Biodiversity: the diversity of living organism on the earth

1. Is the assemblage of different life forms
2. Number of different organism and their relative frequency in an ecological system
3. Variability among the living organisms from all sources including terrestrial and aquatic ecosystems
4. More than 50 million species of plants, animal and micro-organism existing in the world
5. About 2 million organisms have been identified so far
6. Biodiversity, besides its ecological significance provides a socio-economic and monetary asset to the nation
7. Therefore, the knowledge of biodiversity is of immense utility in planning sustainable livelihood and conserving the natural resources

Biodiversity: types

1. Genetic diversity: pertains to range of diversity in plant and animal genetic resources

- It includes diversity among individuals of a species as well as variability among the species

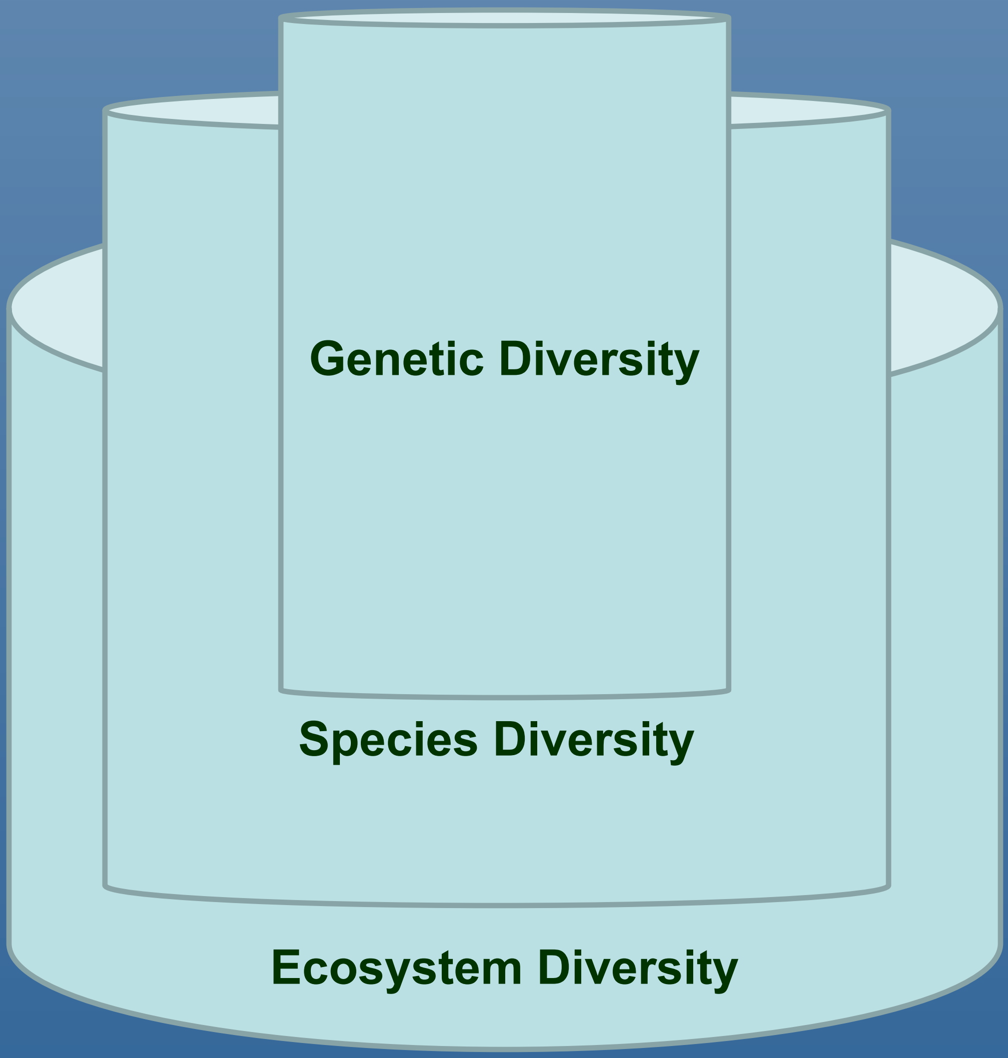
2. Species diversity: variability among the living organism in different ecosystems

