating Capacity.
  soil desert get cooled quickely
- Adaptation → plt / animal → Conservation of water
  plt → reduced scaly leaves → prevent H_2O
  - Succulent leaves - store H_2O
  - Stem flattened → Contain chlorophyll for Photosynthesis.
  - waxy cuticle — leaf → prevent H_2O l

Animal (Conserve H_2O) Insects & Reptiles → Thick bod
live in burrows (low humidity & heat during day) Covering

(b)* **Temperate grassland :** → grasses are predominate over trees & shrubs

trees & shrubs are completely absent or rare

savannas - shrubs & tree are sattered among the grasses.

(c) **polar grassland** → A treeless area beyond the timberline in high latitude region, having a permanently frozen subsoil & supporting low-growing vegetation such as lichens, mosses & shrubs.

- Characterised by → severe cold & strong frigid winds
  - only small annual plt grow in summer

animal → ~~wolf~~, wolf, weasel, arctic fox, reinderer

(1) **Abiotic Components** → C, H, O, N, P S etc
Sulphates, CO_2, H_2O, nitrates, phosphates

(2) **Biotic Components** →

1° **Producer** → diffnt kinds of Grasses
Dichanthium, cynodon, Desmodium, Digitataria, Dactyloatenium, Setaria sporobotuse etc.
local trees & shrubs.

1° **Consumer** → Zebras, Giraffe, gazelles, buffalo rabbit, mouse, wildbeests. antelopes, insects

3 types of deserts

1] Tropical Deserts : found in tropical regions like sahara & Namibia in Africa.

Thar desert & Rajasthan in India

- Scanty or less biotic components.
- Windblown, Sandstorms, Sand dunes are very Common.

2] Temperate Desert → Mojave in Southern California

- very hot temp. during day time in Summer & Comparatively cooler in winters.

3] Cold Desert → very cold winters, warm summer

- Gobi desert in china
- ladakh desert in India.

Abiotic Components → Soil, temp, air, H_2O

Biotic Components → Producers → desert plant showing Xerophytic adaptation like shrubs, bushes few grasses & trees.

thrones bearing plants

- lichens & mosses

Consumers → reptiles, insects, nocturnal rodents & few birds

Single or 2 humped camel - feed tender shoots of plant.

decomposers → Thermophilic bacteria, fungi

Food chain in ecosystem

food chain :→ a series of organism each depend on the next as a source of food.

-The patterns of eating and being eaten forms a linear chain called food chain.

- In the ecosystem various trophic levels are connected through food chain.
- The transfer of food energy from the source in plants through series of os which repeated eating & being eaten is referred as food chain. The transfer of energy from one tropic level (eg. Producer) to the next tropic level (eg. Consumer) is called food Chain.

ex: Phytoplankton → Zooplankton → Small fish → large fish → Man

→ 90% lost for plant's own Envisonment

→ 10 Calaries (1%) stored by plant → Herbirorus (99%) lost at it's level 9 calories → 1 calories Carnivore

- At each tropic level in food chain → large portion of energy is used for it's own maintenance & utility lost as heat.
- organism in each tropic level pass less on less energy than they receive.
- longer food chain → less energy is avalible to the final member.

Grazing food chain →

Producers

(autotropic)

- Synthesise organic food from simple inorganic raw material through photosynthesis utilizing solar energy.
- A part of food synthesised by Producer is used in body building
- rest is utilized in providing energy for various life activities.

Consumer

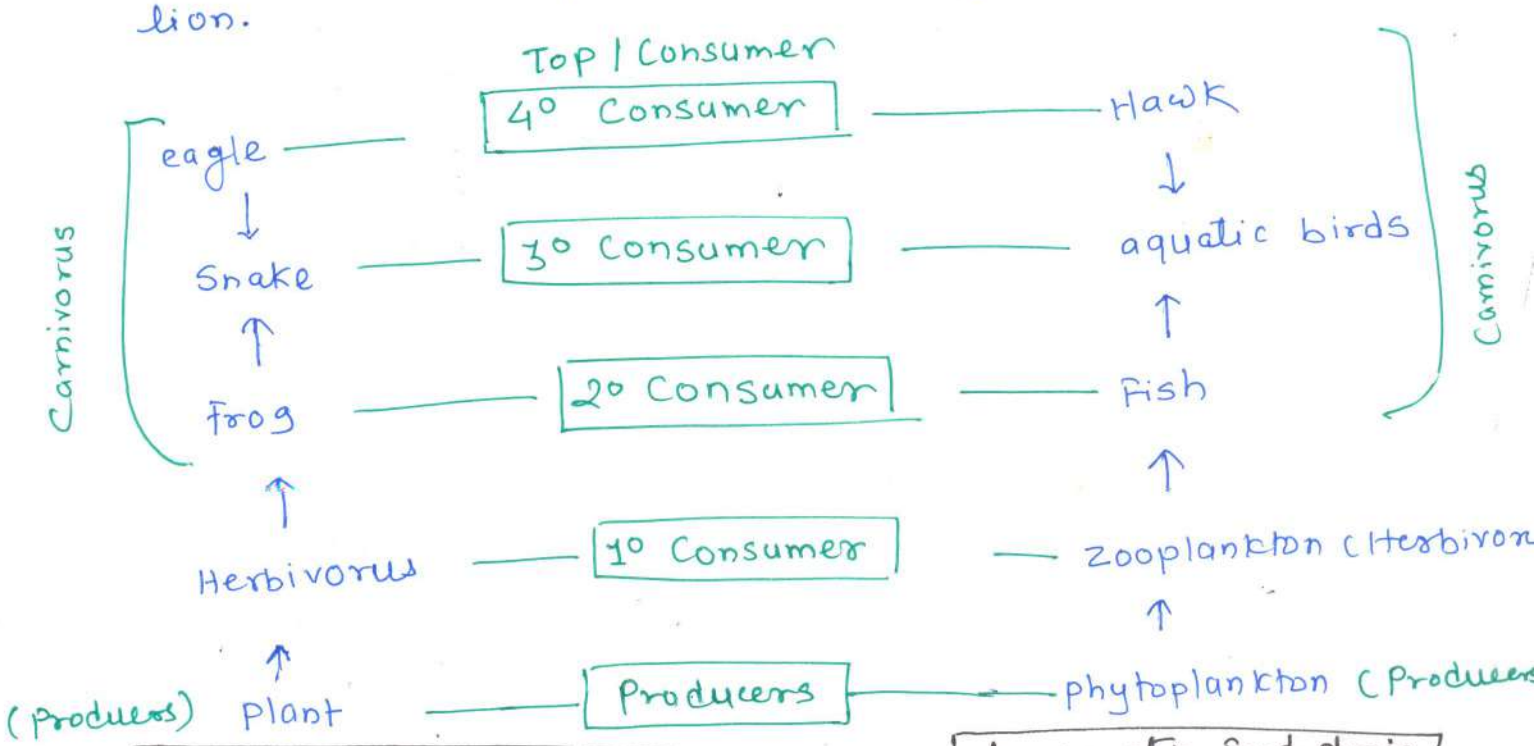
Directly take their food from plant

- pdn energy various life activities.

- herbivores are eaten up by 2nd order consumer.
(1° consumer)

Part of flesh | food → body building | other life activities.

- large Carnivorus Prey up on 2°| 1° carnivorus or Consumers or 2° Carnivorus eg Snake Prey up on frog.
- last order Consumer | top Carnivores eg Shark, Crocodile, tiger lion.



An terrestrial food Chain

An aquatic food chain

Detritus food chain

- start with dead organic matter & passes through detritus feeding Os in soil
- less depend on direct sunlight.
- Depend on influx of organic matter produced another system.
- Detritus food is simply a sub-component of another ecosystem
- large amount of energy flow through detritus food chain.
- food chain help in fixing inorganic nutrient.
- It consist of sub soil os.

(1) Detritus (leaf litter) decomposed by mos in soil (detrivore) → Earthworm (detrivore) → Rat → Snake → Eagle.

(2) Dead leaves → Detritus mos → Crab → Small fishes → large fishes.

Food web

→ Food chains are not isolated but are rather innerconnected with one another.

- "A network of food chains which are innterconnected at various tropic levels, so as to form a no. of feeding connections amongst difft Os of a biotic community is called foodweb"

or food web is a graphical model depicting the many food chain linked together to show the feeding relationships of organism in an ecosystem.

F.W. - Follow the multiple path

F.W - Starts with producers & Ends with Top Carnivores / decomposers

- food chain & food web form an integral part of ecosystem
- food web open several alternate pathways for the flow of energy.
- Allow os to obtain its food from more than 1 ~~thing~~ type of os.

Ex (1) field mouse eaten by wild cat
snake
an owl.

