Environmental Science

EV 20001

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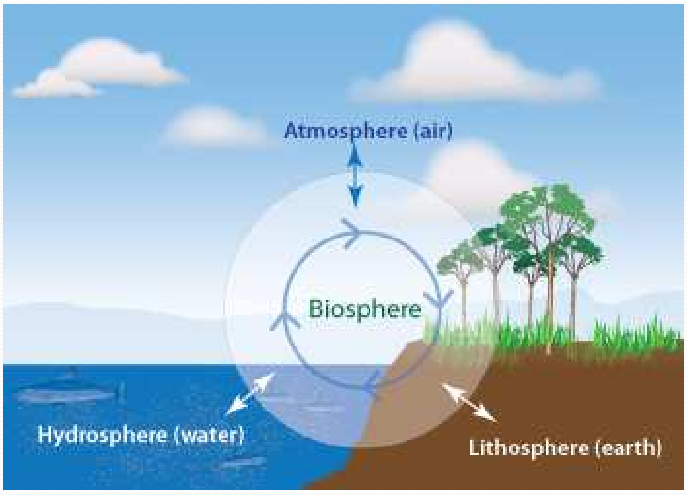
What is Environment ?

- ***Man has always inhibited two worlds***
  - ***Natural World: Plants, animals, air, water and soil of which man himself is a part***
  - ***Built World: Social Institutions & artifacts which he created for himself by using science & technology***
- ***Environment defined as one's surroundings consisting of organisms***
  - I. ***Abiotic : soil, water and air***
  - II. ***Biotic: Living organisms***

Global Environment: The 4 Spheres

The names of the four spheres are derived from the Greek words for:

- ***Stone (litho)***
- ***Air (atmo)***
- ***Water (hydro)***
- ***Life (bio)***



Global Environment: The 4 Spheres

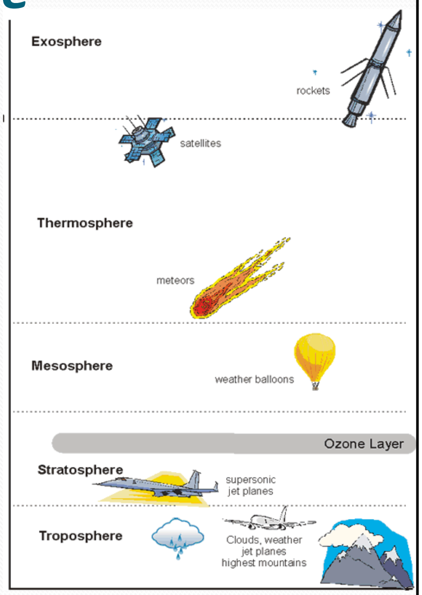
- ***Atmosphere:*** ***blanket of gases and suspended liquids and solids that entirely envelop the earth***
- ***Hydrosphere:*** ***oceans, rivers, lakes and the shallow groundwater bodies that interflow with surface water (70%)***
- ***Lithosphere:*** ***the solid outer section of Earth, which includes Earth's crust, as well as the underlying cool, dense, and rigid upper part of the mantle.***
- ***Biosphere:*** ***all living organisms: includes all of the animals, plants, and microorganisms of earth.***

Atmosphere

- Multilayered envelope of different gases
- Over 10,000 Kms
- Total mass of about 5.15×10^{18} kg (3/4th within 11 Kms)
  - Nitrogen (78.08 %)
  - Oxygen (20.94 %)
  - Argon (0.93 %)
  - Carbon Dioxide (0.03 %)
  - Traces of Gases (0.00174 %) Neon, Helium, Ozone, Hydrogen, Krypton, Xenon, methane & water vapor

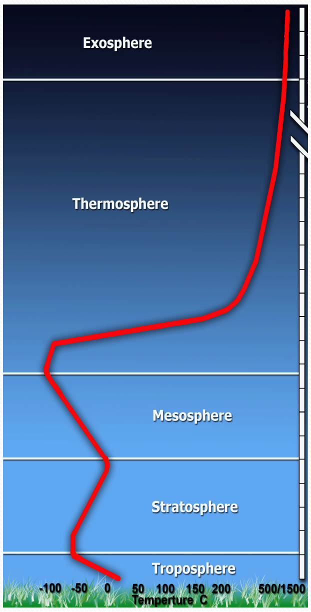
Layers of Atmosphere

Layer	Height (km)	Feature
Troposphere	0 to 12 km	Where we live layer
Stratosphere	12 to 50 km	Stable layer
Mesosphere	50 to 80 km	Meteors burn up layer
Thermosphere	80 to 700 km	High temperature layer
Exosphere	700 to 10,000 km	Molecules exit layer



Troposphere

- Comprises 80 % mass of atmosphere
- Extends from Earth's surface to an average height of about 12 km
  - 8 – 10 Km at Polar Latitudes
  - 10 – 12 Km at moderate Latitudes
  - 16 – 18 Km at Equator
- Contains N_2, O_2, CO_2, Water vapor, inert gases etc.
- Temperature ranges 15°C to -56°C (18 Km)
- Decrease in temperature with increase in height
  - Rate of 5°C per Km in lower region
  - Rate of 7 °C per Km at upper region
- Narrow layer with constant temp. called tropopause separates troposphere from stratosphere



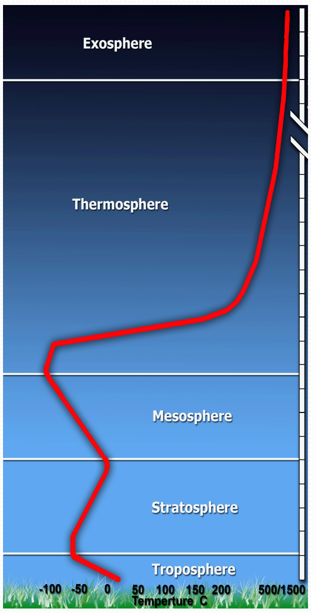
Stratosphere

- Extends upto 50-55 Km from surface of earth
- Temperature variation : -56°C to -2°C
- Ozone Layer , Nitrogen, Oxygen, Nascent Oxygen (O)
- Ozone formed:

$$O_2 + \text{Solar Energy} \rightarrow 2O$$

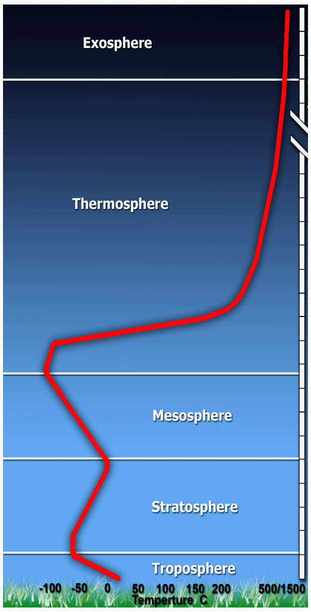
$$O_2 + O \rightarrow O_3$$

- Absorbs harmful UV radiation from the sun
- Aeroplanes fly in lower region of the layer



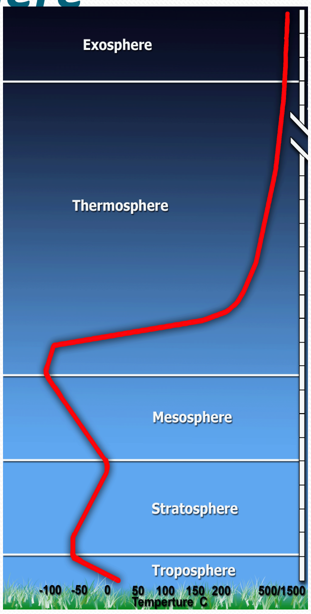
Mesosphere

- Extends from the stratopause at an altitude of about 50 km to the mesopause at 80–85 km.
- Temperature ranges : -2°C to -92°C
[an average temperature around −85 °C]
- Decrease in absorption of solar radiation
- Nitrogen, Oxygen, Nitric Oxides
- Most meteors burn up upon atmospheric entrance in mesosphere.
- Inaccessible to jet-powered aircraft and balloons.
- Mainly accessed by rocket-powered aircraft.



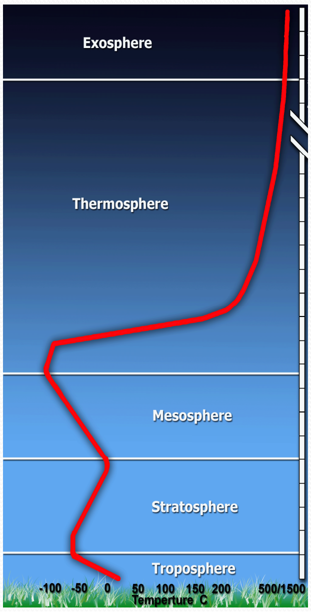
Thermosphere / Ionosphere

- Extends upto the thermopause at about 500–1000 km above sea level.
- Temperature of layer increases with increase in height and could be as high as 1500 °C
- Temperature in the usual sense is not very meaningful, as the air is so rarefied that an individual molecule travels an average of 1 km between collisions with other molecules
- UV & Cosmic radiations of sun causes ionization of molecules or atoms present
- Completely cloudless and free of water vapor.
- Reflects radio waves making wireless communication



Exosphere / Outer Space

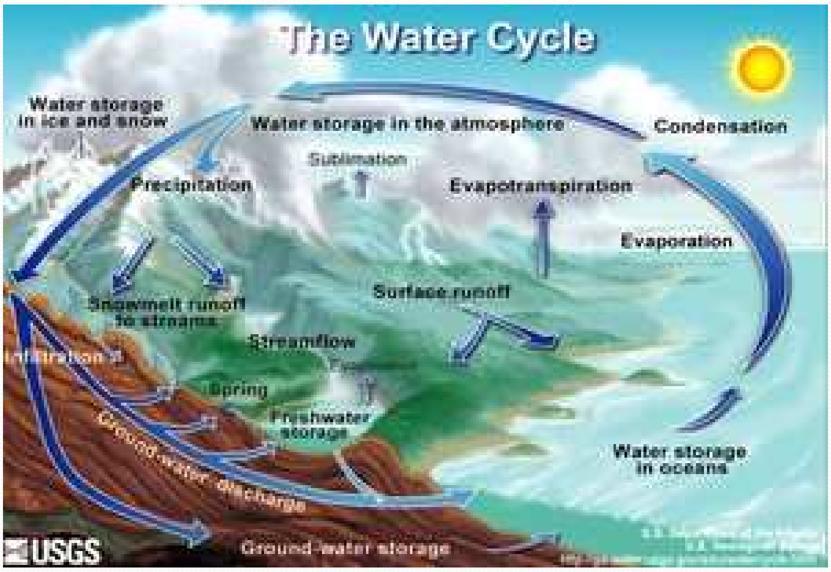
- Topmost layer that extends upto 10,000 Km from earth surface.
- Contains extremely low densities of hydrogen, helium and several heavier molecules including nitrogen, oxygen and carbon dioxide closer to the exobase.
- The atoms and molecules are so far apart that they can travel hundreds of kms without colliding with one another.
- No longer behaves like a gas, and the particles constantly escape into space.
- Temperature increases with increase in height
- Contains most of the satellites orbiting Earth.