- It includes variability between the species

3. Ecosystem diversity: variability among the different ecosystems in the world

Endemic and threatened species

Biodiversity as a complex:



Importance…

- At least 40 per cent of the world's economy and 80 per cent of the needs of the poor are derived from biological resources.
- The richer the diversity of life, the greater the opportunity for medical discoveries, economic development, and adaptive responses to such new challenges as climate change.
- A larger number of plant species means a greater variety of crops
- Greater species diversity ensures natural sustainability for all life forms
- Healthy ecosystems can better withstand and recover from a variety of disasters.

A healthy biodiversity provides a number of natural services for everyone:

1. Ecosystem services, such as
    - Protection of water resources
    - Soils formation and protection
    - Nutrient storage and recycling
    - Pollution breakdown and absorption
    - Contribution to climate stability
    - Maintenance of ecosystems
    - Recovery from unpredictable events
2. Biological resources, such as
    - Food
    - Medicinal resources and pharmaceutical drugs
    - Wood products
    - Ornamental plants
    - Breeding stocks, population reservoirs
    - Future resources
    - Diversity in genes, species and ecosystems
3. Social benefits, such as
    - Research, education and monitoring
    - Recreation and tourism
    - Cultural values

Significance: Important species

Native species

- When a species is grows and get established in a region by the act of only natural processes, with no human intervention

- They are ideally adapted to the local environment, including to the soils, climate, and weather conditions

- Plants that have developed, occur naturally, or existed for many years in an area

Ex. *Abies pindrow, Aesculus indica* etc

Non-Native species

- Non-native (or exotic) plants are those introduced from other areas or enter in a particular community by getting favorable conditions

- Sometimes they were brought intentionally, to feed cattle or grow food or as ornamentals.

- Some of these plants may become invasive, putting high degree of adverse impact on the natural ecosystems

- It has been realized that invasion of non-native species can dramatically change the composition of native and endemic species

- These species threaten biodiversity by direct competition with native and endemic species or by altering ecosystem properties

Ex. *Prunus cornuta , Prunus persica, Salix daphnoides*

Invasive species: *Lantana camara*

Endemic species

1. **Endemism is the ecological state of being unique to a particular geographic location, such as a specific island, habitat type, nation or other defined zones**

2. **The extreme opposite of endemism is cosmopolitan distribution**

3. **Endemic types or species are especially likely to develop on biologically isolated areas such as islands because of their geographical isolation**

4. **Endemics can easily become endangered or extinct if their restricted habitat changes, particularly but not only due to human actions, including the introduction of new organisms**

5. **Endemics define the uniqueness of an area or plant communities**

Ex. *Saussurea obvallata, Picrorhiza kurrooa* are endemic to Himalaya and Forest owlet, Grey Junglefowl, Laughing Thrush

Types of species of biological importance

1. *Umbrella species:* A species with large area requirements for which protection of the species offers protection to other species that share the same habitat

   An Umbrella effect is the protection extended by the presence of an umbrella species to other species in the same habitat.

Ex. Northern spotted owls and old growth forest : ex. Molluscs and salamanders are within the protective boundaries of the northern spotted owl.

2. *Keystone species:* are described as playing a critical role in maintaining the structure of an ecological community, affecting many other organisms in an ecosystem and helping to determine the types and numbers of various other species in the community

Ex. *Banksia prionotes* (Acorn Banksia) is the sole source of nectar for honeyeaters, which play an important role in pollination of numerous plant species.

3. *Dominant species:* any species which is more numerous than its competitors in an ecological community

Ex. In sub-temperate Himalayan region *Quercus* Species is dominant in most of the forests

4. *Indicator species:* any biological species that defines a trait or characteristic of the environment. Indicator species can be among the most sensitive species in a region, and sometimes act as an early warning to monitoring biologists.