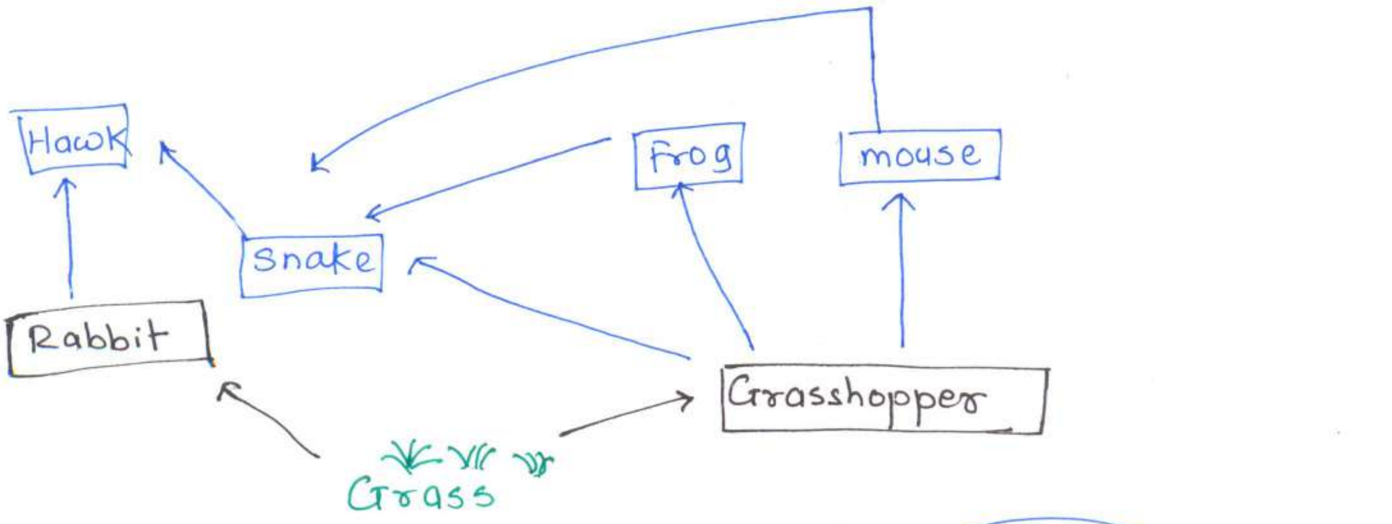
(3) Wolf or Jackel → rabbit
deer

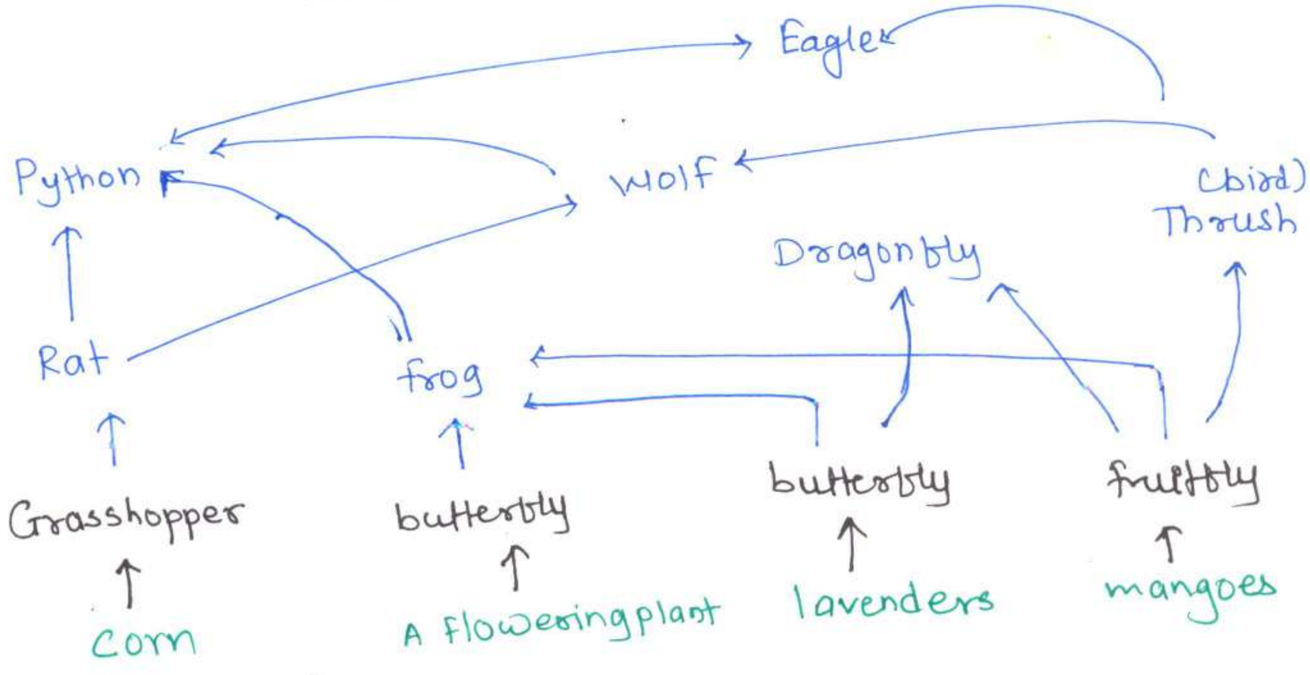
(2) Wild cat —eat→ birds
mice
squirrels etc.

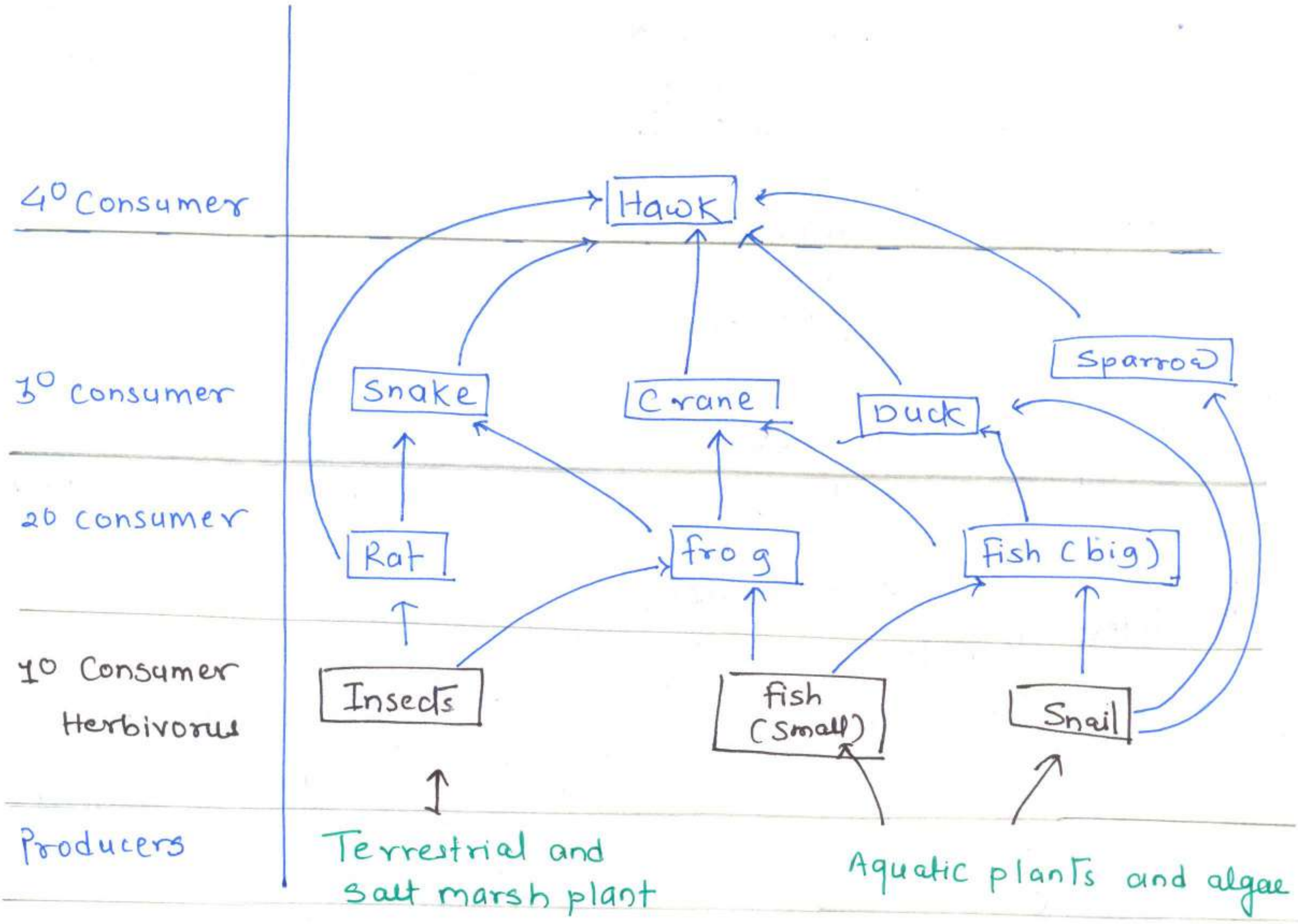
Generally (1) a food web operates according to taste & food Preferences of the Os at each tropic level,

(2) avaliability of food source.

ex → tigers do not eat fish or crabs but in Sunderbans they are forced to feed on them in absence of natural Prey.







4° Consumer
3° consumer
2° consumer
1° Consumer
Herbivorus
Producers
Hawk
Snake
Crane
Duck
Sparrow
Rat
frog
Fish (big)
Insects
fish (Small)
Snail
Terrestrial and salt marsh plant
Aquatic plants and algae

Fig: Food web

Concept of Eutropication / hypertrophication.

- Eutrophos - well nourished
- It is one of the effects of H_2O pollution of H_2O bodies. Eutrophication occurs after water bodies have been overloaded with minerals & nutrients (phosphate / nitrates) which induce excessive algal ~~blooms~~ growth & cause depletion of dissolved O_2. (hypoxia)
- This may result from released of untreated domestic waste ie sewage water / decomposed products / phosphate / nitrates coming from agricultural runoff directly in to the H_2O bodies.
- The entry of such minerals & nutrients through organic inorganic waste the water bodies become highly productive & nourishing this process is kn as "Eutropication"
- Due to eutropication the lakes & rivers get invaded by algal blooms which grow rapidly due to excessive nutrients present in H_2O.
- Unusual shifting of algal flora in to blue green algae that creates problem for aquatic fauna.
- algae produces toxins & aquatic life is severely affected and food chain is distrubed
- many algal sps dies rapidly & grow rapidly that again intensify the dead organic waste in H_2O which secret toxin
- The decomposers +nt in H_2O starts decomposition of dead algae huge amt of O_2 is used for decomposition process so as a result there is decrease in dissolved O_2.
- ↓se in dissoved O_2 affects aquatic fauna & ultimately anaerobic condition formed where only pathogenic anaerobic bacteria can survive.