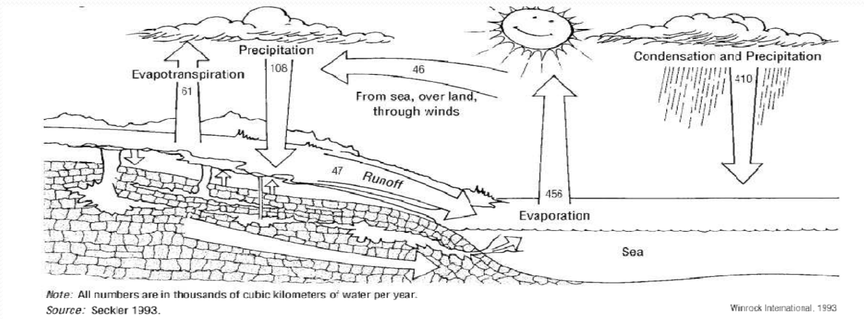
Hydrosphere

- Water Resources: Oceans, Seas, Lakes, Rivers, Streams, Glaciers, Polar ice caps, Water Vapor, Ground water
  - Solid (Snow) / Liquid (Water) / Gas (water vapor)
- Oceans occupy 70.8 % of earths surface, and contain 97 % of hydrosphere with total volume 1376 X 10^6 Km^3
- Polar ice caps & Glaciers : 2%
- Fresh water for consumption: 1 %
- Solubilising properties of transforming nutrients & ions from soil to plant body and animal body

Hydrosphere: The Water Cycle



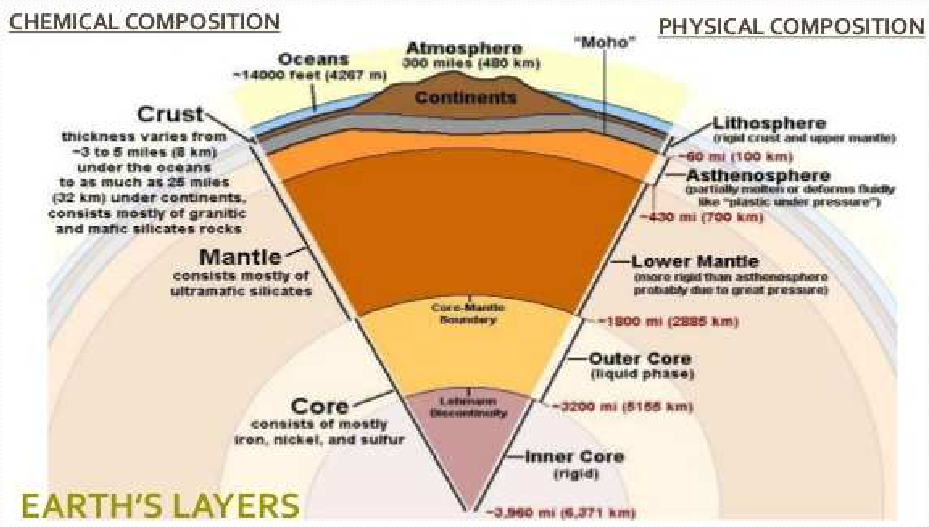
Hydrosphere: Global Water Balance



Location	*Surface Area (km²)*	*Water Volume (km³)*	*Percentage of Total Water*	*Estimated Average Residence Time of Water*
Oceans	**361,000,000**	**1,230,000,000**	**97.2**	**Thousands of years**
Atmosphere	**510,000,000**	**12,700**	**0.001**	**9 days**
Rivers and streams	**—**	**1,200**	**0.0001**	**2 weeks**
Groundwater (shallow to depth of 0.8 km)	**130,000,000**	**4,000,000**	**0.31**	**Hundreds to many thousands of years**
Lakes (freshwater)	**855,000**	**123,000**	**0.01**	**Tens of years**
Ice caps and glaciers	**28,200,000**	**28,600,000**	**2.15**	**Tens of thousands of years and longer**

***Source:* U.S. Geological Survey.**

Lithosphere: Earth Layers



Lithosphere: Earth Layers

- Crust, Mantle, Core
  - Core: high density solid materials (Fe+Ni); 5,430 °C
  - Mantle: 2880 Km thick made of hard rocks (Fe+Mg)
  - Crust: Lithosphere part with thickness : 16-50 Km
- The rigid outer part of the earth, consisting of the crust and upper mantle is called ***Lithosphere***, which constitute the hard and rigid outer layer of the Earth.
- The lithosphere extends from the surface of Earth to a depth of about 70–100 km.
- Weathering of crust causes soil an important abiotic factor supplies necessary water & nutrients to plant

Biosphere (Environment)

- Thin shell that encapsulates the earth comprising lithosphere, hydrosphere and atmosphere.
- Providing sustenance to all the living organisms that ***primarily exists from 3 meters below ground to 30 meters above it***. In the oceans and seas, most aquatic life inhabits a zone that stretches from the surface to ***about 200 meters below***.
- Some species can live far outside of these ranges, as high as 8 km above earth surface and 8 km beneath the ocean surface. Microorganisms are known to survive well beyond even these ranges.
- ***1.5 million species*** have been identified in biosphere.
- The waste product in the gaseous, liquid and solid waste forms are discharged into the biosphere.
- Abiotic & biotic environment is linked in terms of energy flow, biogeochemical cycles.

Environmental Ecology

Ecology

- Greek word *oikos* means home
- Latin and Greek roots of word *logic* refers to scientific study or thought

- **Study of the Home**

Ernst Haeckel 1869:

- **Study of the relationships between an organism and its environment**
- **Study of the relationships which determine the distribution and abundance of organisms**

Hierarchy of Ecology

Hierarchy of Ecology

Species (or organism) –

- Individuals identified by their common genetic makeup, behavior, physical characteristics and ability to breed with one another
- Ecologists study the above characteristics which have evolved to make the species successful in its habitat

Hierarchy of Ecology

Population –

Individuals of a particular species within a given area

- **Defined within some kind of physiographic region** such as a mountain range or contiguous habitat, and **not by political boundaries**
- Ecologists study the distribution and abundance of populations within their habitats
- Preservation of each population is important in preserving the gene pool of successful characteristics for the continued adaptation and evolution of earth's biota

Hierarchy of Ecology

Community –

- Consists of all the living organisms (the **biota**) in a given area and their interrelationships
- Understanding the relationships between competitors, predators, prey, diseases, food supply etc. can shed light on the cause-effect relationships influencing population distribution and abundance

Hierarchy of Ecology

Ecosystem –

- **Biotic** and **Abiotic** components of a habitat and their interrelationships
- Form the working units of nature in which populations and communities work in balance with one another and with the non-living environment

Hierarchy of Ecology

Biome –

- A collection of different ecosystem that share similar climate conditions.
- In a biome one can find ecosystems involving pond, forest, rivers & streams etc.
- Primarily there are two main types of biomes known as aquatic and terrestrial.
- Aquatic biomes are of two main types known as freshwater biomes and marine biomes.

Hierarchy of Ecology

Biosphere –

- All the biomes or ecosystems on earth and their interrelationships
- Only with the advent of global monitoring, satellite imagery, and computer modeling have attempts to study the biosphere been seriously made
- Biospheric data is still sketchy and few cause-effect relationships have been elucidated
- But global ecology is acquiring urgency as global warming and other problems accelerate

Ecology: Group of Sub-disciplines

- **Behavioral Ecology:**

  Individuals affects their ability to survive and reproduce. Since a population is composed of individuals behavior directly impacts population level phenomena, such as population growth rate.

- **Autecology (or Physiological Ecology)**

  Physical factors; such at temperature change, seasonality, soil nutrient composition, affect the survival and reproduction of individual organisms.

Interdisciplinary Aspects of Ecology

- Economists
  (to determine the costs of environmental change)
- Engineers
  (to predict and modify the effects of human activities)
- Sociologists and anthropologists
  (to understand how human society views, uses, and affects the natural environment)
- Ethicists and theologians
  (about the basis of ethical behavior)

Major Ecosystem Services

- **Direct:**
  - Water supply
  - Oxygen supply
  - Food supply (oceanic fisheries, pollination, natural pest predators)
  - Extractive renewable commodities (wood, some fuels, some fertilizers)
  - Recreation

Major Ecosystem Services

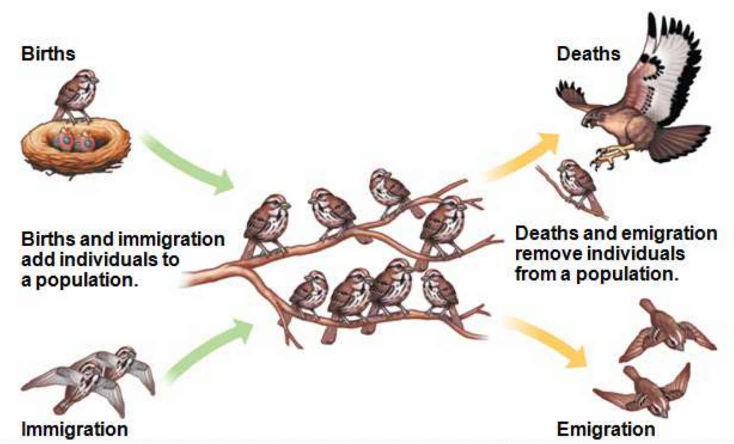
- **Indirect:**
- Nutrient cycling
- Atmospheric regulation (CO_2, SO_2, O_3, NO_3 levels)
- Climatic buffering (run-off control, heat dissipation, wind amelioration)
- Waste elimination (sewage, agricultural pollution)
- Erosion control

Population Ecology

- A **population** is a group of individuals of a single species living in the same general area
- Populations are described by their boundaries and size
- **Density** is the number of individuals per unit area or volume
- **Dispersion** is the pattern of spacing among individuals within the boundaries of the population
- **Distribution:** Patter n of dispersal of individuals in that area

Factors Controlling Population Density

- *Population density has a dynamic perspective*



Sizing a Population

- In most cases, it is impractical or impossible to count all individuals in a population
- Sampling techniques can be used to estimate densities and total population sizes
- Population size can be estimated by either extrapolation from small samples, an index of population size (e.g., number of nests), or the **mark-recapture method**