Ex. *Polygonum polystychum* can be seen near camping areas

5. ***Flagship species:*** ***Flagship species act as symbols for the threats to the broader ecosystem in which they occur, and can thus act as catalysts for wide-ranging conservation activities***

species that have the ability to capture the imagination of the public and induce people to support conservation action and/or to donate funds

species that serve as symbols and rallying points to stimulate conservation awareness and action

Ex. Polar bears are a flagship species for conservation in the Arctic region, for example, while giant pandas fulfill the role for the Yangtze River Basin in China

6. ***Charismatic species:*** **Species with widespread popular appeal that environmental activists use to achieve conservation goal. Environmentalists seek to use the leverage provided by charismatic and well known species to achieve more subtle and far-reaching goals in species and biodiversity conservation.**

Ex. Lion, Bengal tiger, gray wolf, giant panda etc.

Native and Non-Native Species

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Invasive species: Lantana camara

Endemic and threatened species

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Endemic and threatened species

Causes:

- Agriculture
- Urban growth
- Mining of oil, metals and minerals
- Large scale construction i.e., Road
- Slash-and-burn techniques employed by some cultures

Ex. *Saussurea obvallata, Picrorhiza kurrooa* are endemic to Himalaya and Forest owlet, Grey Junglefowl, Laughing Thrush

Laughing Thrush, India


Grey Jungle Fowl, India

Endemic and threatened species

Status of endemism

Country/region	Total no of flowering plants	Endemism
World	297000	**25000**
India	17000	5000
IHR	8000	3200

Endemic and threatened species

Threatened species:

1. species facing different types of threat either natural or man-made and could soon become extinct in all or most of its natural range

2. Threatened species are any species (including animals, plants, fungi, etc.) which are vulnerable to endangerment in the near future

3. The World Conservation Union (IUCN) is the foremost authority on threatened species, and treats threatened species not as a single category, but as a group of different categories, depending on the degree to which they are threatened

Endemic and threatened species

Threatened species: IUCN criteria

1. Extinct (EX)
2. Extinct in the Wild (EW)
3. Critically Endangered (CR)
4. Endangered (EN)
5. Vulnerable (VU)
6. Near Threatened (NT)
7. Least Concern (LC)
8. Data Deficient (DD)
9. Not Evaluated (NE)

Threatened (3–5)

Extinct (EX): A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual.

Extinct in wild (EW): These taxa are known only to survive in cultivation, and not recorded from their past wild range even after the survey of their whole life cycle period.

Ex. *Acorus calamus, Curcuma caesia*

Critically Endangered (CR): An observed, estimated, inferred or suspected population size reduction of ≥ 90% over the last 10 years or three generations, whichever is the longer

- **Extent of occurrence estimated to be less than 100 km^2**
- **A Severely fragmented or known to exist at only a single location.**
- Area of occupancy estimated to be less than 10 km^2
- Population size estimated to number fewer than 250 mature individuals

Ex. *Aconitum heterophyllum, Dactylorhiza hatagirea*

Endangered (EN): An observed, estimated, inferred or suspected population size reduction of ≥ 50-70% over the last 10 years or three generations, whichever is the longer

- **Extent of occurrence estimated to be less than 5000 km^2**
- **Severely fragmented or known to exist at no more than five locations.**
- **Area of occupancy estimated to be less than 500 km^2**
- **Population size estimated to number fewer than 2500 mature individuals.**

Ex. Angelica glauca , Fritillaria roylei

Vulnerable (VU): An observed, estimated, inferred or suspected population size reduction of ≥ 30-50% over the last 10 years or three generations, whichever is the longer.

- Extent of occurrence estimated to be less than 20,000 km^{2}.
- Area of occupancy estimated to be less than 2000 km^{2}.
- Population size estimated to number fewer than 10,000 mature individuals

Ex. Aconitum violaceum , Sassurea obvallata

Near Threatened (NT): A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

Ex. Momordica charantia , Barleria prattensis

Least Concern (LC): A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

Ex. Acacia catechu , Melia azedirach

Data Deficient (DD): A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status

Ex. Arisaema tortuosum , Gardinia gummifera

NOT EVALUATED (NE)

A taxon is Not Evaluated when it is has not yet been evaluated against the criteria.