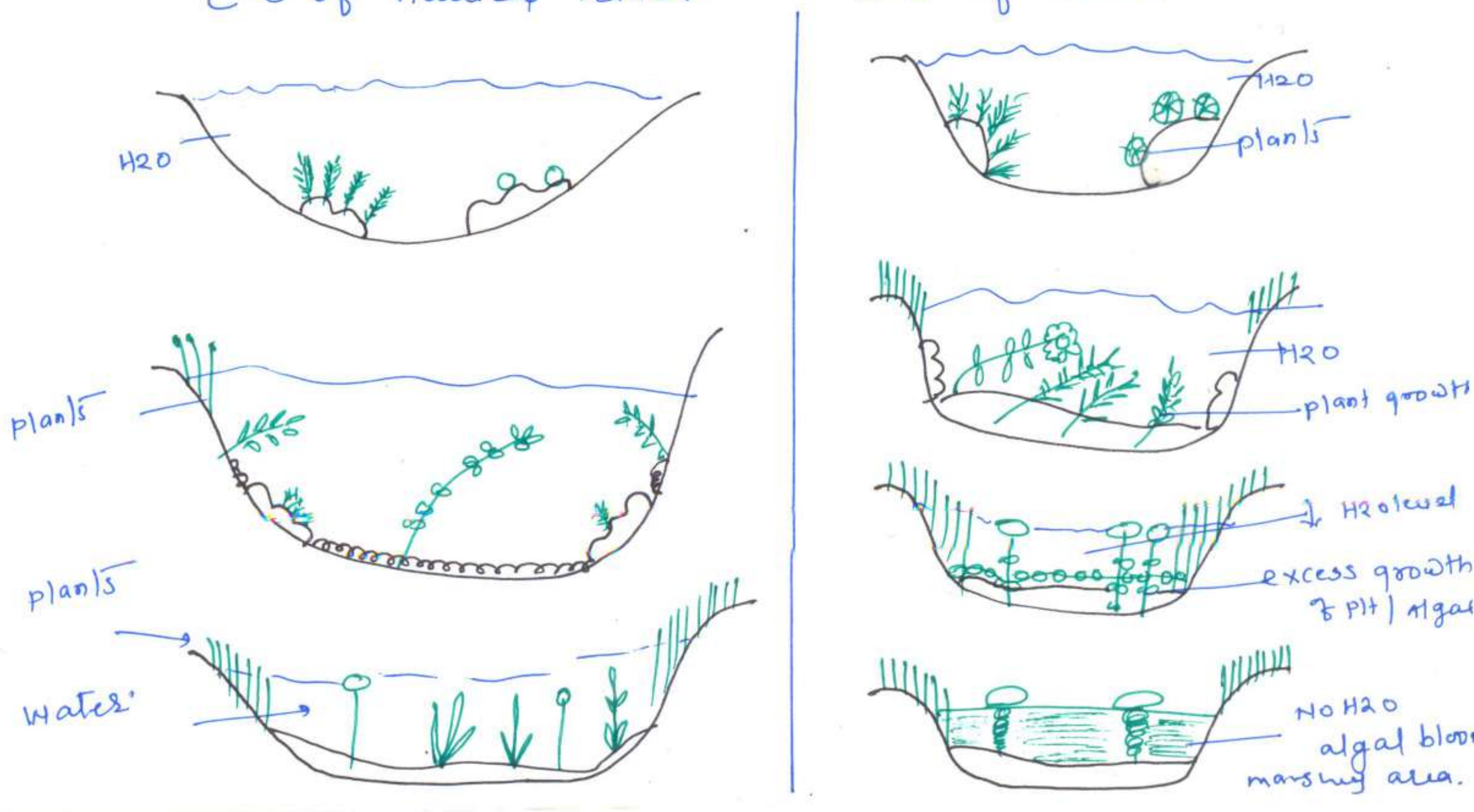
eg. Potomac river in US
Mono lake , in California.

- The fish kills in Nigeen lake 2012, Nigeen lake is part of Dal lake - ~~Kaish~~ Srinagar, Jammu & Kashmir.
- lake in Erie in USA Ex. of eutrophication due to addition of more than 80 tons of phosphate daily in 1965
- Due to man made addition of phosphates. lake invaded with algal blooms producing unpleasant odour, clogging pipes, interfering with fishing & navigation.

Water ways can be prevented by following methods.

1. Treatment ~~with~~ of sewage water to remove harmful waste, excessive nutrients & organic debris, excessive nutrients, organic waste
2. Harvesting of living or dead algae periodically from affected water bodies to prevent decomposition.
3. To remove excess dissolved ~~ox~~ nutrients from H_2O by applying chemical & physical methods. Precipitation, biological nitrification denitrification, electrolysis, reverse osmosis etc.

C.S of natural river   C.S of eutropic river.



" Ecological Pyramids "

Ecological pyramids is graphic representation of an ecological Parameter like no. of individual, amount of biomass or amount of energy Present in various tropic levels of a food chain with Producer forming the base & top Carnivores the tip.

- British ecologist invent Charles Elton (1927), Kn Eltonion Pyramids
- In a Pyramid, various steps of food chain are represented Sequence with Producers at base, herbivorus above then followed by Primary Carnivores then 2° & then Top Carnivore
- An ecological pyramid can be upright [largebase, Pointed tip]
  Inverted [narrow base, broader tip

or Spindle shaped [narraw at base & tip with broaderpart in the middle.

- 3 imp parameter → no. of individual
  amt of biomass
  amt of energy.

Pyramid of numbers

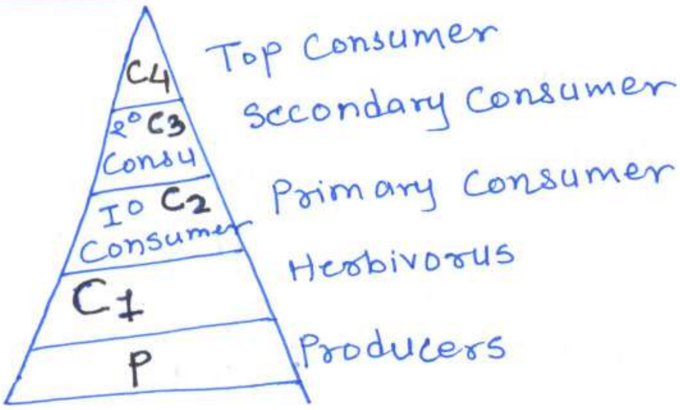
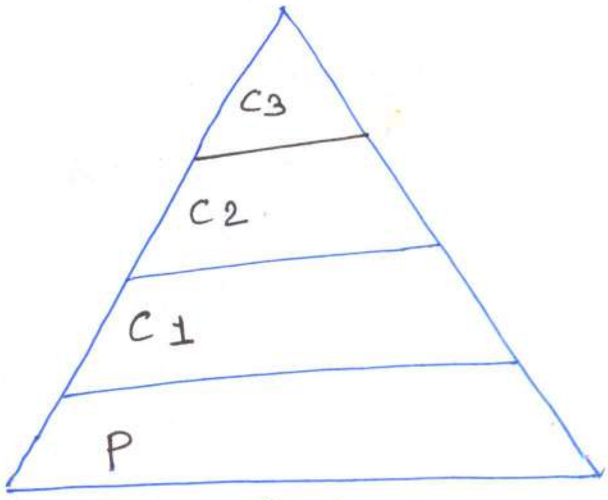


fig: In grassland
(upright



In a Pond
(upright)

- A graphic representation of no. of individuals/unit area of various trophic levels. Stepwise with producers forming the base & top carnivores the tip, is called pyramid of no.
- Pyramid of no. indicates numerical relationship betn diffnt tropic levels of the food chain.
- mostly the Pyramid of no. is straight or upright with no. of individuals in successive higher tropic levels goes on decreasing from base to apex.
- The maximum no. of individual occurs at producer level
- Producers support small no. of herbivorus.
- Herbivorus support few carnivorus & so on.
- Top carnivores are very new in no.
- Ex In grass land → large no. of grass or herbs support a no. of grasshoppers $\xrightarrow{S}$ frogs $\xrightarrow{S}$ snakes $\xrightarrow{S}$ support very few $\xrightarrow{S}$ peacocks or falcons

In Pond Ecosystem → large no. of phytoplankton $\xrightarrow{\text{Support}}$ Zooplankton $\xrightarrow{\text{Support}}$ Carnivores fishes (Small) $\xrightarrow{\text{Support}}$ Top Carnivores fishes (large) $\xrightarrow{\text{Support}}$ stork / kingfisher.

- In food chain, the organism of higer tropic level are dependent for food & energy on Os of lower tropic level.
- At each tropic level about 90% of food is wasted or consumed up in respiration & 10% is transferred to the higher tropic level.
- Therefore the no. of individuals in the successive tropic levels decreases from base to the tip & the shape of pyramid is upright.

Pyramid of Biomass

- The amt of living or organic matter present in a perticular environment is called biomass.
- It is measured in fresh or dry weight.
- A graphic representation of biomass present sequencewise/ unit area of diffnt tropic levels. with producers at the base & top carnivores at the tip. is called pyramid of biomass
- Ex. In terrestrial ecosystem. the maximum biomass occurs in producers & there is progressive decrease in biomass from lower to higher tropic levels.
  - It is found that 10 to 20% of biomass is transferred from one tropic level to next in food chain.
  - Thus 1000 kg vegetation produces a biomass of only 100 kg of herbivores, which in turn form only 10 kg of biomass of I[st] order carnivores, that gives rise just 1kg of biomass in 2nd order of carnivores & so on.
-

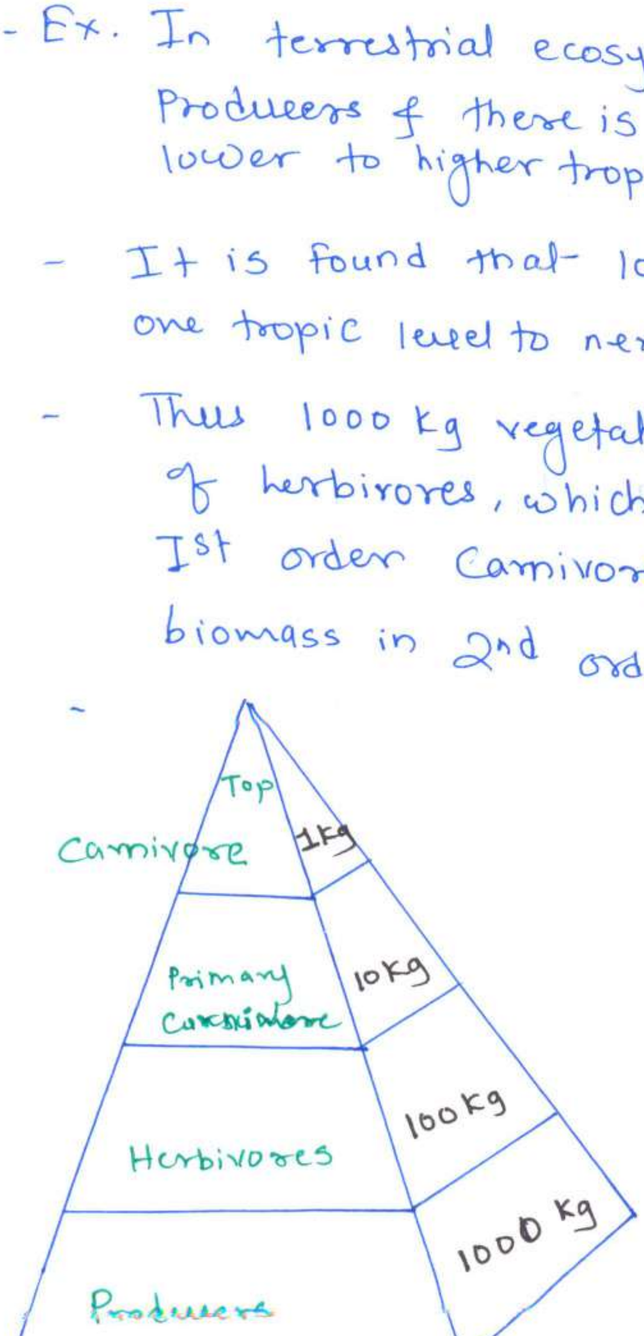
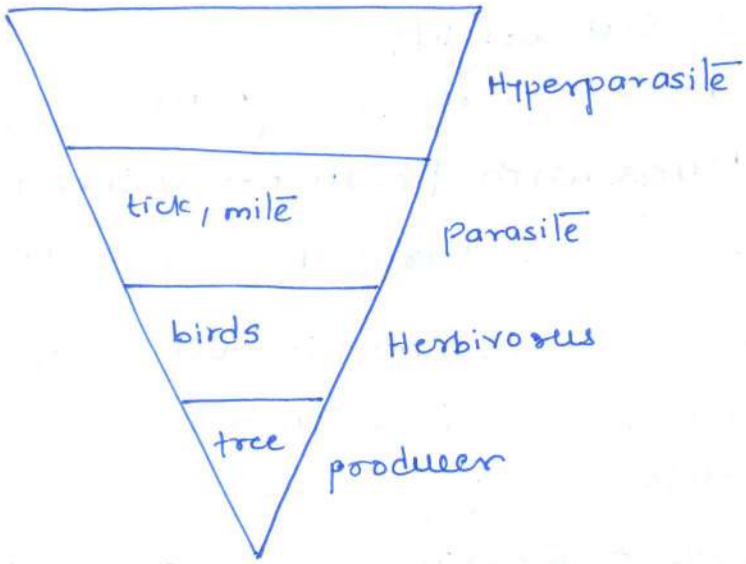