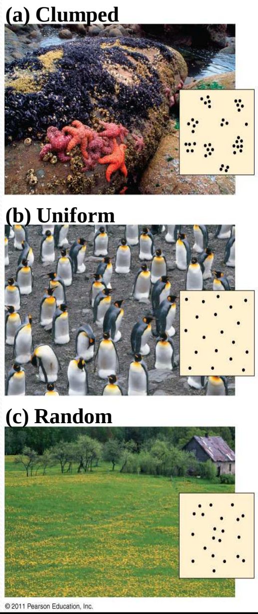
Sizing a Population

- **Mark-recapture method**
  - Scientists capture, tag, and release a random sample of individuals (s) in a population
  - Marked individuals are given time to mix back into the population
  - Scientists capture a second sample of individuals (n), and note how many of them are marked (x)
  - Population size (N) is estimated by

$$N = \frac{sn}{x}$$

Patterns of Dispersion

- Environmental and social factors influence the spacing of individuals in a population
- Dispersion may also be influenced by resource availability and behavior
- In a clumped dispersion, individuals aggregate in patches
- A uniform dispersion is one in which individuals are evenly distributed
- In a random dispersion, the position of each individual is independent of other individuals, typically occurs in the absence of strong attractions or repulsions



Species Distribution

Factors affecting the distribution of species:

Plants	Animals
temperature	
water	
light (intensity/wavelength)	breeding sites
soil pH	food supply
soil salinity	territory
mineral nutrient availability	

Demographics

- **Demography** is the study of the vital statistics of a population and how they change over time
- The population dynamics is studied using statistical and mathematical tools.
- Demographics can include any statistical factors that influence population growth or decline, but several parameters are particularly important:
  - Population size
  - Density
  - Age structure
  - Fecundity (birth rates)
  - Mortality (death rates)
  - Male/Female ratio

Life Table

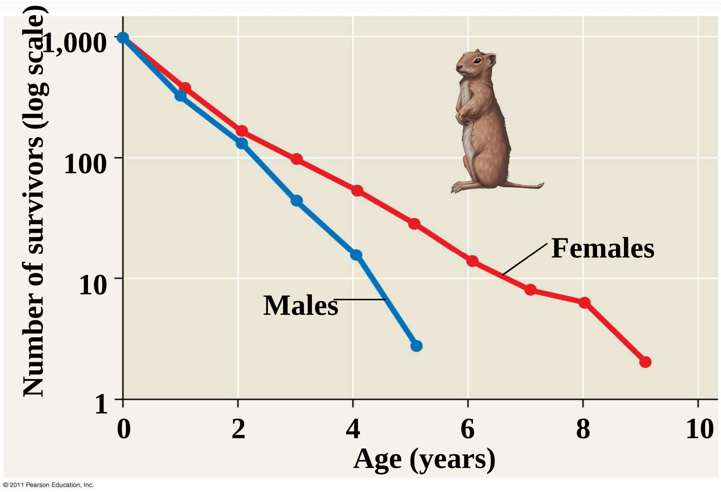
- An age-specific summary of the population
- Best made by following the fate of a **cohort**, a group of individuals of the same age
- The life table reveals many things about a population including age specific survival pattern of males and females

	FEMALES					MALES				
Age (years)	Number Alive at Start of Year	Proportion Alive at Start of Year	Number of Deaths During Year	Death Rate[†]	Average Additional Life Expectancy (years)	Number Alive at Start of Year	Proportion Alive at Start of Year	Number of Deaths During Year	Death Rate[†]	Average Additional Life Expectancy (years)
0–1	337	1.000	207	0.61	1.33	349	1.000	227	0.65	1.07
1–2	252[‡]	0.386	125	0.50	1.56	248[‡]	0.350	140	0.56	1.12
2–3	127	0.197	60	0.47	1.60	108	0.152	74	0.69	0.93
3–4	67	0.106	32	0.48	1.59	34	0.048	23	0.68	0.89
4–5	35	0.054	16	0.46	1.59	11	0.015	9	0.82	0.68
5–6	19	0.029	10	0.53	1.50	2	0.003	2	1.00	0.50
6–7	9	0.014	4	0.44	1.61	0				
7–8	5	0.008	1	0.20	1.50					
8–9	4	0.006	3	0.75	0.75					
9–10	1	0.002	1	1.00	0.50					

Ex: Life table of Belding's ground squirrels

Survivorship Curves

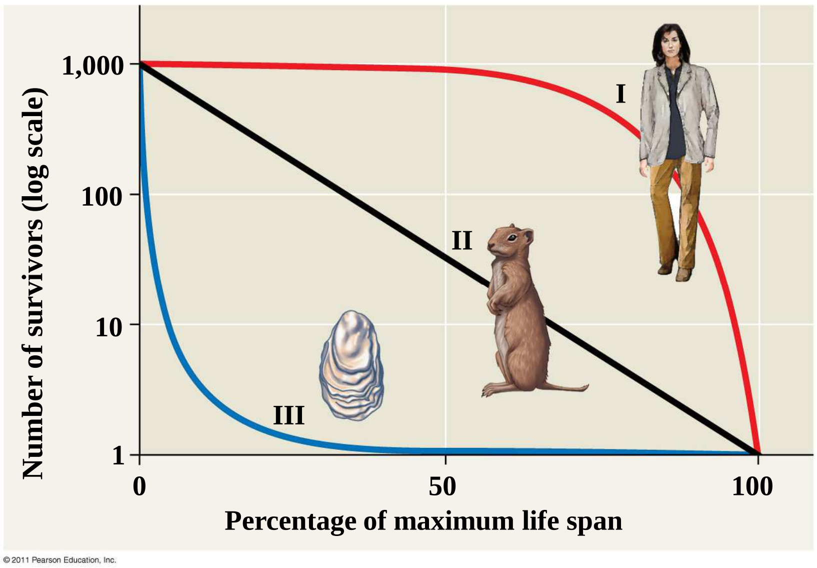
A graphic way of representing the data in a life table



Survivorship Curves

- Survivorship curves can be classified into three general types
  - ***Type I:*** low death rates during early and middle life and an increase in death rates among older age groups
  - ***Type II:*** a constant death rate over the organism's life span
  - ***Type III:*** high death rates for the young and a lower death rate for survivors
- Many species are intermediate to these curves

Survivorship Curves



Population Growth

- Under an idealized situation, population grows exponentially
- It is useful to study population growth in an idealized situation as it help to understand the capacity of species to increase and the conditions that may facilitate this growth

Change in population size = Births + Immigrants entering population – Deaths – Emigrants leaving population

- If immigration and emigration are ignored, a population's growth rate (per capita increase) equals birth rate minus death rate

Population Growth

- The population growth rate can be expressed mathematically as

$$\frac{\Delta N}{\Delta t} = B - D$$

where ΔN is the change in population size, Δt is the time interval, B is the number of births, and D is the number of deaths

- Births and deaths can be expressed as the average number of births and deaths per individual during the specified time interval

$$B = bN$$
$$D = mN$$

where b is the annual per capita birth rate, m (for mortality) is the per capita death rate, and N is population size

Population Growth

- The population growth equation can be revised as

$$\frac{\Delta N}{\Delta t} = bN - mN$$

- The per capita net rate of increase (r) is given by: $r = b - m$

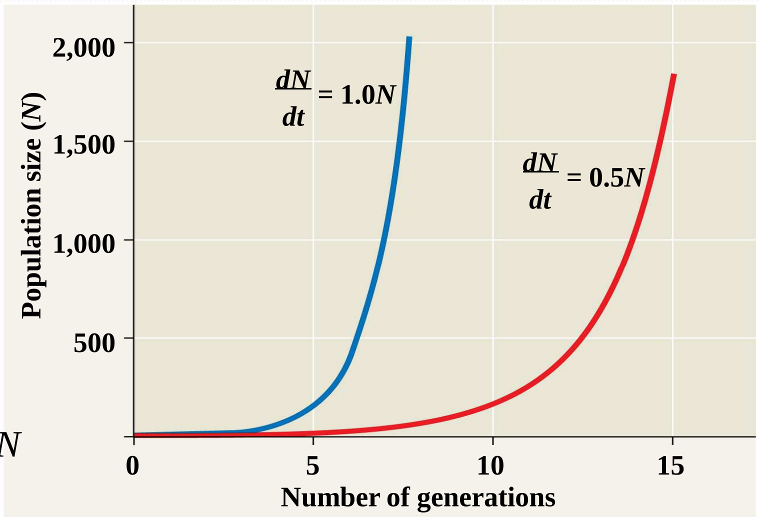
$$\frac{\Delta N}{\Delta t} = rN$$

- When the birth rate equals the death rate ($r = 0$), the net population growth becomes zero
- Under idealized conditions, the rate of increase is at its maximum, denoted as r_{max}

$$\frac{dN}{dt} = r_{max}N$$

Population Growth

- Exponential population growth results in a J-shaped curve

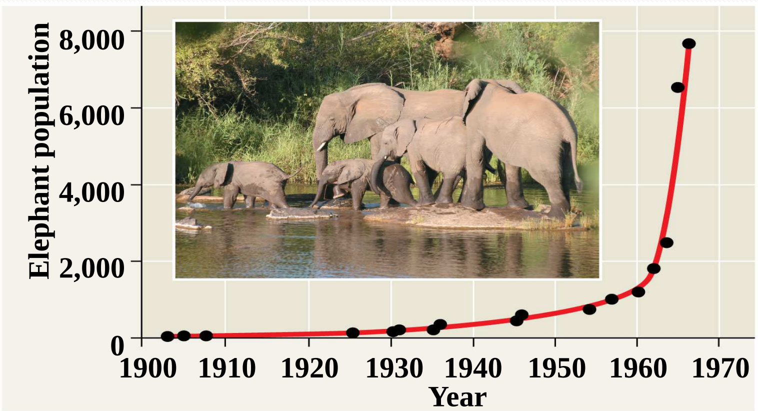


$$\frac{dN}{dt} = r_{max}N$$

Population Growth

- Exponential population growth example:

The elephant population in Kruger National Park, South Africa, grew exponentially after hunting was banned



Population Growth

Resource Dependent Population Growth

- Exponential growth cannot be sustained for long in any population due to limited availability of finite resources
- A more realistic population model limits growth by incorporating carrying capacity of the system
- **Carrying Capacity** (*K*) is the maximum population size the environment (particular ecosystem) can support
- Carrying capacity varies with the abundance of limiting resources
- The model describing how a population grows under limited resources and a fixed maximum sustainable population (carrying capacity) is commonly known as **Logistic Growth Model**

Population Growth

Logistic Growth Model

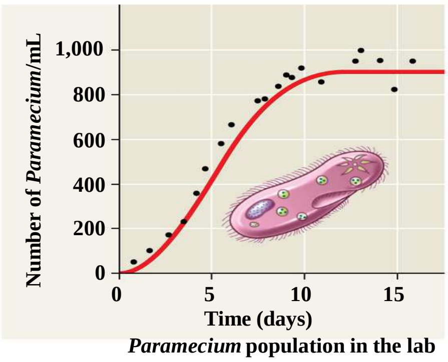
- The per capita rate of increase is proportional to existing population as well as the factor indicating the gap between carrying capacity and existing population.
- The rate declines as carrying capacity is reached

$$\frac{dN}{dt} = r_{\max} N \frac{(K - N)}{K}$$

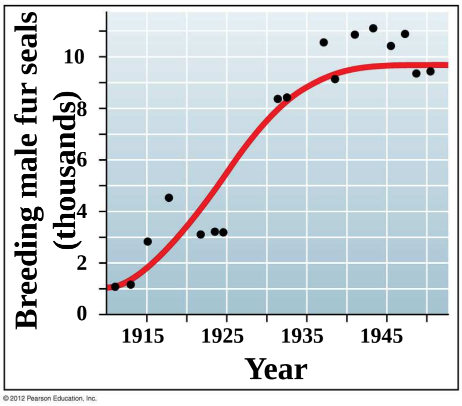
- The logistic model of population growth produces a sigmoid (S-shaped) curve