Conservation of Biodiversity

In-situ

- when conservation of biodiversity is done in its natural habitat or natural environment

- is best, easiest, most advantageous and most feasible method to conserve natural biodiversity

Ex-situ

- when conservation of biodiversity is done outside its natural habitat or natural environment

- Sometimes, due to genetic or environmental factors, species unable to survive in natural habitats

- Species can be protected through maintaining individuals in artificial conditions

Conservation of Biodiversity: *In-situ*

Aims at:

- Establishment of new protected areas based on utility, distinctiveness and endangerment of species
- Coordinating new and existing protected areas to facilitate gene flow to ensure proper representation of species and habitats
- Ensuring conservation outside the network of protected areas
- Minimizing or banning the activities like over-exploitation, pollution, introduction of exotic species etc.
- Encouraging continuous and traditional agricultural practices
- Encouraging public participation in planning and management of protected areas
- Conducting periodical reviews of protected areas and plan for assessing present and future needs

Conservation of Biodiversity: *Ex-situ*

Aims at:

- Facilitating biodiversity conservation, public education and sustainable development
- Encouraging the establishment of seed or gene bank or endangered species
- Strengthening the facilities for conservation of crop and livestock genetic resources
- Developing shot term and long term management plans for biodiversity conservation and sustainable use
- Encouraging captive farming and breeding facilities for highly exploited areas of biological resources
- Creating an international fund for biodiversity conservation

Conservation of Biodiversity

In-situ

- Wild life sancturies
- National parks
- Biosphere Reserves
- Sacred Grooves
- Other

Ex-situ

- Zoo
- Botanical garden
- Gene or seed Bank
- Tissue culture
- Captive breeding programme

Community processes and patterns

- **The earth's atmosphere would not support life if it were not regulated by totality of life in the biosphere**
- **The evolution of organisms and their environment are closely coupled as a single process through self-regulation**
- **The above mentioned hypothesis is known as Gaia hypothesis**
- **The hypothesis in nature is achieved through negative feedback**
- **Negative feedback is feedback that regulates a process or set of events by turning it off or slowing it down**

Community processes and patterns

- Earth is a purposeful design of organized living things who stabilize their atmosphere and climate such as control on population size through negative feed back
- The mechanism of a community or system to reach up to a stable state is known as homeostasis
- is the property of a system that regulates its internal environment and tends to maintain a stable, relatively constant condition of properties such as temperature or pH or species number etc
- The process or study of homeostasis to understand the complexity of community is known as cybernetics; also known as science of control
- Human interference has destroyed many homeostatic mechanisms which resulted in community with lesser stability

Biogeochemical Cycle:

- Ecosystems have two major aspects: i) Structural and, ii) functional
- The processes, energy and material flow give the ecosystem its functional aspects
- Nearly 40 elements are required for proper growth and development of living organism
- Most important are C, H, O, P, K, N, S, Ca, Fe, Mg, Zn etc
- These materials flow from abiotic to biotic components and back to the non-living components in a cyclic manner
- The flow involves not only living organisms but also a series of chemical reactions in the abiotic environment, thus called biogeochemical cycles

Biogeochemical Cycle:

1. Gaseous cycle

- The reservoir for the element is either atmosphere or hydrosphere (ocean)

- These elements include water, nitrogen, carbon dioxide, sulphur oxygen,, chlorine, bromine and fluorine

2. Sedimentary cycle

- The reservoir for the elements is earths crust

- Elements made available to ecosystem either through weathering of rocks or decomposition of sediments and cycle through soil and organisms