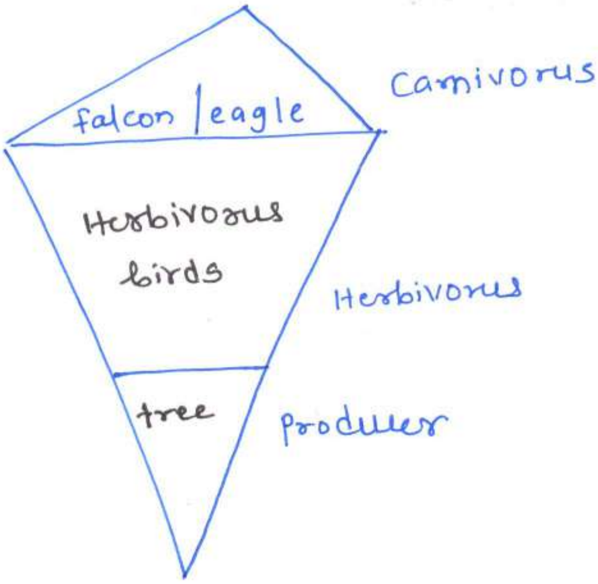
fig: Terrestrial ecosystem – Upright pyramid – Biomass

In a tree ecosystem an inverted pyramid is obtained
- a large tree Provides food to several herbivorus birds.
- Birds support the large population of ectoparasite.



A] Inverted pyramid of no → Tree.

In a tree ecosystem - Spindle-shaped pyramid is formed
- when a large tree support → large no. of Herbivorus birds
- Then birds are eaten by carnivorus birds like falcon, eagle which are smaller in no.



B] Spindle shaped pyramid of no.

- In an aquatic habitat the pyramid of biomass is inverted, when biomass of tropic level depends on the reproductive potential & longitivity of the member.
- Biomass is high only in case of long-lived organisms. Thus biomass of photoplanktons is less than the zooplankton
- Biomass of zooplankton is less than Primary consumer
- Biomass of 1° Consumer is less than 2° Consumer
- Biomass of 2° Consumer is less than Top carnivores or Consumer.

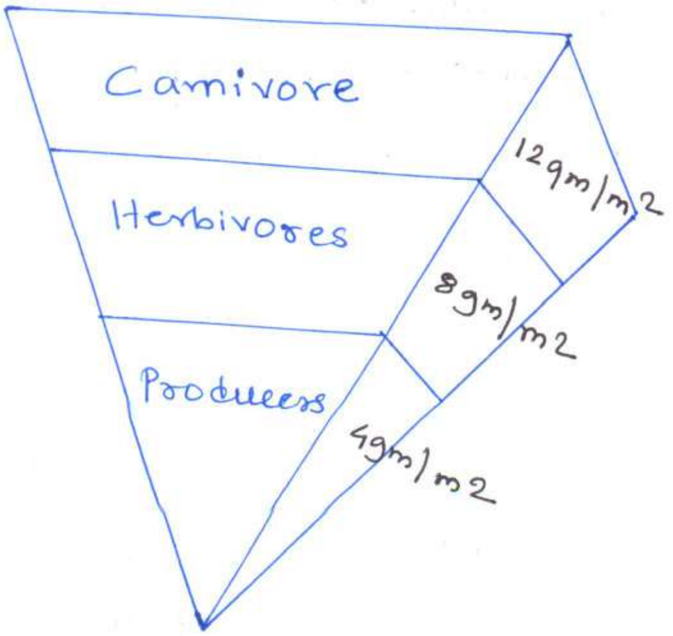


Fig: Inverted Pyramid in an aquatic ecosystem - biomass.

Pyramid of Energy

- A graphic representation of amt. of energy trapped/unit time & area in diffnt tropic levels of food chain with producers forming the base & top carnivores at the tip is called pyramid of energy.
- Pyramid of energy is always upright.
- The energy content is generally expressed as K cal/m2/yr or KJ/m²/yr.

- maximum energy content is not in the Producers.
- The energy content is decreases as it passes in to higher tropic levels, because of its utilization in Performing life activities & overcoming entropy as well as dissipation as heat.
- Ex. according to Odum (1971), In pond ecosystem, phytoplankton traps 31080 kJ/m2/yr of Solar energy
  - The zooplankton & other herbivores, which feed on phytoplankton, Possess an energy content @ 7980 kJ/m2/y
  - They (Herbivores) support 1° Carnivores (insect, larva, Small fishes) with an energy Content of 2100 kJ/m2/yr
  - The 2° Carnivores (large fishes) which feed on I° Carnivores have an energy Content of 126 kJ/m2/yr.

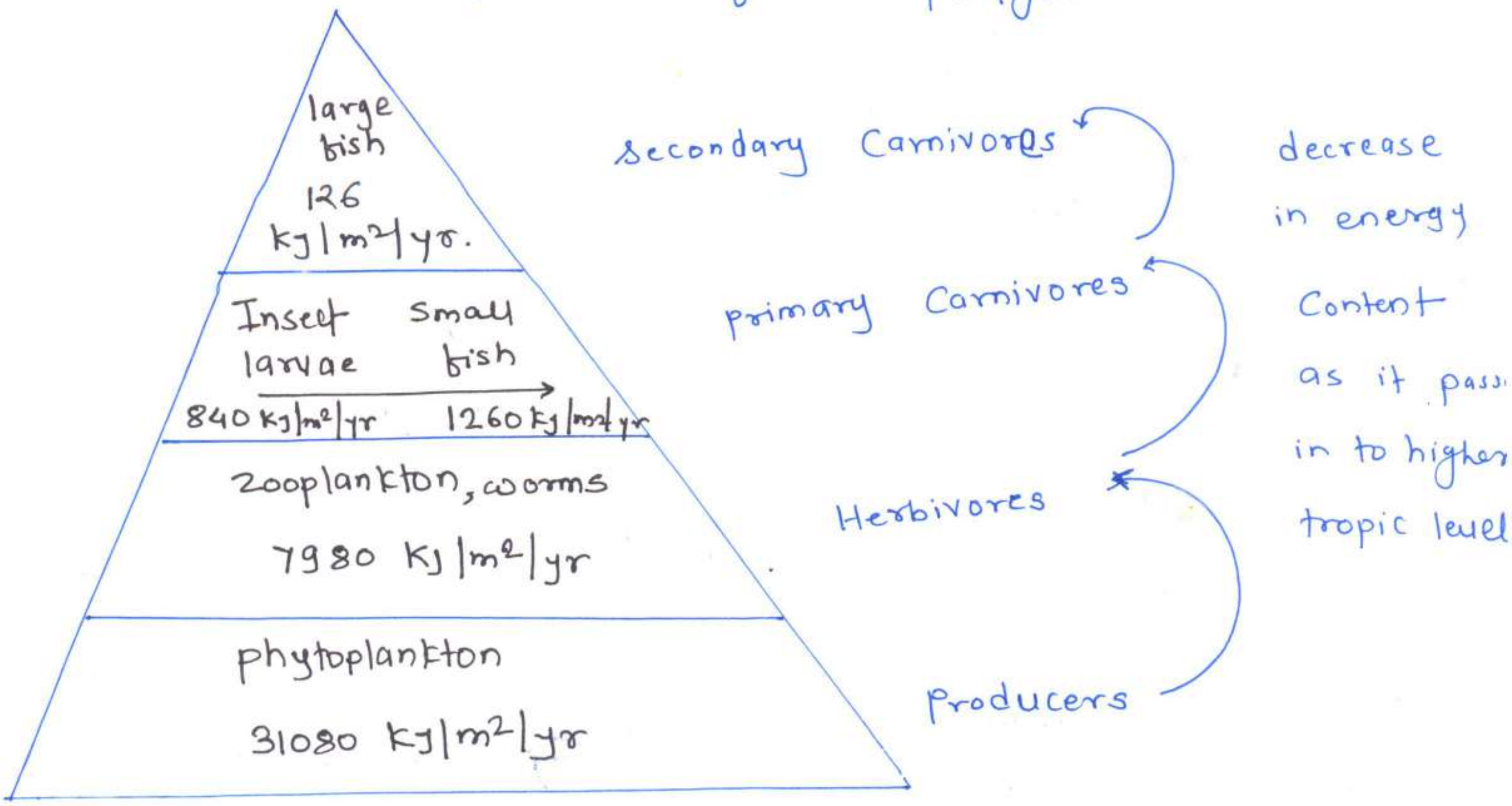


Fig: Pyramid of energy — always upright

"Population"

Population ecology is the study of Population in reation to the environment. It includes environmental influces on Population density and distribution, age, structure, and variation in population size.

Definition of population:—

Population can define as a group of interbreeding organism of the same species in particular area in given time.

or

The population is whole number of individuals or inhabitants in an area or country.

Monospecific population — It is population of individuals of only one species.

Polyspecific or mixed population → It is population of two or more species which is often referred as Community.

Characteristic of Population

1. Population size
2. Population density
3. Dispersion patterns
4. Demographics → Statistical studies of population & the factors which changes over time.
5. Survivorship curves
6. Population growth.

Population size → is the number of individual/ organism in a population.