Population Growth

Logistic Growth Model



Paramecium population in the lab



Population Growth

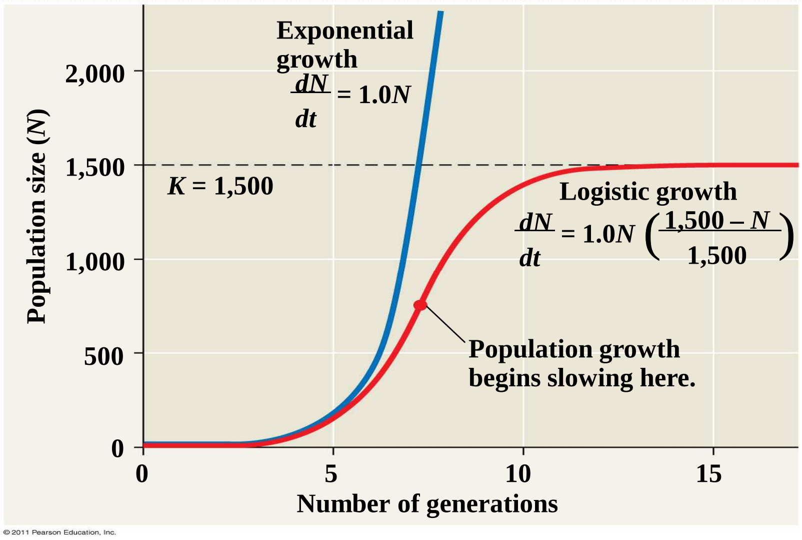
Logistic Growth Model vs Exponential Growth

N	*rN*	*(K – N)/K*	*G = rN(K – N)/K*
10	1	0.99	0.99
100	10	0.9	9.00
400	40	0.6	24.00
500	50	0.5	25.00
600	60	0.4	24.00
700	70	0.3	21.00
900	95	0.05	0.25
1,000	100	0.00	0.00

$K = 1{,}000$; $r = 0.01$

Population Growth

Logistic Growth Model vs Exponential Growth



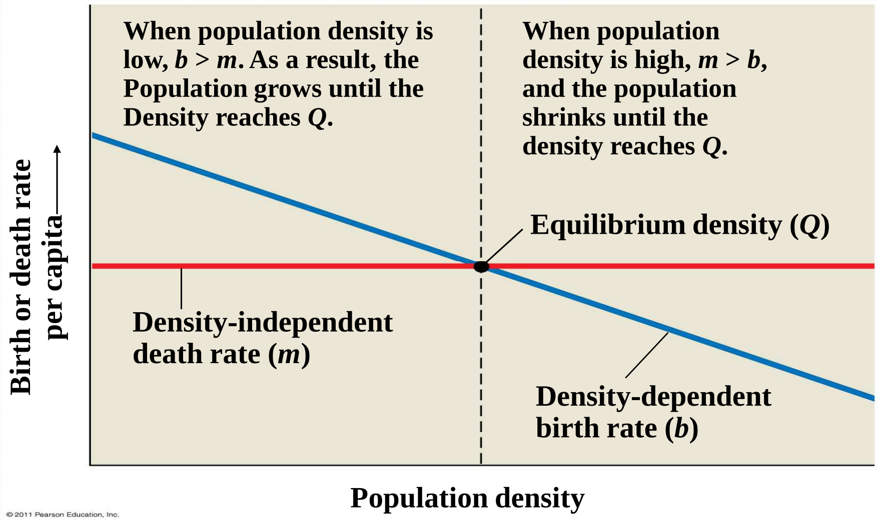
Population Growth

Density dependent and Density independent Growth

- Organisms have finite resources, which may lead to trade-offs between survival and reproduction
- Some plants produce a large number of small seeds, ensuring that at least some of them will grow and eventually reproduce
- Other types of plants produce a moderate number of large seeds that provide a large store of energy that will help seedlings become established
- Natural selection follows either of the following two approaches:
  - ***K*-selection**, or density-dependent selection, selects for life history traits that are sensitive to population density
  - Birth rates fall and death rates rise with increasing population density
  - ***r*-selection**, or density-independent selection, selects for life history traits that maximize reproduction.
  - Birth rate and death rate do not change with population density

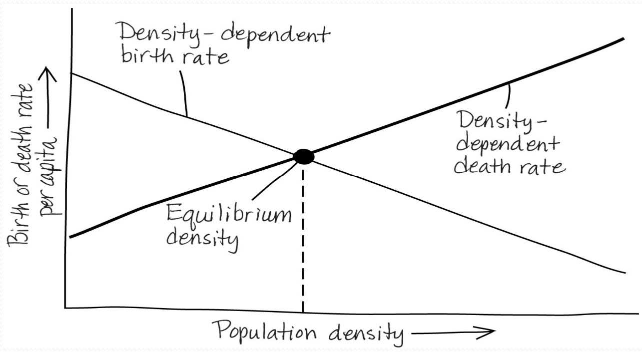
Population Growth

Density dependent and Density independent Growth



Population Growth

Density dependent Growth



Density-dependent birth and death rates are affected by many factors, such as competition for resources, territoriality, disease, predation, toxic wastes, and intrinsic factors

Population Growth

Factors for Density Dependent Population Regulation

- **Competition for Resources:** In crowded populations, increasing population density intensifies competition for resources and results in a lower birth rate
- **Territoriality:** In many vertebrates and some invertebrates, competition for territory may limit density
- **Toxic Wastes:** Accumulation of toxic wastes can contribute to density-dependent regulation of population size
- **Intrinsic Factors:** For some populations, intrinsic (physiological) factors appear to regulate population size
- **Disease:** Population density can influence the health and survival of organisms. In dense populations, pathogens can spread more rapidly
- **Predation:** As a prey population builds up, predators may feed preferentially on that species

Population Growth

Factors for Density Independent Population Regulation

- In many natural populations, abiotic factors such as weather may affect population size well before density-dependent factors become important.
- **Density-independent factors** may include
  - Natural disasters
  - Fires,
  - Storms,
  - Habitat destruction by human activity, or
  - Seasonal changes in weather.

Species Interaction

Types of Species Interactions

An ecological community is a group of actually or potentially interacting species, living in the same place

A community is bound together by the network of influences that species have on one another.

There are four main classes of two-way interactions, and many possible pathways of indirect interaction.

Type of Interaction	Sign	Effects
mutualism	+/+	both species benefit
commensalism	+/0	one species benefits, one is unaffected
competition	-/-	each is negatively affected
predation(includes herbivory, parasitism)	+/-	one species benefits, one harmed

Species Interaction

Competition

- **Competition** describes the active demand between two or more organisms for a resource.
- Competition may be:
  - **Intraspecific**: between individuals of the same species.
  - **Interspecific**: between individuals of different species.
- Each competitor is inhibited in some way by the interaction.

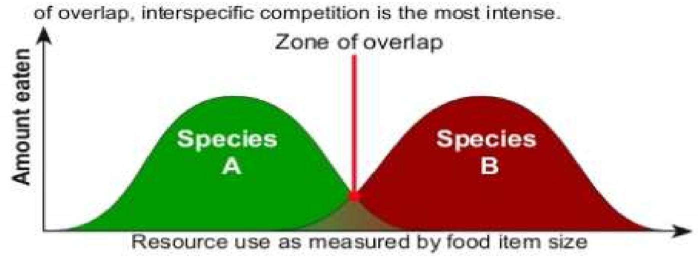
Intraspecific competition: hyaenas

Interspecific competition on a reef

Species Interaction

Gause's Principle

- **Gause's competitive exclusion principle** states:
  "two or more resource-limited species, having identical patterns of resource use, cannot coexist in a stable environment:
  one species *will be better adapted and will* ***out-compete*** *or otherwise* ***eliminate*** *the other(s)".*
  - If two species compete for some of the same resources (e.g. food items of a particular size), their **resource use curves** will overlap. In the zone of overlap, interspecific competition is the most intense.



Species Interaction

Predator-Prey Relationships

- There are many instances in nature where one species of animal feeds on another species of animal, which in turn feeds on other things. The first species is called the predator and the second is called the prey.

Population Cycle

Predator-Prey Relationships

- Classical population ecology holds that stable population cycles are a result of predator–prey interactions.
- Population cycles are periodic fluctuations in a population's abundance.
- Some oscillations can also be a result of a population overshooting and undershooting carrying capacity
- Although stable population cycles are relatively rare in nature.
- The predator–prey model depicting population cycle was first proposed by Lotka (1925) and Volterra (1926).

Population Cycle

Predator-Prey Relationships

- This account describes the population of the predator and the prey via two first-order differential equations that explicitly mention the population of the prey (*V) and the predator (P), respectively:*

$$dV/dt = rV - \alpha VP$$

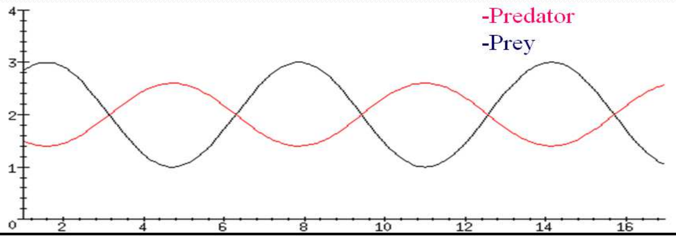
$$dP/dt = \beta VP - qP$$

where r, q, α, β are constants determined empirically: r is the intrinsic rate of increase in prey population in the absence of predators; q is the per capita death rate of the predator population; α is a measure of *capture efficiency*, which is the effect of a predator on the per capita growth rate of the prey population; and β is a measure of conversion efficiency, which is the ability of the predator to convert prey into per capita predator growth

Population Cycle

Predator-Prey Relationships

- Theoretically, the predator can destroy all the prey so that the latter become extinct.
- However, if this happens the predator will also become extinct since, it depends on the prey for its existence (assumption).
- What actually happens in nature is that a cycle develops where at some time the prey may be abundant and the predators few. Because of the abundance of prey, the predator population grows and reduces the population of prey. This results in a reduction of predators and consequent increase of prey and the cycle continues.