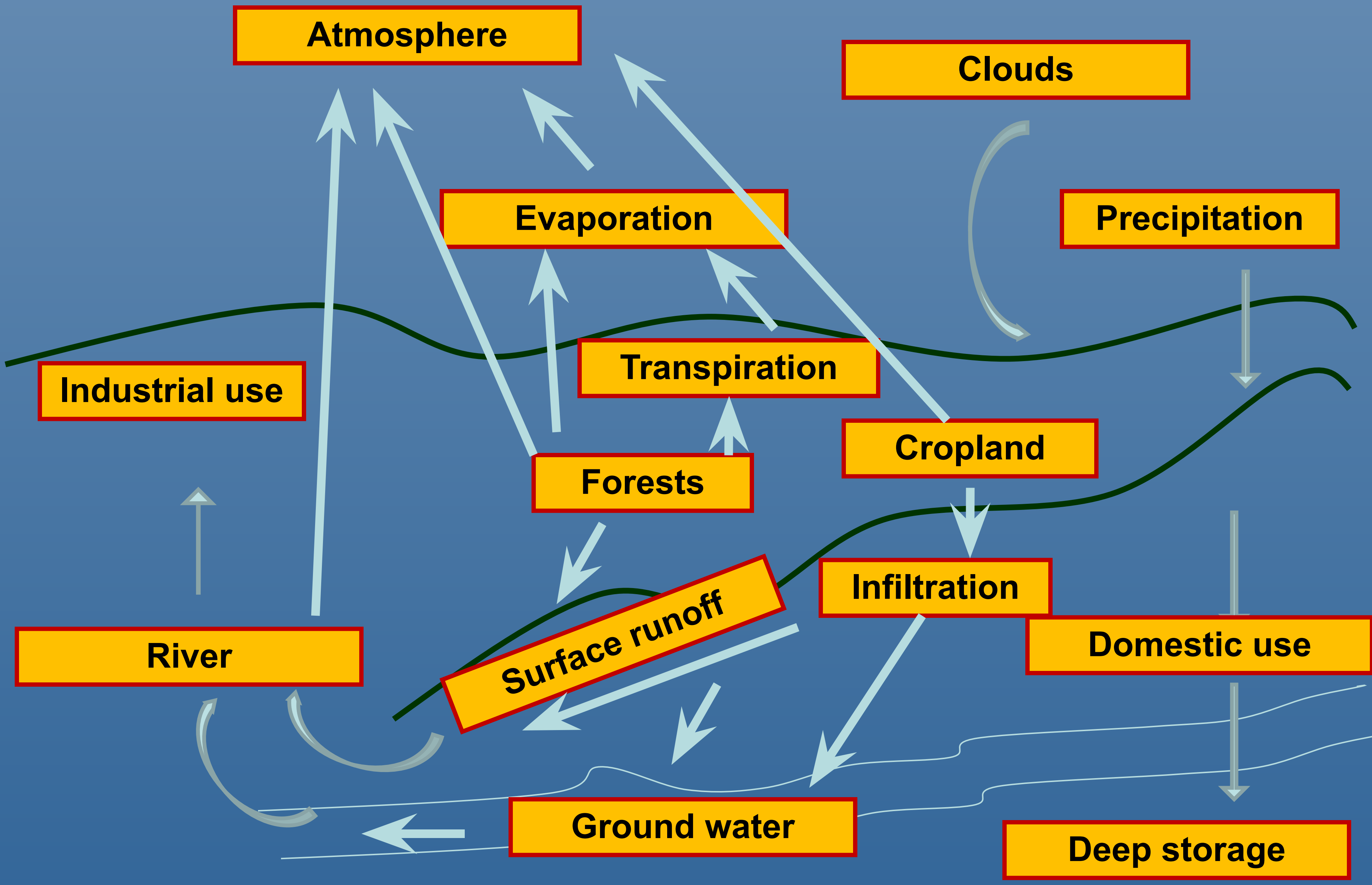
- Elements include calcium, phosphorus, sodium, potassium, magnesium, iron, zinc, copper, manganese, nickel, cobalt, aluminum, boron, iodine, lead, selenium, molybdenum and silicon

Biogeochemical Cycle:

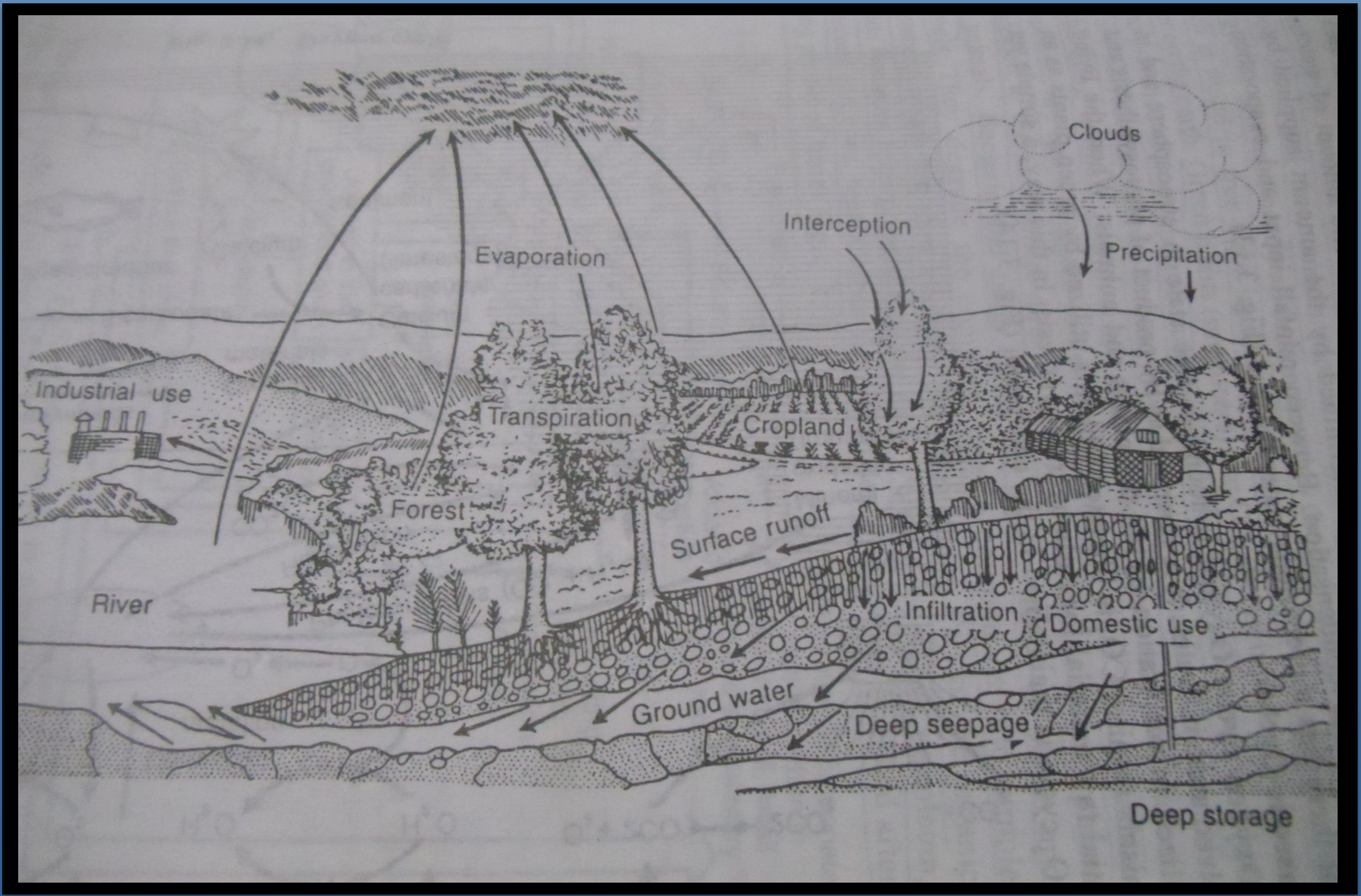
1. *Water cycle*

- Interchange of water between atmosphere, land and sea and between living organisms and their environment is accomplished through water cycle
- It involves evaporation, transpiration, cloud formation and precipitation
- Water of atmosphere reaches the earth surface through precipitation and reaches to atmosphere through evaporation and transpiration
- Between rainfall input and evaporation output there lies a precarious water balance

Biogeochemical Cycle: Water cycle



Biogeochemical Cycle: Water cycle



Biogeochemical Cycle:

2. Carbon cycle

- Gaseous CO_2 is the most important one regarding climate change as exhibits a warming effect
- The only source of carbon to autotrophs is the small amount of CO_2 (0.03 % v/v) in the atmosphere
- Carbon is present in all carbohydrates, fats, proteins and nucleic acids
- The main source are atmospheric carbon dioxide; dissolve carbon dioxide in water, and the rocks containing carbonate such as lime stone
- CO_2 in atmosphere comes from respiration of animals, plants (small amount), decay, volcanic action, burning of coal, oil, gas etc
- Also found in coal and petroleum have its origin in plants that