Population Density → is measurement of the no. of people in an area. It is an average Number

- It is usually shown as the number of People per square kilometer.

Population density changes with time & space.
Density distinguished as follows:→

(1) Numerical density → [No. of individuals per unit area or volume]

When the size of individuals in a Population is relatively uniform as birds, insects or mammals etc the density is expressed in numbers. is referred as ~~de~~ numerical density.

(2) Biomass density → [biomass per unit area / or volume]

when size of population is variable like trees, fishes or mixed population then it is measured in terms of biomass density.

Calculated by various ways → dry weight
wet weight
volume
carbon
nitrogen weight etc.

(3) [Absolute No. of individuals in population] Abundance

- Smaller individuals are abundant than larger

eg. Insects are more abundant than reptiles.

exception → birds are less than mammals.

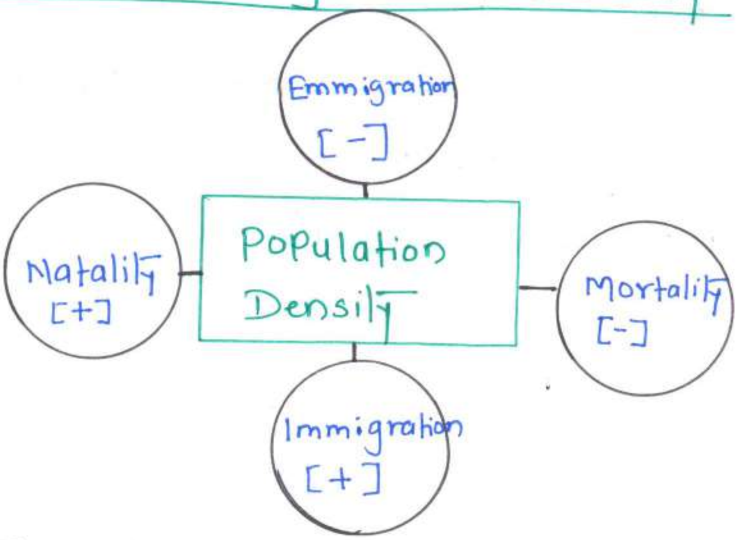
(4) Crude population Density (No or biomass per unit space)
Ecological or specific density (no. of biomass | unit habitat space)
In nature Os are mostly found in clumped | groups
rarely shows → uniform distribution
Ex. Plant Cassia toxa → found more in shady places
Cassia toxa → exposed area
} Crude + densi

only shady area population
-"- exposed -"- ———— } ecological / specific density

Density Can be Calculated in terms of no. of individuals or biomass per unit area. = $D = N/A$

Where D = Density
N = No. of individuals of sps
A = area

"Various factors affecting Population density"



Natality : –
The birthrate, which is ratio of total live births to total population.

Mortality : –
The death rate, which is ratio of the total no. of deaths to the total population.

Immigration : — No. of Os moving into area.
Emigration : — No. of Os moving out of the area.

Example → If in a Pond there are 1200 Rohu fish last yr & through reproduction 800 new Rohu fish are added. the current Population 2000 Calculate birth rate

800/2000 = 0.4 offspring/fish/yr.

Natality : Production of new individual by birth ('hatching/ birth/ germination/ fission).

No. of Individuals borne/ unit time.

Natality ⟶ 2 Types ① maximum or Absolute or physiological
② Ecological or Realised

① Absolute ⟶ Maximum pdn of new individual under constant & ideal environmental condition.

② Ecological ⟶ Pdn of new individual under all existing environmental.
[All possible limiting factors]

Ecological Natality changes with size, composition, Evn. factors.

ΔN_n = Production of new individual

$\Delta N_n / \Delta t$ = the absolute natality rate

$\Delta N_n / N \Delta t$ = the specific natality rate.

N = Initial no. of population/ total population.

n = new individuals in population

t = time

Δ = a change in value.

Mortality → defined as rate of death in Population / unit time expressed in % of individual deaths in population per unit time.

M. – Rate varies from sps to sps.

(1) Minimum or specific or potential mortality → minimum death of new individual under constant & ideal envisonmental condn in Population. [death → aging & senescence.]

(2) Ecological / Realised mortality → death of new individual under all existing envisonmental condition. [stress, disease, Predation, Competition, density, etc.]

Mortality exp. as death of individual of a population in given time. = $M = D/t$

M = mortality
D = No. of deaths in population
t = time.

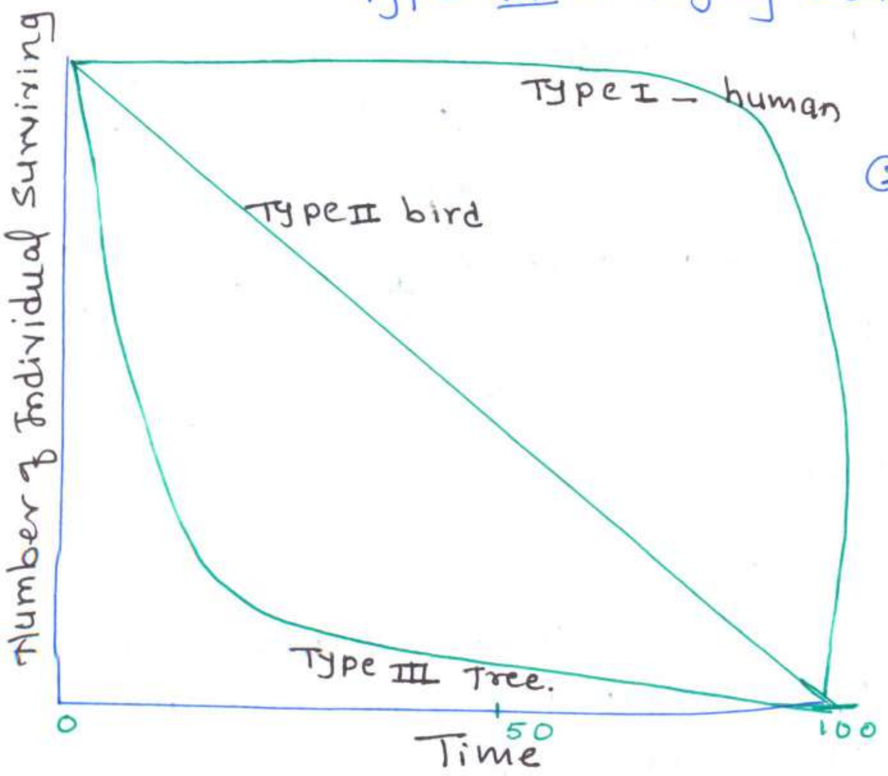
D] **fecundity** → physiological reproductive potential or actual reproductive performance of an individual which measure in terms of no. of eggs, seeds, asexual propogation

- Ability to reproduce.
- Parental Care is imp. factor which affects fecundity rate.
- Invertebrate → 1000 to 500,000 eggs → parental care is not there
  mammals → 1 to 12 offsprings → parental care is there.

i) Semelparity → os reproduce only once during lifetime.
ii) Iteoparity → os reproduce repeatedly

Survivorship curve :

- Graph showing the no. or Proportion of individuals surviving at each age for a given species or group (♀/♂)
- Constructed for a given cohort (a group of individual of roughly the same age) based on a life table.
- 3 Types — Type I – Highly Convex
  Type II – Diagonal straight-line curve
  Type III – Highly Concave curve



③ Type III – Characterised by high mortality at early ages & near about constant at all other life stages.

Ex. Insects, oyster shell fish, oak trees octopus etc.

① Type I Survivorship curve → characterised by the low mortality rate in young as well as adult

- High survival rate.
- All individual born at the same shows similar physiological lifespan. & die about the same age.

Ex → human, deer, mountainshe[ep]

② Type II → Constant survivorship, in which rate of mortality is nearly constant at all ages of a population.

- uniform decline in or decrease in the no. of individua[ls]

Ex. Hydra, American robin (bird), Gull,

Every sps has different age.

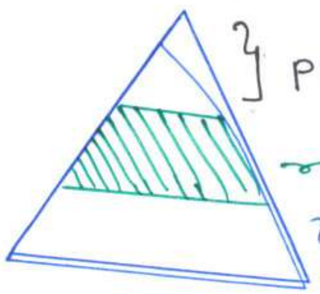
The age ratio of a population at various age group determines the reproductive ability of the population. Growing population has more % of young individuals & in decline population there is large no. of old age groups.

- There are 3 imp ecological ages in any population which are called as age pyramids.

1) Pre-reproductive : (0-14) (Juvenile) dependant age gp)
2) reproductive : (15-44) (adult)
3) Post reproductive : (ages 45 and up) (old age)

Diffnt age group proportion of the population represented geometrically is referred as age pyramids.

i) Pyramid with Broad Base / Triangular structure →



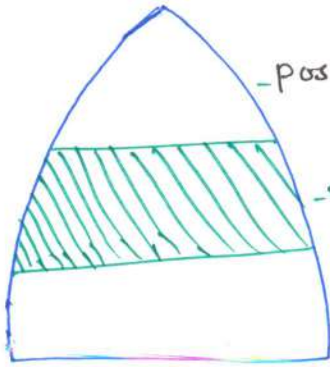
young population

- It is rapidly growing population
- high % of young individuals in the population.
- The natality rate is high & it grows exponentially
- pyramid shows broad base

Example : yeast / Housefly / Paramoeca
 4m.

- Population of India.

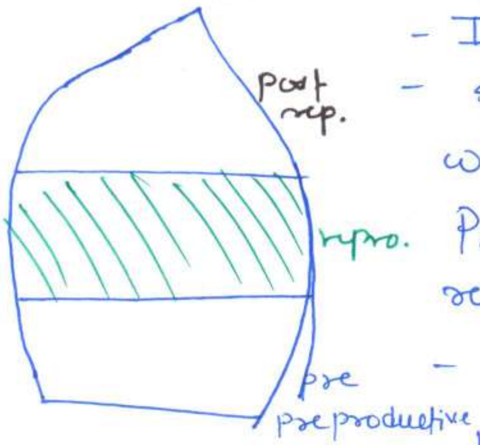
ii) Bell-Shaped polygoan : →



Stable population

- In this pyramid - popul^n shows equal no. of young & middle aged individuals ie pre-reproductive & reproductive age groups become more or less equal in siz
- Post-reproductive groups are smallest
- It is Stationary population as population growth is slow & stable.
- Ex. Pop^n of Developed coun like U.S.A

3) Urn - Shaped pyramid



- It is declining Population
- show low % of young individuals when birth rate is drastically reduced ie Pre - reproductive group is very less than reproductive & post - reproductive
- Population declines.
- Ex. Japan.