Population Cycle

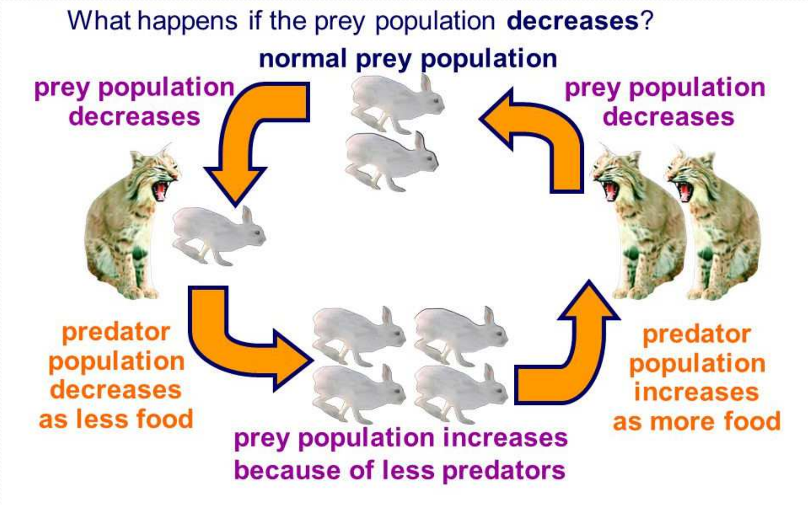
Predator-Prey Relationships

predator density	predator - prey -	predator + prey -
	predator - prey +	predator + prey +

prey density

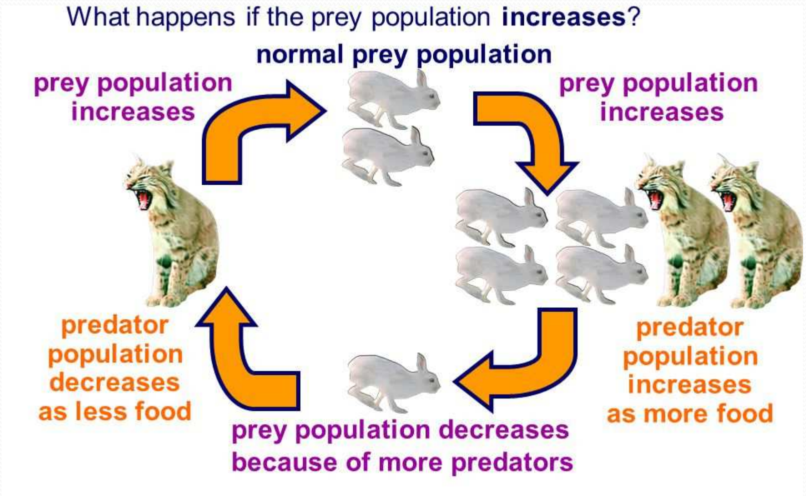
Population Cycle

Predator-Prey Relationships



Population Cycle

Predator-Prey Relationships



Ecosystem

ABIOTIC COMPONENTS	BIOTIC COMPONENTS
Sunlight	Primary producers
Temperature	Herbivores
Precipitation	Carnivores
Water or moisture	Omnivores
Soil or water chemistry (e.g. P, NH_4^+)	Detritivores

All of these vary over space/time

Ecosystem

Structural & Functional Features

Autotrophic Component: Includes all green plants & grasses on land & phytoplankton in water

- **Photoautotrauphs:** Manufacture their food using energy from the sun through process of photosynthesis. Members called as producers as they convert solar energy into chemical energy with the help of inorganic substances such as water, CO_2 & organic substances such as enzymes
- **Chemoautotrauphs:** Energy generated in oxidation reduction process, Sulphur Bacteria

Ecosystem

Structural & Functional Features

Heterotrophic Component:

All living organisms which are unable to prepare their own food, and utilize, rearrange and decompose the complex materials synthesized by autotrophs

Consumers: consumes the food prepared by producers.

- ***Herbivores:*** Primary consumers that live on plants. Ex. grasshoppers, deer, cattle, elephant
- ***Carnivores:*** Secondary consumers that live on Herbivores. Ex. tiger, leopard, foxes, wild cats etc.
- ***Omnivores:*** Animals like fox, rat etc. and man feed on both herbivores & carnivores

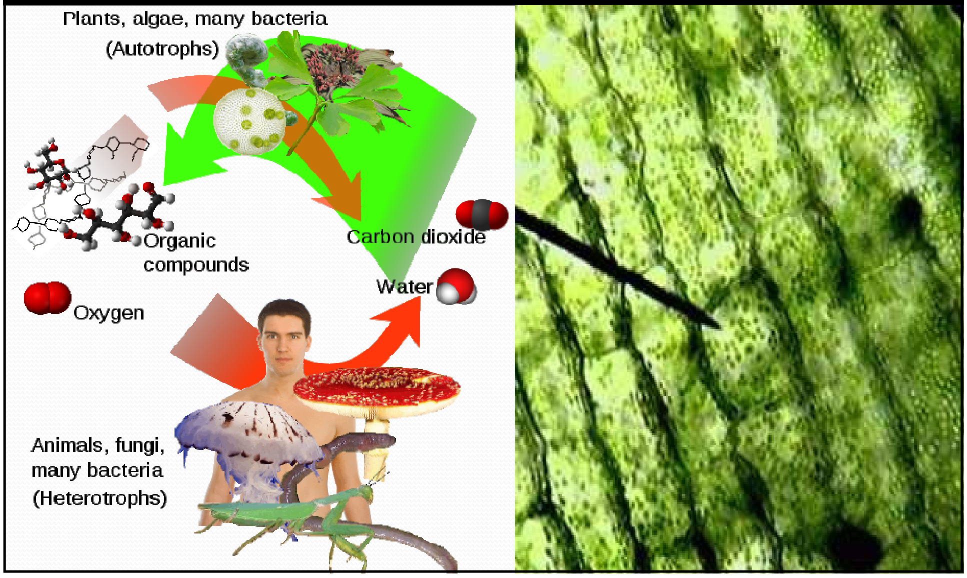
Detritivores: Decomposer microorganisms like bacteria and fungi which break down the complex matter of dead bodies of producers & consumers & release nutrients to be used by plants

Ecosystem

Functional attributes of Ecosystem

- Primary & Secondary Production
- Food Chains
- Energy Flow
- Cycling of Nutrients
- Diversity – Interlink between organisms
- Homeostasis & Feed Back
- Development & Evolution of Ecosystem

$6CO_2$ Carbon dioxide | $6H_2O$ Water | Light | $C_6H_{12}O_6$ Sugar | $6O_2$ Oxygen



Food Chain and Food Web

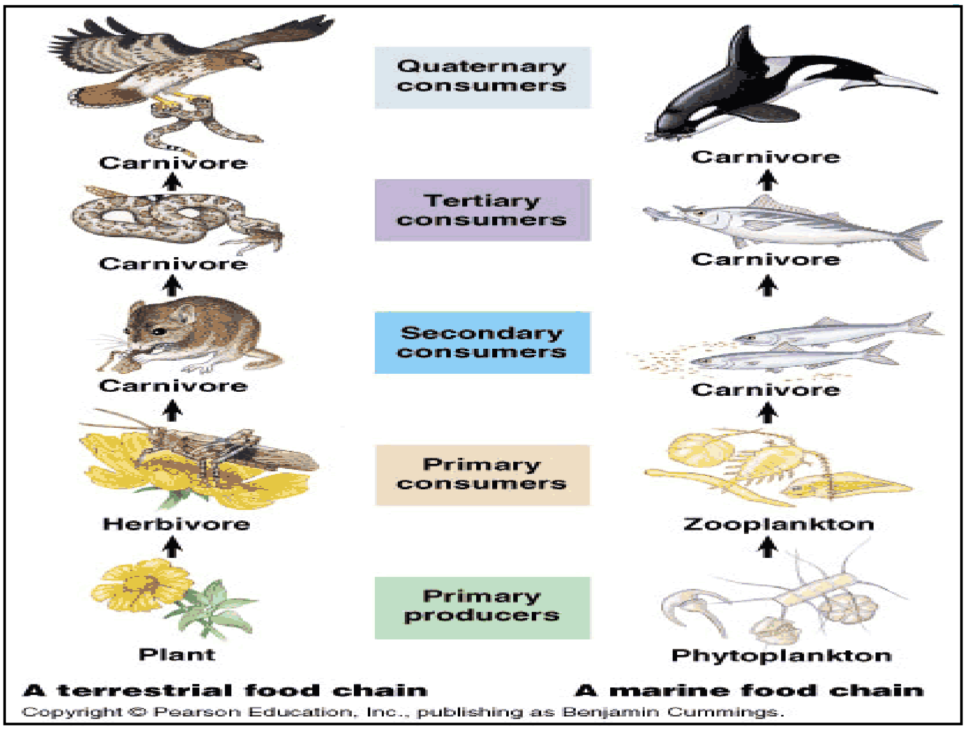
Food Chain

Transfer of food energy from plant sources through a series of organisms with repeated stages of eating & being eaten is called food chain

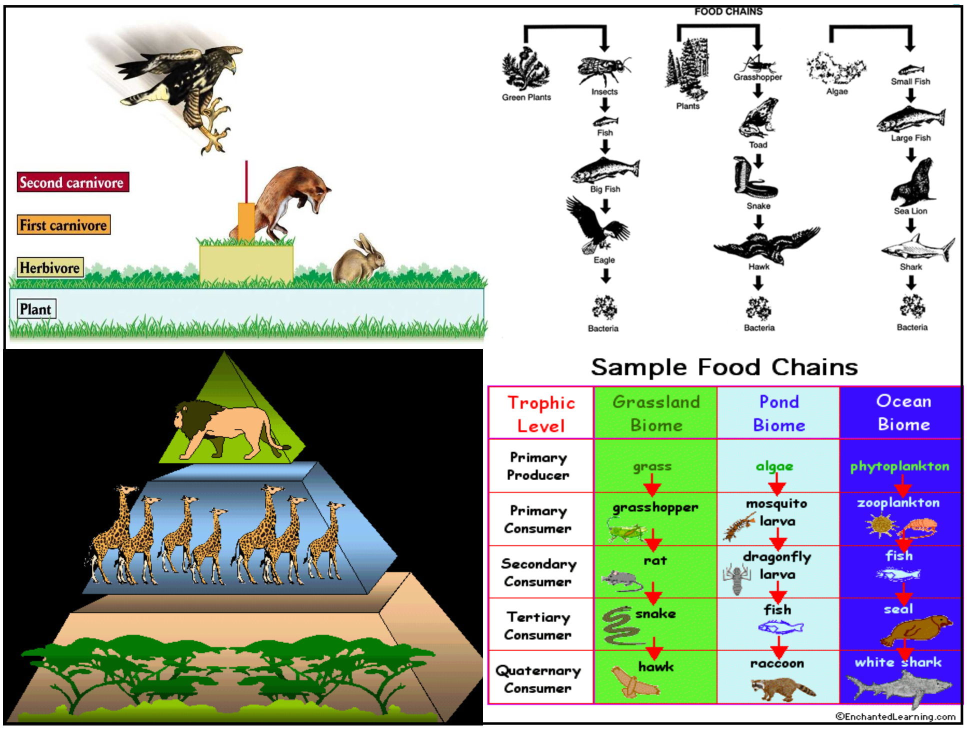
A diatom may be eaten by a copepod , inturn eaten by small fish, again forms the food source for a large fish & so on