Biogeochemical Cycle:

2. Carbon cycle

- Cycle starts from utilization of CO_2 in the formation of carbohydrates in plants
- A part of carbohydrates is converted into lipids, proteins, and other complex organic compounds and stored in plant tissue
- Organic compounds of plans after digestion synthesized into other forms by herbivores and carnivores
- Oxidation of organic substances during respiration and decomposition results in release of CO_2
- the fossil fuels also consist of carbon in the reduced organic form (due to incomplete decomposition)
- Greatest quantity of carbon is located in sea water in the form of carbonate and bicarbonate ions

2. **Carbon cycle**

- Anaerobic bacteria like **Methano-bacterium, Methanococcus and Clostridium** reduce carbon to methane (CH_4) which is a major component of natural gas (marsh, sewer gas)

- In aquatic environment phytoplankton fix the CO_2 and zooplankton act as primary consumer provide food to small animals

- CO_2 by respiration react with water (H_2O) to form carbonic acid (H_2CO_3) and the carbonic acid dissociated in bicarbonate and carbonate

- $CO_2 + H_2O \leftrightarrow H_2CO_3$ (Carbonic acid)
- $H_2CO_3 \leftrightarrow H^+ + HCO_3$ (Bicarbonate)
- $HCO_3 \leftrightarrow H^+ + CO_3$ (Carbonate)

- When there is less CO_2 in atmosphere, carbonic acid dissociated to release CO_2 into the atmosphere

- When there is deficit of CO_2 in the water, movement of CO_2 is

2. Carbon cycle

- Total CO_2 in the atmosphere = 700 billion tons
- Respiration released CO_2 = 115 billion tons/yr
- Photosynthetically fixed CO_2= 115 billion tons/yr
- Coal and Oil consists CO_2= 10000 billion tons
- Carbon in sea= 50 times the atmosphere (35000 billion tons)

Biogeochemical Cycle:

3. ***Oxygen cycle***

- **Atmospheric air contains 21 % oxygen**
- **Without oxygen there would be no combustion or respiration and no CO_2 cycle**
- **Living organism receive O_2 by respiration and used in oxidation of food results in the production of water, CO_2 and energy**
- **Thus oxygen taken in respiration is given back to the atmosphere in form of CO_2**
- **CO_2 used by plants for food preparation and O2 released, thus oxygen enters organism through respiration and leaves through photosynthesis**
- **Oxygen cycle is interlinked with water and carbon cycle that is why in most literatures they are put under same heading "The carbon-hydrogen-oxygen cycle"**

Biogeochemical Cycle:

4. **Nitrogen cycle**

- Atmosphere contains approx. 79% nitrogen (3,800,000 billion tons) but animals and plants cant not make use of gaseous nitrogen
- Rocks (sediments and crust): 14,400,000 billion tons
- Ocean : 20,000 billion tons
- Land plants and animals: 12 and 0.2 billion tons respectively
- Ocean plants and animals: 0.8 and 0.17 billion tons respectively
- Dead organic matter on the land : 760 billion tons
- Dead organic matter in the ocean: 900 billion tons

Biogeochemical Cycle:

4. Nitrogen cycle

- Of all elements which plant absorb from the soil, nitrogen is the most important for plant growth
- It is required for the synthesis of aminoacids, proteins, enzymes, chlorophylls, nucleic acids etc.
- Plants obtain nitrogen from the soil in form of ammonium, nitrate and nitrite ions
- Atmospheric nitrogen is not directly available to organism with exception of BGA and nitrogen fixing bacteria
- Nitrogen cycle consists of six major steps:
- 1. Nitrogen fixation; 2. Nitrogen assimilation; 3. Ammonification; 4. Nitrification; 5. Denitrification and; 6. Sedimentation