Declining Population

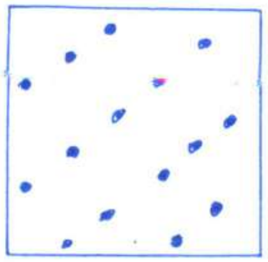
G) Sex - ratio → is the ratio of no. of ♀ in relation to ♂.
As per fisher's Principal, in most of the sexually reproducing sps it is 1:1. f. affecting the sex ratio → birth rate, death rate, immigration emigration etc.

- some animals does not show 1:1 ratio → as they reproduce by parthenogenesis ex. Bees, ants, aphids etc.
- ♀ ↑

H] Dispersal and Dispersion → "The dispersion of a population is the pattern of spacing among individuals within the geographic boundaries."

3 types → Random, Uniform, Clumped

Uniform Dispersion - Evenly spaced distribution, in which member of the Population maintain a minimum distance from one - another.



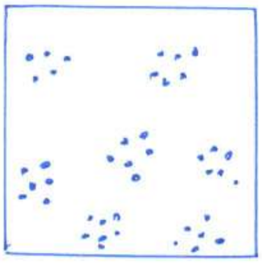
- In Plants due to Competition for H_2O, Sunlight, or available nutrients.
Ex: Creosote bushes in mojave desert
- In animals due to strong territoriality
Ex. desert lizard Uta sp.

Example : Birds nesting on small island, king penguins on South Georiga Island in the South Atlantic ocean often exhibit uniform spacing.

② Clumped → is pattern when individuals are aggregated in patches.

- most frequent pattern of distribution in a popn.

Reasons → Some area of habitat are more suitable than other.



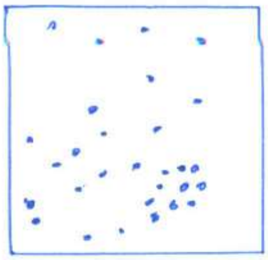
- Heterogeneous environment with resour concentrated in patches
- Tendency of offspring to remain with parents
- mating or social behaviour of the individual.

Ex: wolves living in groups ↑ses the effectiveness of hunting, spreads the work of protecting & caring for young. fish, herds of elephants.

③ Random

→ - It is a spacing pattern based on total unpredictability / Random.

- least common



Reasons → members of a spp do not frequently interact with 1 another.

- Not heavily influenced by the microenvironments within their habitat.

Ex. wind-dispersed seeds of Dandelions spread widely & sprout where they fall randomly & later germinate.

The population shows charateristic pattern of ↑se which are called population growth forms.

Growth forms represent the interaction of biotic potential & Environmental resistance.

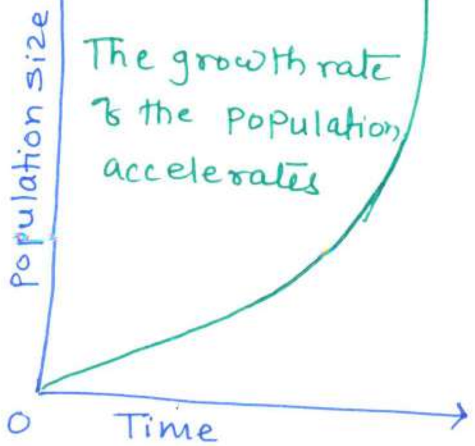
The population dynamics is done by 3 approaches ex.

- mathematical model → theoretical / simulation.
- laboratory studies
- field studies

Exponential Growth / Unlimited Population growth →

If a population has a constant birth rate through time & is never limited by food or disease.

- Exponential growth explain the population growth increases in ideal environment & also express the capacity of sps to increase the population.
- Exponential growth shows J shape curve.
- Members of population reproduce at a steady state rate.
- At the beginning rate is slow, then population doubles with each generation until reach to indefinite large population size.
- Example → Population increased in size per unit time as per manner like 1, 2, 4, 8, 16, 32, 648.....



a] Exponential [unrestricted] growth

- With exponential growth the birth rate alone controls how fast (or slow) the population grows

$$dN/dt = r_{max} N$$

- As population size (N) ↑ses, rate of population ↑ses (dN/dt) gets larger.

$N_t = N_0 e^{rt}$

N_t = no. of individual at time t
N_0 = Initial no. of individuals
e = base of natural logarithms
r = (r_{max}) per capita rate of increase.
t = number of time intervals.

Example → 14 million people tnt in country in 2005, where 0.028 were born & 0.008 died during year.
r = natality rate minus mortality rate per yr.
r = 0.028 − 0.008 = 0.02 substituting the exponential growth equation.

N_{10} = 14 million × $2.718^{0.02 \times 10}$
= 17 million.

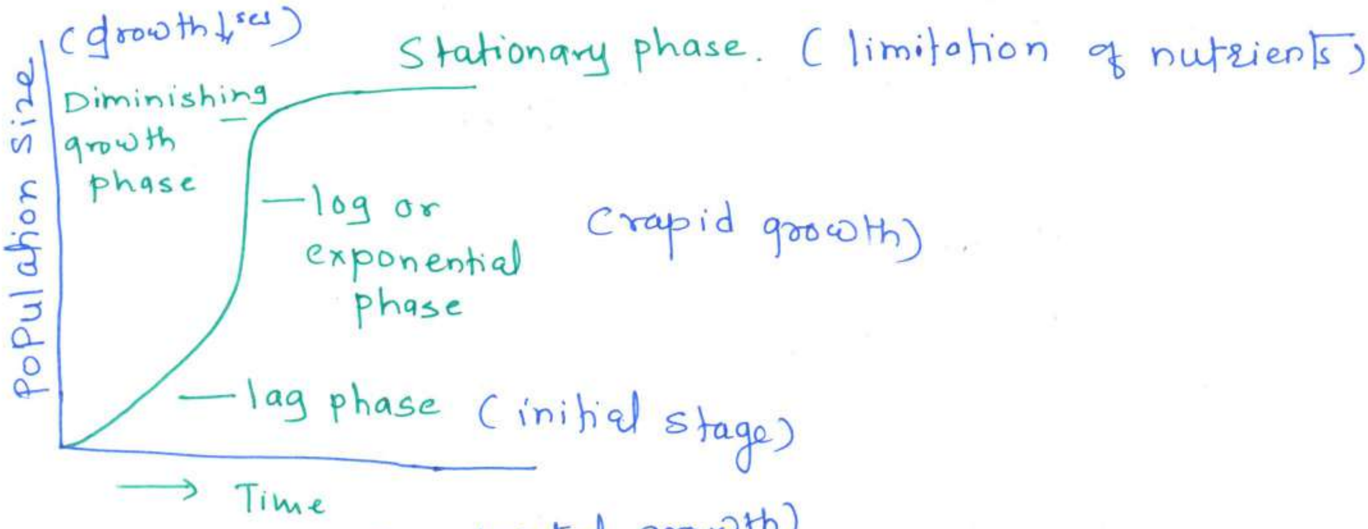
(0.02 × 10) = 0.2

$x^2 = \frac{2}{2} = h$

$14 \times (2.718)^{0.2}$
= 14 × 1.2214
= 17.0996

Logistic Growth / Realistic Population Growth: →

- S shape Curve | sigmoid forms.



logistic (restricted growth)

- The growth the population is at 1st slow (Positive acceleration phase), then become very rapid (logarithmic phase) & finally slows down as the environmental resistance increases (−ve acceleration phase) until an equilibrium level is reached around which the popln size fluctuates more or less irregularly according to the constancy or variability of given environment
- The Carrying capacity of equilibrium density is represented by the letter "K"

$$dN/dt = r_{max} N(1 - N/K) \quad \text{or}$$

$$\frac{dN}{dt} = r_0 N \left[\frac{K - N}{K}\right]$$

- r max = maximum per capita rate of increase under ideal cond
- When N nears K, the right side of the equation nears zero.
- As Population size increases, logistic growth rate becomes a small fraction of growth rate.

- Highest when $N = K/2$

Or r_0 = innate capacity of population to ↑se
N = Population size
K = highest population density / Carrying capacity.

The Peak constant level represented by K or upper level of Sigmoid Curve is called the maximum carrying capacity.

If K = 1,000 and population size are low (N=100), even though $(K-N)/K$ is close to 1, population size are so small that growth is small, dN3

$$\frac{dN}{dt} = (0.1)(100) \times \frac{(1,000-100)}{1,000} = 9$$

At the medium values of N, (K-N)/K is less close to value of 1 but population growth is larger because there are a larger no. of reproducing females 3 If K = 1,000, N = 500, r = 0.1, then.

$$\frac{dN}{dt} = (0.1)(500) \times \left(\frac{1000-500}{1000}\right)$$

$$= 25$$

At larger value of N, (K-H)/K becomes small, resources are close to being used up, & population growth is again small, If K = 1000, H = 900, r = 0.1 then,

$$\frac{dN}{dt} = (0.1)(900) \times \frac{(1000-900)}{1000} = 9$$

Density - Independent limiting factor

- Natural disasters
- climate

- Regulate the population without considering its density
- operates on large & small population.
- Density independant factors are more effective due to natural disaster's like – strom
  floods
  droughts
  jungle fire
  tsunamis
  earthquakes
  volcanoes
  land slide

Disturbance or disintegration of natural habitat & certain human activities such as forest cutting
pollution
dam buidding etc

Can cause decrease in species population. no matter how large or small it is.

- A worst strom may kills more than 70% bird species.
- Some die due to direct fire.
- others who will survive, will also die because of food & water inadequacy, as well as shelter.

Density independent Factor's determine population changes & set the stage for existance of population.

Abiotic factors → (1) General effects of weather on population.

Ex. (1) Heavy rains that reduces insect population.

(2) Winds carry migrating insects out to sea.

(3) Increase in humidity which produces condition suitable for Epizootics (outbreak of H1N1) outbreak of disease affecting animal of one kind at the same time.

(4) Insect blown-up (destroyed) to snow covered mountain peaks

(2) Effects of Temperature on Development

- Developmental time ↓ses with ↑se in temperature. or
- Developmental Rate ↑se with ↑ in temp.
- The time of year and geographical location can dramatically affect the growth of an insect with respect to temp.

Ex → grasshopper sps. Camnula pellucida when reared at 32°C produce - 20-30 times as many as eggs than those reared at 22°C.

(3) Effects of climate on Population

The combination of temp, air movement, humidity & rainfall can dramatically affect the success of a natural enemy in a given location.

- These variables (temp, air, humidity & rainfall) considered together are equivalent to the term climate.

"Sampling methods in Population Ecology"

- To know the number and distribution pattern of plants or other organism in desired area,
- It is not possible to count all of them by manually.
- Then counting of few representative parts of the study area is called as sampling.