Base of the food chain is formed by a plant , grazed by herbivore, preyed by carnivore, another carnivore

Natural Food Chain



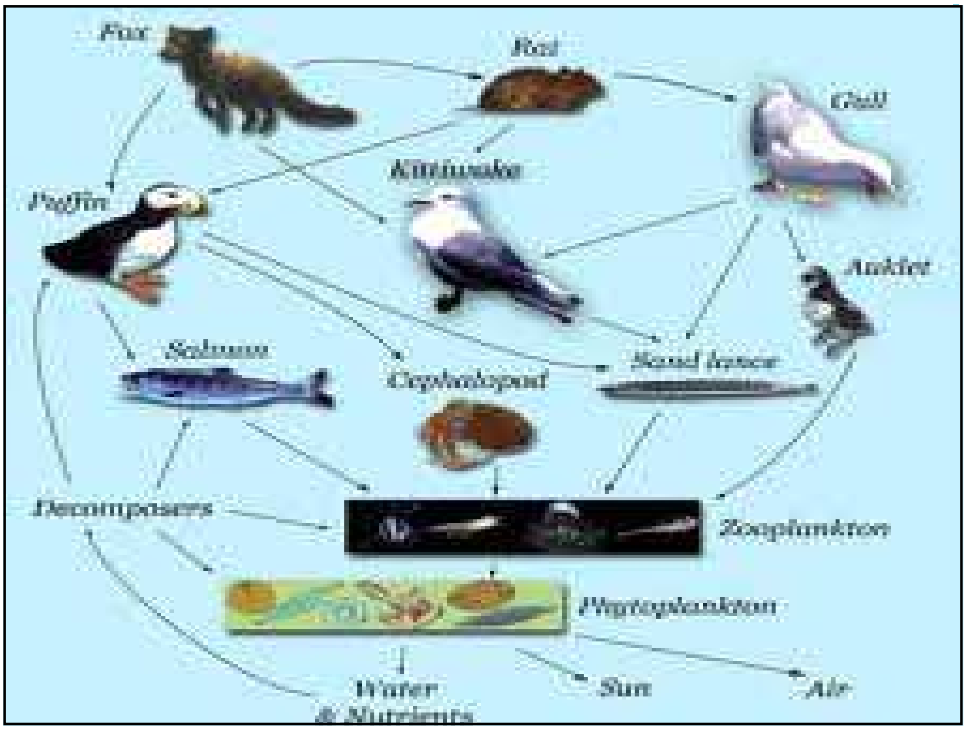
Type of Ecosystem	Producers	Herbivores	Primary Carnivores	Secondary Carnivores	Tertiary Carnivores
A. Grassland Ecosystem	1. Grasses	Insects	Frogs	Snakes	Predatory Birds
	2. Grasses	Rats and Mice	Snakes	Predatory Birds	
	3. Grasses	Rabbit	Fox	Wolf	Lion
B. Pond Ecosystem	Phytoplank-ton	Zooplanktons	Small Fishes	Large Fishes	Predatory Birds
C. Forest Ecosystem	Trees	Phytophagous Insects, Herbivore Mammals	Lizards Birds Foxes	Lions Tigers Etc.	

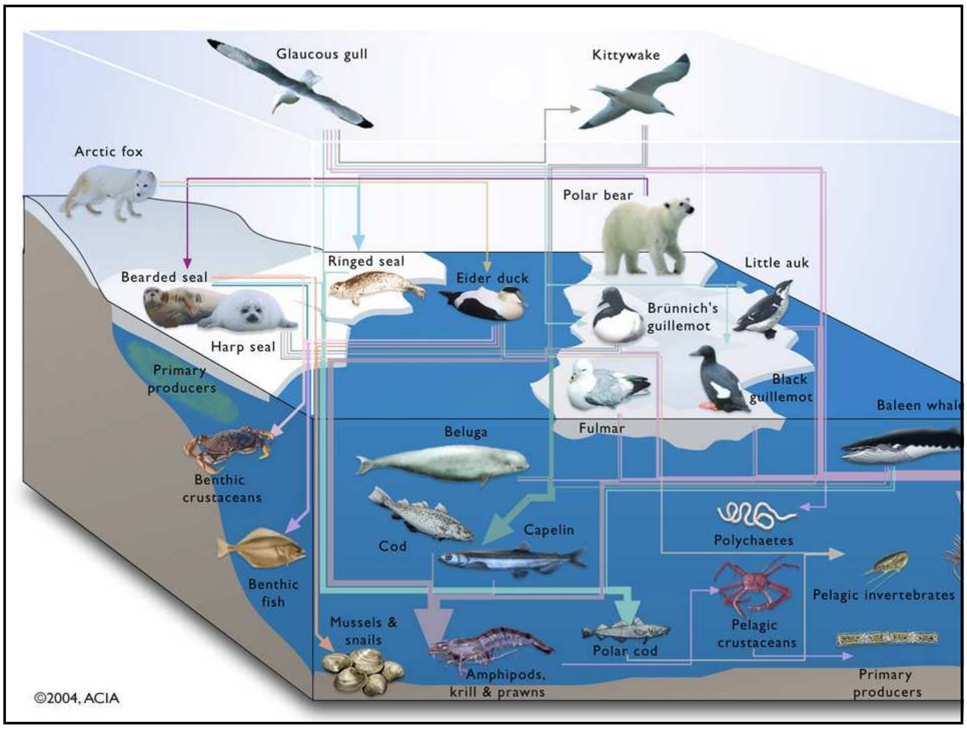


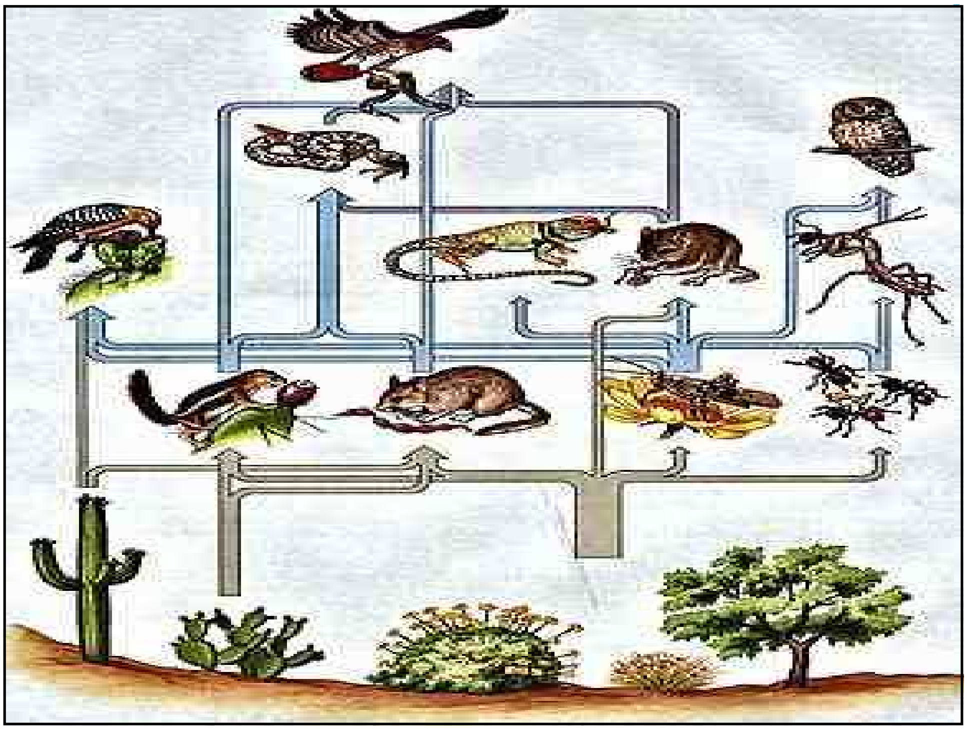
Food Chain and Food Web

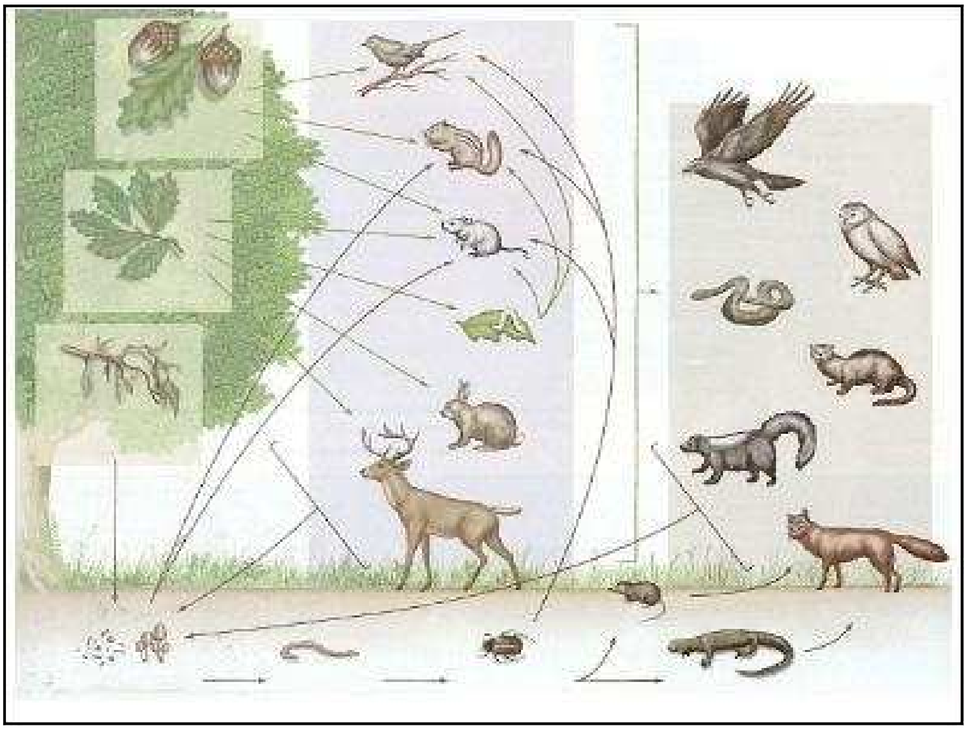
Food Web

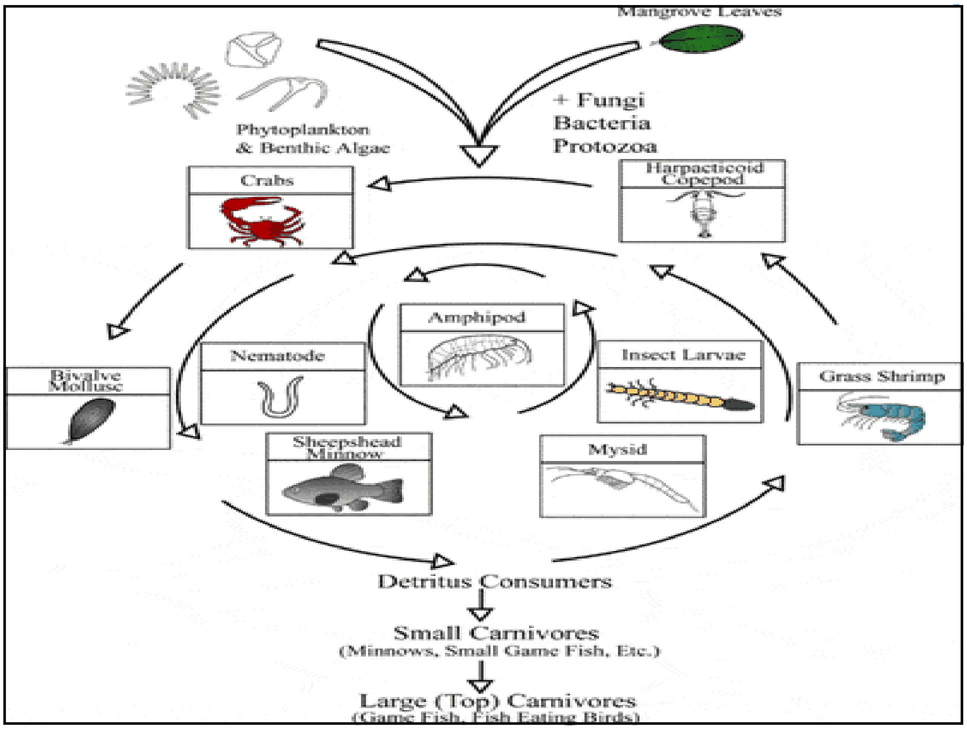
- In ecosystems food chains are not isolated sequences; rather they are interconnected with one another & usually form a complex network with several linkages
- An organism may be food source for many organisms
- Defined as network of food chains connecting different types of organisms at different tropic levels so that there is number of options of eating & being eaten at each higher tropic level
- Very Important in maintaining stability of ecosystem

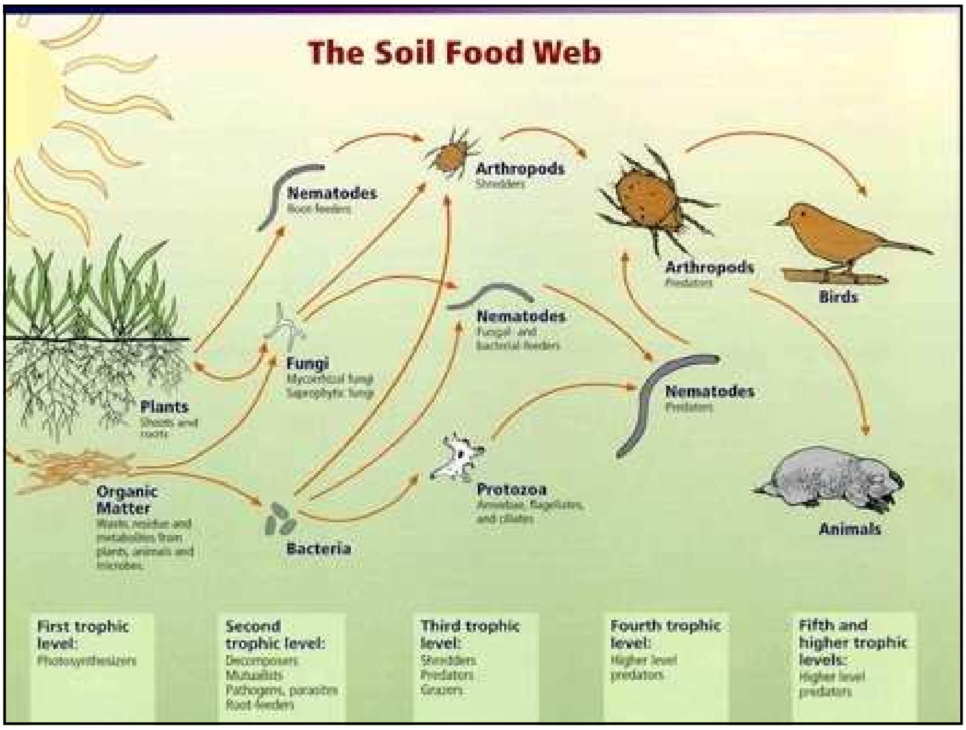

Fox
Rat
Gull
Kittiwake
Puffin
Auklet
Salmon
Cephalopod
Sand lance
Decomposers
Zooplankton
Phytoplankton
Water
& Nutrients
Sun
Air


Glaucous gull
Kittywake
Arctic fox
Polar bear
Bearded seal
Ringed seal
Eider duck
Little auk
Brünnich's guillemot
Harp seal
Primary producers
Black guillemot
Fulmar
Baleen whale
Beluga
Benthic crustaceans
Cod
Capelin
Polychaetes
Benthic fish
Pelagic invertebrates
Mussels & snails
Pelagic crustaceans
Polar cod
Amphipods, krill & prawns
Primary producers
©2004, ACIA





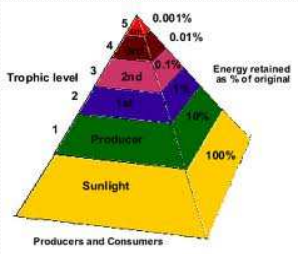

Mangrove Leaves
Phytoplankton
& Benthic Algae
+ Fungi
Bacteria
Protozoa
Crabs
Harpacticoid Copepod
Amphipod
Nematode
Insect Larvae
Bivalve Mollusc
Grass Shrimp
Sheepshead Minnow
Mysid
Detritus Consumers
Small Carnivores
(Minnows, Small Game Fish, Etc.)
Large (Top) Carnivores
(Game Fish, Fish Eating Birds)


The Soil Food Web
Nematodes
Root-feeders
Arthropods
Shredders
Arthropods
Predators
Birds
Nematodes
Fungal- and bacterial-feeders
Fungi
Mycorrhizal fungi
Saprophytic fungi
Plants
Shoots and roots
Nematodes
Predators
Organic Matter
Protozoa
Amoebae, flagellates, and ciliates
Animals
Bacteria
First trophic level:
Photosynthesizers
Second trophic level:
Decomposers
Mutualists
Pathogens, parasites
Root-feeders
Third trophic level:
Shredders
Predators
Grazers
Fourth trophic level:
Higher level predators
Fifth and higher trophic levels:
Higher level predators

Food Chain and Food Web

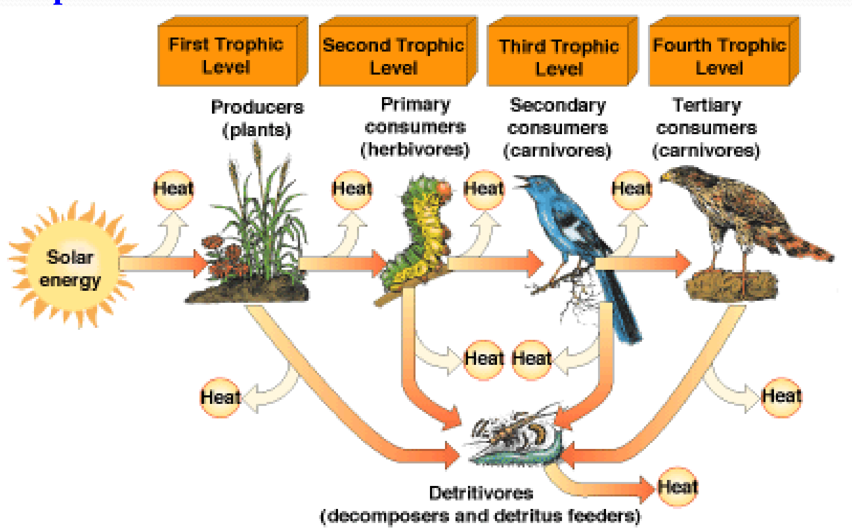
Tropic Levels

- In food chain each food level is known as tropic level
- The amount of energy available to the organisms at each trophic level decreases as one moves up the food chain since energy is lost as heat and organisms use energy to sustain themselves
- Because of that, the number of organisms also decreases
- Only approximately 10% of the energy is transferred to the next trophic level
- Helps in movement of toxic substances in the ecosystem & problem of biomagnifications



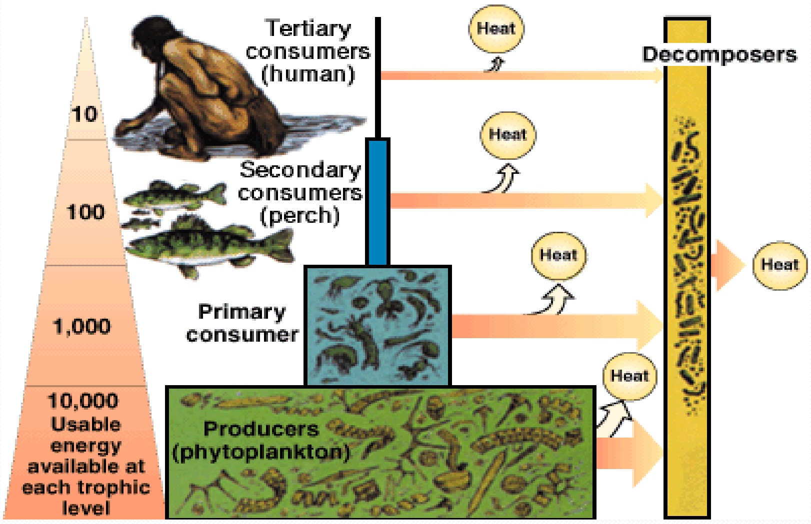
Food Chain and Food Web

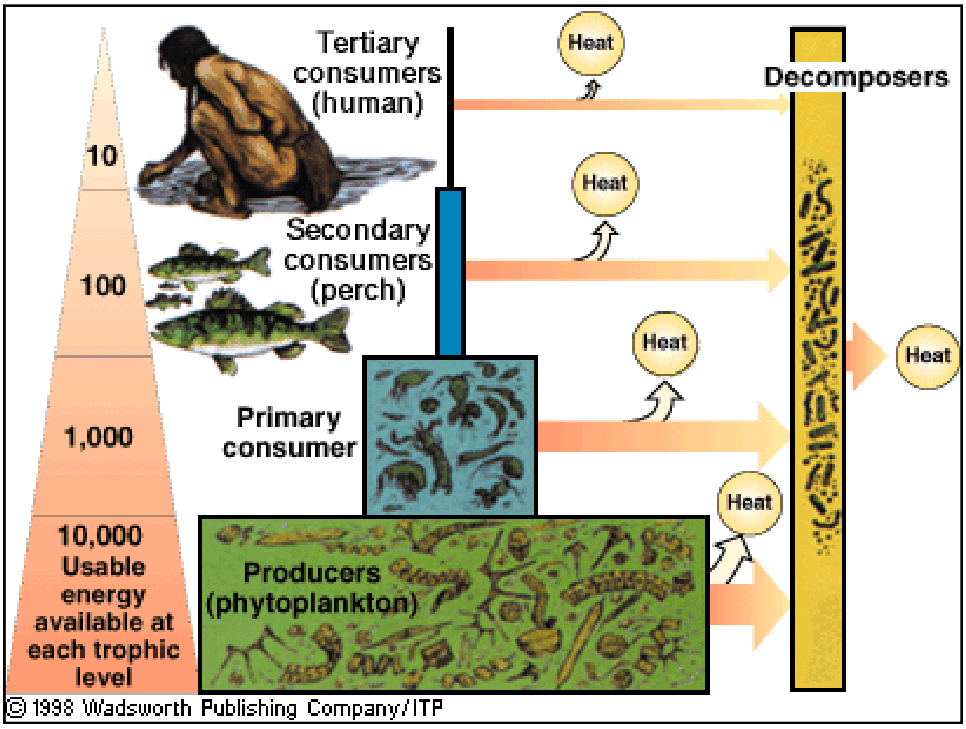
Tropic Levels



Food Chain and Food Web

Tropic Levels

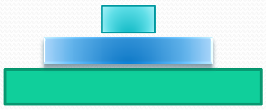




Ecological Pyramid

A graphical representation of number of individual or amount of biomass or quantity of energy present in various tropic levels of a food chain with the producer forming the base & top carnivore the apex