Sampling method → Density is measured by this method.
- depends on the Type of os and its natural abundance & distribution.

(1) Quadrant method :→ This sampling method is classic tool, a series of squares (quadrants) of set size mainly used in ecology & geography to study plant population or for other objects of large area.

- A quadrant is suitable frame, mostly squares for sampling of plants of varying size areas.

Sampling of plants or slowly moving animals (as snails) can be done using a sampling square called a quadrant.

- plant ecologist R. pound & F. E Clements develop the use of quadrant method in 1900 to study the plant population.
- This method is use to find out similarities or differences in composition & structure betn various plant communities.
- It is of 4 Types

1. list quadrat : list of sps tnt in perticular quadrant.
2. list - coart Quadrat : Includes the population of each sps in every representative quadrant.
3. Chart Quadrat : It is graphical presentation of area covered by grass, mat or mosses etc. It help to show in change in community in future.
4. Clip quadrat : Biomass or weight of each sps is studied in this method. fresh or dry weight of uprooted individuals or branches or fruits recorded.

Grazing animals shows effects on vegetation, so it should be studied by fencing the quadrats by proper material.

$$\text{No. of quadrats sampled in the unit} = \frac{\text{Area of unit} \times \text{tot. no. of qu}}{\text{Total area of habitat}}$$

② Line Transect method or line - intercept Sampling method

- string of measuring tape to mark out a line
- commonly used to measure the % of vegetation, coverage, woody debris, mat, plant, or animal abundance etc
- Muttlak & Sadooghi - Alvandi 1993

This transect may be single, multiple, L- shaped unequal length.

- Steps for line transect

① make two measurements of particular item or plant or individual; transect length & maximum width. ③ measure bare region/area.

② If there is multiple items of interest (eg 2 plt sps) repeat steps 1 & 2

- Calculate the density for each plant species or items of interest

Density of plt sps × total reciprocal of maximum plt/vegeta by the unit area/ total length of transect.

- less time required.

Ⓑ Belt Transect method

- String or measuring tape required to mark out a line
- This method record the information of abundance of perticular sps as well as presence or absence of it.
- In this transect line comes out across the surveyed area & quadrat is on beginning marked point on the line
- The individual (plt / Animal) identified inside the quadrat & their abundance is recorded.
- Animal can be counted or collected. to find no %. of plant species.
- Cover is the area of the quadrat occupied by the above ground parts of sps when view from above;

"Population Regulation / limits to Population growth"

Environment limits Population growth by altering birth & death rate by 2 factors density dependant factor
density independent factor

Density - Dependant factor : are the factors which become more effective when population size is large in compared with limited resources.

1) Competition — for — Resource
2) Predation
3) Parasitism
4) disease

- The limited resources → food, water, shelter niche, males etc.
- Sets or affects the carrying Capacity 'K' [maximum population size of the species]
- High Population density ↑ses the mortality rate when overcrowded.
- Dense Population which leads to physiologi stress and ultimately minimises the reproduction
- Ex. Overcrowding of parasite on / in host kills the host.
- Intraspecific competition for food or prey can lead to decrease the natality (birth rate) rate.
- In animal population territoriality is one of the limiting factor.

Density dependent factor operates in a large population & causes the population either to ↑se or ↓se depending on how it affects the ecosystem.

Ex. Huge population can deplete an area's natural resources & food supply. this cause shortage of food & shelter cause reduction of area's population due to hunger, thirst, & lack of shelter.

Gause's studied the growth pattern of 2 sps of paramoecium ie P. aurelia & P. Caudtum when Cultured together and separately

- Both species are fed on bacteria,
  yeast,
  oatmeal medium in culture tube in the lab.

- Bacteria → occured more in oxygen-rich upper part of culture tube.

- yeast → oxygen poor lower part of culture tube.

- Each paramoecium sps was slightly different size

- Gause calculated population growth as combination of no.s of individuals per millilitre of solution multiplied by their unit volume to give a population volume of each species.

- When paramoecium grown separately. Population of both the species shows sigmoidal growth pattern.

- When both species grows together, their growth patterns were sigmoid in the 1st week,
- but later there was gradual increase of P. aurelia & gradual decrease in population of P. caudatum.

- This is due to both sps are using bacteria as food, but P. aurelia grew at a rate six time faster than P. caudatum.

- The P. aurelia did not grow to the level, it had done when grown separately because some competition occured betn both species.

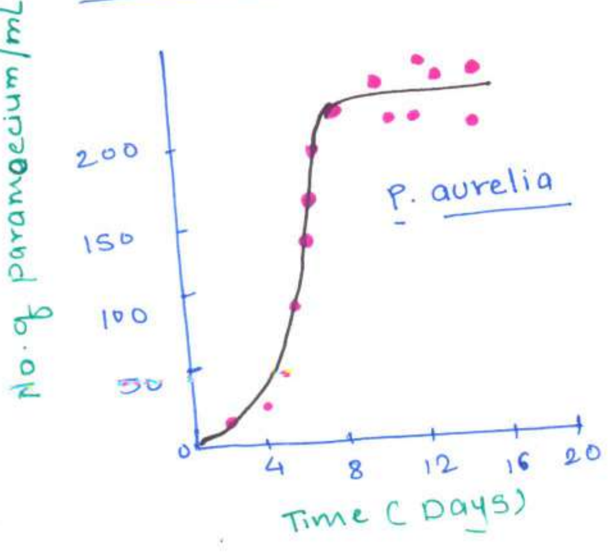
- From this experiment Gause concluded that species with exactly the same requirements can not live together in same place & use same resources.

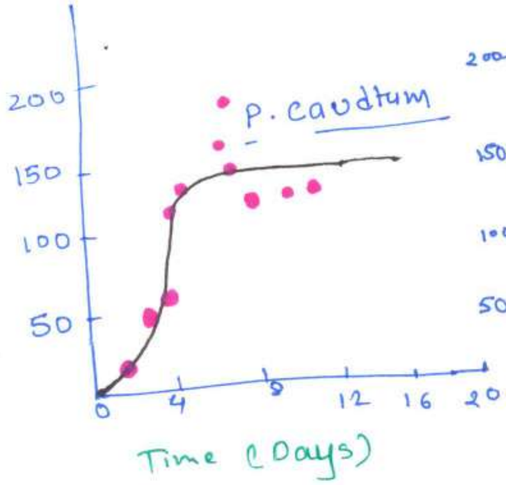
Gause's Prineipal of competition Exclusion.

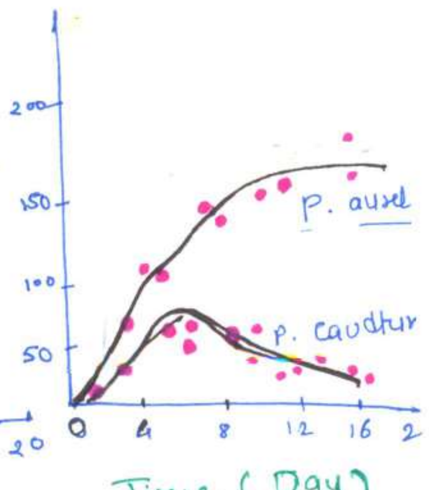
Two speeies Competing for same resources can not co-exist

- In interspeeific competition, if 2 diffnt speeies population require a common resourse for living, this resource is limiting, the 2 sps faces the competition.
- Here 1 sps population will survive as it exerts greatest negative effect on their competitors.
- 1 sps will survive & there will be an exclusion or displacement of one of the population by competition.
- This is called Gause's Principal of competition exclusion which states that "complete competitors cannot exist".
- Both speeies co-exist indefinitely only when interspeeific competition is less intense.
  - Neither population raches the carrying capacity (maximum poln) in presence of other.
  - population have equally negative effects on the growth of each other.
  - But interspecific competition is stronger than intraspeeific competition.

Example of laboratory interaction







"Population Interaction"

Most ecosystem contain popln of many sps that interact in ~~vital~~ various ways so that changes in 1 population will have the effect on the other population. A no. of such interactions

1. Competition → betn memb. of same ~~sps~~ SPS / trophic level
2. Predation → Predator is an OS that eats another organism
3. mutualism → 2 Species live together in close association both are benefited.
4. Commensalism → 1 OS gets benefited, other neither get benefit nor harmed
5. Amensalism → 1 organism harm to other organism without benefit or harm.

(1) Competition — Population 1 ⇄ Population 2 (− / −)

(2) Predation — Prey popln ⇄ Predator popln (+ / −)

(3) Mutualism — Population 1 ⇄ Population 2 (+ / +)

(4) Commensalism — population 1 ⇄ population 2 (+ / 0)

(5) Amensalism — Population 1 ⇄ Population 2 (0 / +)

"Single - Channel energy Model"