The standing crop, productivity, number of organisms, etc. of an ecosystem can be conveniently depicted using “pyramids”, where the size of each compartment represents the amount of the item in each trophic level of a food chain.

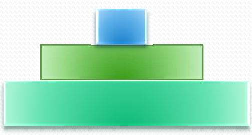


carnivores
herbivores
producers

Ecological Pyramid

Pyramid of Energy

Due to the Laws of Thermodynamics, each higher level must be smaller than lower levels, due to loss of some energy as heat (via respiration) within each level

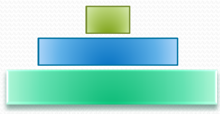


carnivores
herbivores
producers

Ecological Pyramid

Pyramid of Number

Since the size of individuals may vary widely and may not indicate the productivity of that individual, pyramids of numbers say little or nothing about the amount of energy moving through the ecosystem

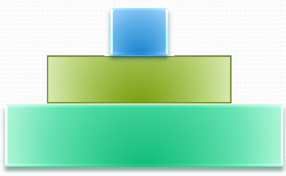


# of carnivores
# of herbivores
# of producers

Ecological Pyramid

Pyramid of Mass

If the biomass produced by a trophic level is summed over a year (or the appropriate complete cycle period), then the pyramid of total biomass produced must resemble the pyramid of energy flow, since biomass can be equated to energy



carnivores
herbivores
producers

Ecological Pyramid

Inverted Pyramids

- A pyramid of numbers may be inverted at specific times, i.e., a higher trophic level may have a larger no. than a lower trophic level

- Pyramids of energy and yearly biomass production can never be inverted, since this would violate the laws of thermodynamics.

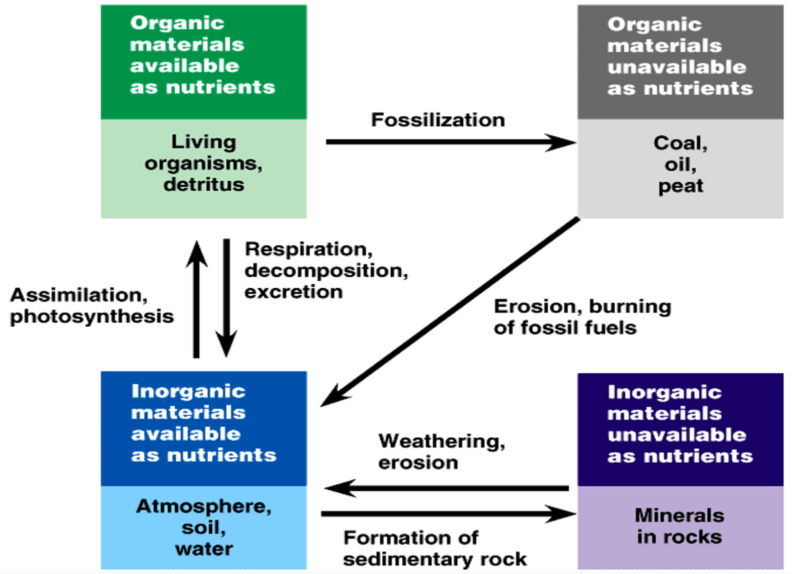
- Pyramids of numbers can be inverted, since the amount of organisms at any one time does not indicate the amount of energy flowing through the system.

Nutrient Recycling

Macronutrients: *carbon*, *oxygen*, *hydrogen*, *nitrogen*, *phosphorus*, *sulfur*, *chlorine*, *potassium*, *sodium*, *calcium*, *magnesium*, *iron* etc.

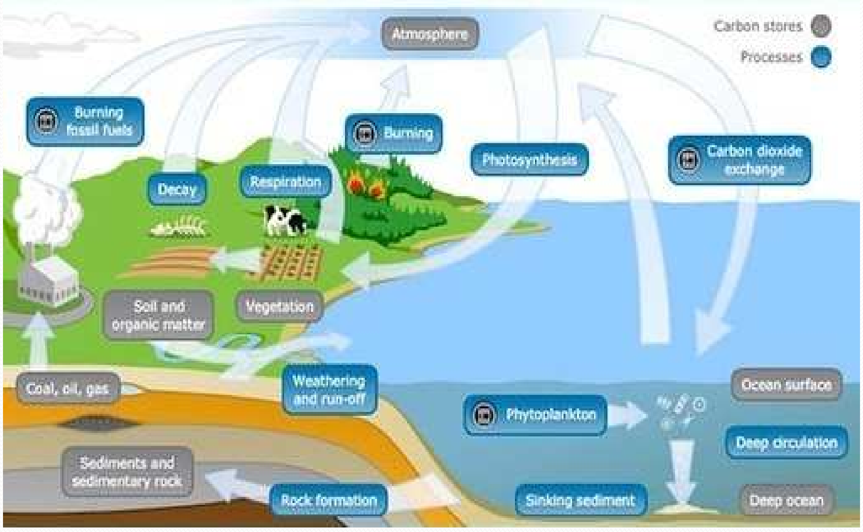
Micronutrients: *aluminium*, *boron*, *bromine*, *chromium*, *cobalt*, *fluorine*, *gallium*, *iodine*, *manganese*, *molybdenum*, *selenium*, *silicon*, *strontium*, *tin*, *titanium*, *vanadium*, *zinc*

Nutrient Recycling



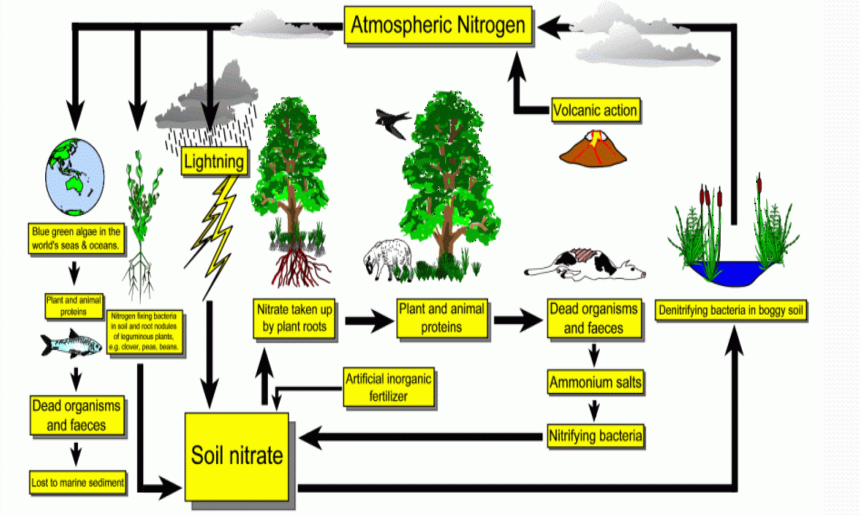
Nutrient Recycling

Carbon Cycle



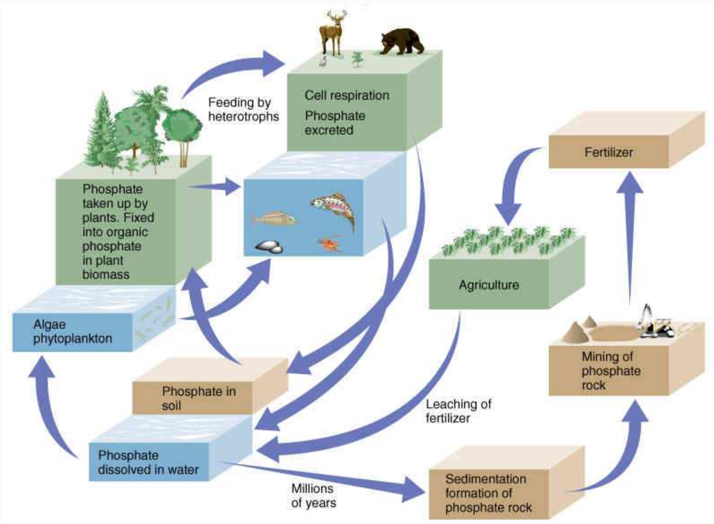
Nutrient Recycling

Nitrogen Cycle



Nutrient Recycling

Phosphorous Cycle



Biodiversity

Biodiversity is the variety and differences among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are a part. Thus, in essence, biodiversity represents all life.

India is one of the mega biodiversity centres in the world and has two of the world's 18 'biodiversity hotspots' located in the Western Ghats and in the Eastern Himalayas.

The forest cover in these areas is very dense and diverse and of pristine beauty, and incredible biodiversity.

According to an MoEF Report (1996), the country is estimated to have over 45,000 plant species and 81,000 animal species representing 7% of the world's flora and 6.5% of its fauna. The 1999 figures are 49,219 plant species representing 12.5% and 81,251 animal species representing 6.6%.

Biodiversity

Types:

Genetic Diversity:

It is a type of biodiversity which deals with the living organisms genetically i.e. variation in the genes of the species and the genetic make up of species differ from each other to produce a new generation is categorized as genetic diversity.

Species Diversity:

The change happening in the variety of different types of living organisms present in different places in the same geographical area is referred as specie diversity. etc.

Biodiversity

Types:

Ecological Diversity:

As we know that ecology is the study of different communities among their environment so, it is that branch of biodiversity which deals with variation in the ecological area or environment such as desert, forests, grassland, streams and coral reefs etc. is known as ecological diversity.

Functional Diversity:

Functional diversity is that type of biodiversity which is the study of different types of chemical processes of species fir their survival on the land. These processes include such as energy flow and cycling of matter etc.