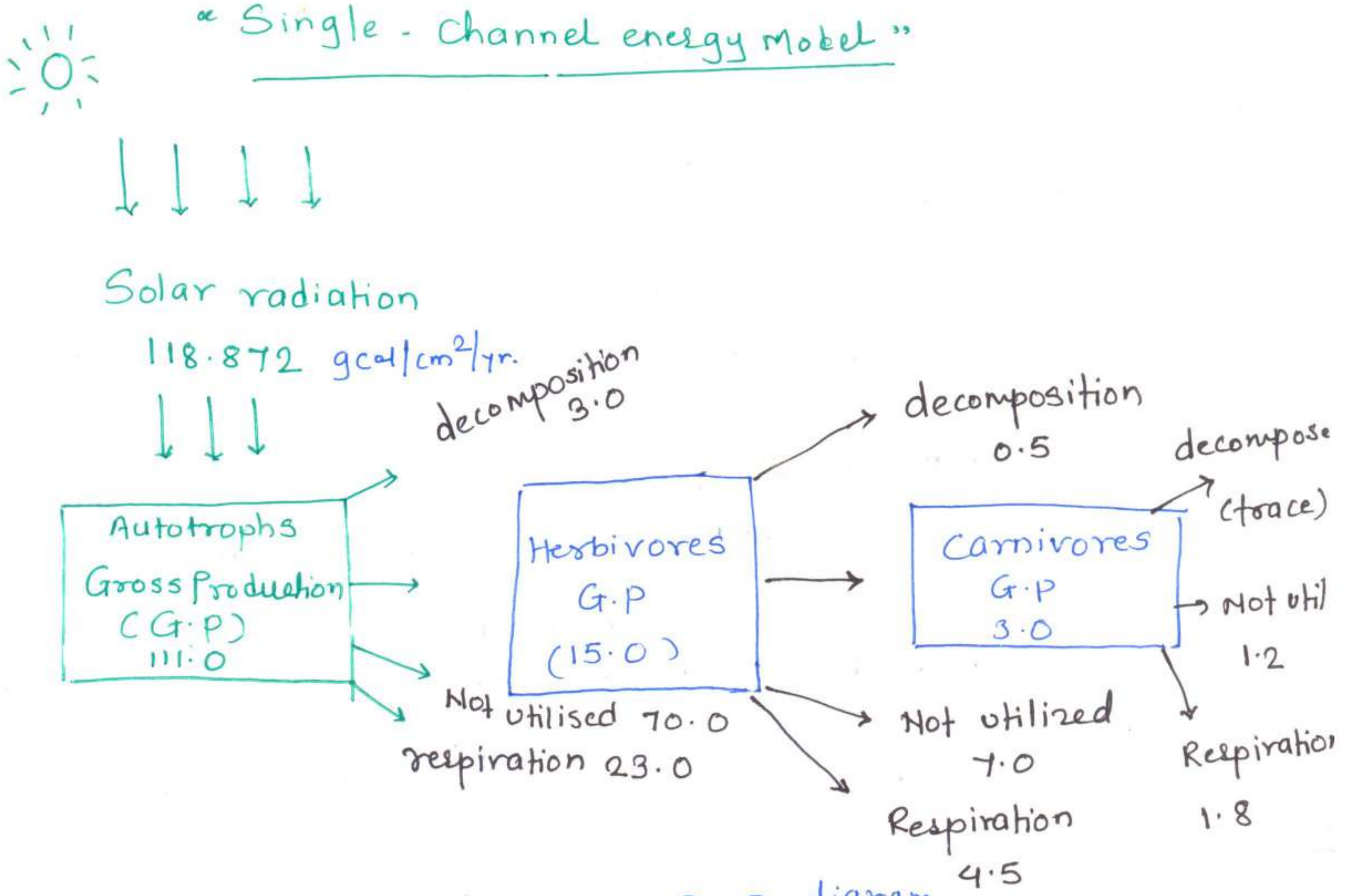


Fig: Energy Flow digram of lake. g cal/cm²/yr

Energy flow in Ecosystem:

- transformation of energy from 1 tropic level to another in an ecosystem can be termed energy flow or ecological dynamics
- Energy flow in ecosystem is Unidirectional
- To understand ecosystem from energetic point of view → ① The efficiency of Producers in absorption & conversion of Solar energy.

② Solar energy to chemical energy & use of this chemical Chemical energy by consumers

③ input of energy in the form of food & its efficiency of assimilation.

④ loss through respiration, heat, excretion etc ⑤ gross net pdn.

Energy: → is ability to do work.

Energy Pattern & Flow are governed by Ist & IInd law of thermodynamics.

Ist law: → "Energy is neither created nor destroyed" but it Can transform from 1 form to another form.

IInd law → every step of energy transformation & Flow through a System = gradual loss of the ability to do work/energ

- It state that when work is done energy is dissipated or dispersed.
- work is done when 1 form of energy is transformed into another form.

① Total incoming solar radation 118, 872 g cal/cm2/yr 118,761 g cal/cm2/yr remain un-utilized, & thus

② Gross production (net production plus respiration) by autotrophs is 111 g cal/cm2/yr with an efficiency energy capture of 0.10%

③ It may noted that 21% of this energy or 23 g cal/cm2/yr is Consumed in metabolic reaction of autotrophs for their growth development, maintenance & reproduction.

④ It may seen 15 g cal/cm2/yr are consumed by herbivores.
- that graze or feed on autotrophs - this amounts to 17% of net autotroph production.

⑤ Decomposition (3 gcal/cm2/yr) accounts for about 3.4% of net production.

⑥ The remainder of the plant material, 70 g cal/cm2/yr or 79.5% of net production, is not utilized at all but becomes part of accumulating sediments. much more energy is avaliable for herbivore than is Consumed.

(1) A Simplified energy flow model of 3 tropic levels, indicates that the energy flow is greatly reduced at each successive tropic level from producers to Herbivorus & then to Carnivorus

(2) transfer of energy from one level to another, major part of energy is lost as heat or other form. there is sucessive reduction in energy flow (ie total energy input & total assimilation) or 2° dry production & respiration component

(3) 3,000 kcal of total light falling up on green plant, approximately 50% (1500 kcal) is absorbed, of which only 1% (15 kcal) is converted to 1st tropic level.

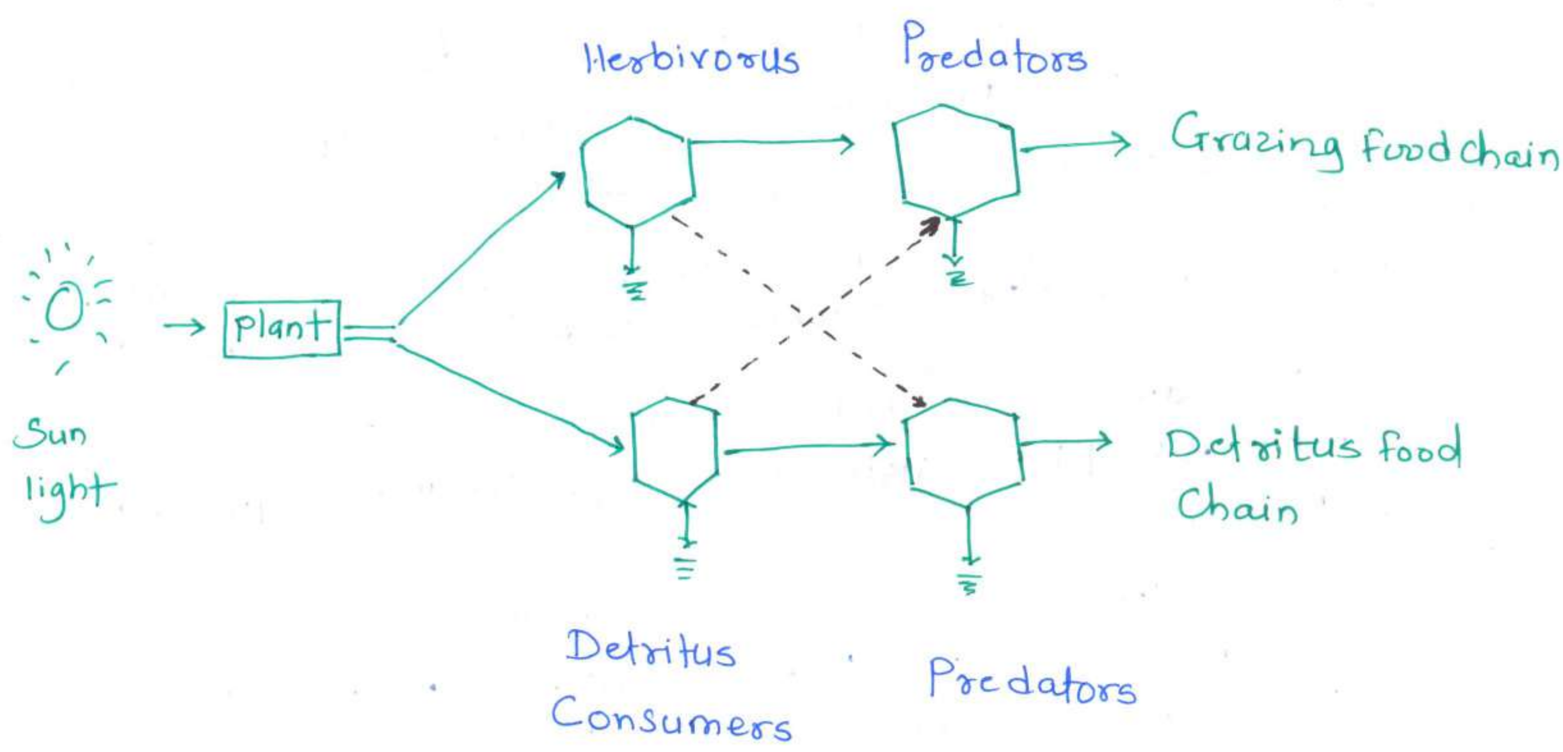
(4) Thus Net Primary Production is 15 kcal. Secondary Productivity (P_2 & P_3) tend to be about 10% at successive consumer trophic level ie herbivores & carnivores, although efficieney may be sometimes higer, as 20% at carnivore level ie (P_3 0.3 kcal).

(5) It become evident that there is successive reduction in energy flow at successive tropic level.
Thus shorter food chain, greater food chain energy would be avaliable
- Increase in the length of food chain there is loss of energy. or more energy will be avaliable.

(6). Reduction in energy flow shown as '<u>pipes</u>' in the digram

(7) 1 gm of an alga may be equal to many grams forest tree leaves, due to the fact that the rate of pdn (metabolism

Y- Shaped energy Flow model



① Y- Shaped model indicates 2 food chains namely the Grazing food chain & detritus food chain are under natural condition, not completely isolated from one another.

② The grazing food chain beginning with green plant base going to herbivorus and the detritus food chain beginning with dead organic matter acted by microbes, then passing to detritivor & their consumers.

③ Dead bodies / feces of small animal that were once part of the grazing food chain incorporated in the detritus food chain. The distinction between 2 food chain of time lag (a period of time betn one event & another) between the direct consumption of living plant and ultimate utilization of dead organic matter.

- In Grazing food chain, there is importance of Grazing food chain
- In Some ecosystem detritus food is important.

④ The imp point in Y shaped model is 2 food chains are not isolated from each other. Y Shaped model is more realistic & Practical working model.

Y - shaped model confirms to stratified structure of ecosystem

It separates the grazing and detritus chains (direct consumption of living plant & utilization of dead organic matter)

The micro-consumer (absorptive bact / fungi)
the macro-consumer (phagotrophic animal eg. Paramoecium differ greatly in size-metabolism relation (E.P. odum 1983)

Proposed by odum. Y-shaped model is applicable to any living component like plant / animals / mos / individual / Population or tropic group.

This model depicts basic pattern of energy flow in ecosystem Under natural conditions, these Os are inter-related in a way that several food chains become interlocked this result in to a complex food web.

a) Complexity of food web depends on the length of food chain. Thus in nature, there operate a multichannel energy flow. But in these channel belong to either of 2 basic food chains - Grazing or detritus.

(12) unidirectional flow of energy. The energy is captured by the autotrophs does not revert back to solar input; which is passes to herbivorus does not pass back to the autotrophs As energy moves through various tropic levels it is no longer available to the previous level. Due to 1 way flow of energy, the system would collapse if primary source the sun, were cut off.

(13) The is Progressive decrease in energy level at each tropic level