Biogeochemical Cycle: Nitrogen cycle

1. ***Nitrogen fixation:*** *conversion of free nitrogen of atmosphere into biologically acceptable form or nitrogenous compounds*

a. ***Physiochemical or non-biological:***

- atmospheric nitrogen combines with oxygen during lightening or electric discharge in the clouds and produces nitrogen oxides

$$N_2 + 2(O) \xrightarrow{\text{Electric}} 2NO$$

$$2NO + 2(O) \xrightarrow{\text{Discharge}} 2NO_2$$

$$2NO_2 + (O) \longrightarrow N_2O_5$$

- Nitrogen oxides get dissolved in rain water and on reaching earth surface they react with mineral compounds to form nitrates and other nitrogenous compounds

$$N_2O_5 + H_2O \longrightarrow 2HNO_3$$

$$2HNO_3 + CaCO_3 \longrightarrow Ca(NO_3)_2 + CO_2 + H_2O$$

- During combustion (high temperature and pressure) some nitrogenous compounds (ammonia) form by reaction of hydrogen and nitrogen (Industrial nitrogen fixation)

Biogeochemical Cycle: Nitrogen cycle

b. Biological:

- BGA fix significant nitrogen in ocean, lakes and soil
- N_2 fixing organism combine the gaseous nitrogen with hydrogen obtained from respiratory pathway to form ammonia
- Ammonia reacts with organic acid to form aminoacids
- BGA both symbiotic and non-symbiotic: Nostoc, Anabaena etc
- N2 fixing free living bacteria: Azotobacter, Clostridium etc
- N2 fixing symbiotic bacteria: Rizobium
- Fungi: Frankia (actinomycetes)

Biogeochemical Cycle: Nitrogen cycle

2. ***Nitrogen Assimilation:***

- **Inorganic nitrogen in form of nitrite, nitrate and ammonia is absorbed by plants and converted into nitrogenous organic compounds like aminoacids**
- **Aminoacids are used in synthesis of proteins, enzymes, chlorophylls etc**
- **In animals, plant proteins are first broken into amino acids during digestion**
- **Those amino acids are absorbed and manipulated into animal proteins, nucleic acids etc**

Biogeochemical Cycle: Nitrogen cycle

3. ***Ammonification*:**

- **Dead organic remains of plants and animals are acted upon by a number of microorganisms**

- **These organisms utilize organic compounds in their metabolism and release ammonia**

- **Ex. Actinomycetes and baccili**

4. ***Nitrification*:**

- **Some bacteria use energy of dead organic matter in their metabolism and convert ammonia into nitrite like Nitrosomonas, Nitrococcus etc**

$$2NH_4 + 2O_2 \longrightarrow NO_2 + 2H_2O + \text{energy}$$

- **Conversion of nitrite to nitrates is brought about by Nitrobcter, Nitrocystis etc**

$$2\ NO_2 + O_2 \longrightarrow 2NO_3 + \text{energy}$$

Biogeochemical Cycle: Nitrogen cycle

5. ***Denitrification:***

- **Ammonia and nitrates are converted into free nitrogen by Thiobacillus denitrificans, Pseudomonas aeruginosa etc**

$$2NO_3 \rightarrow 2NO_2 \rightarrow 2NO \rightarrow N_2O \rightarrow N_2$$

6. ***Sedimentation:***

- **Nitrates of the soil are washed down to the water or leached deep into the earth along with percolating water**
- **Nitrates thus lost from the soil surface are locked up in the rocks**
- **Nitrogen of rock is released only when the rocks are exposed or weathered**

Biogeochemical Cycle:

5. Phosphorus cycle

- The main reservoir of the phosphorus are the rocks and natural phosphate deposits which formed in previous geological eras
- By weathering, leaching and mining these rocks get eroded and phosphates released to the ecosystem
- Phosphorus occurs in the soil as rock phosphate, calcium phosphate, iron phosphate, aluminum phosphate etc
- Large part of phosphate escapes to the sea and get deposited in marine deposits and deep ocean sediments
- The phosphate deposited in deep ocean sediments is never returned to the continent and thus lost
- Phosphorus absorbed by plants in form of phosphate ions H_2PO4 and HPO_4 and used in synthesis of organic compounds

Biogeochemical Cycle: ***Phosphorus cycle***

- Here it enters the food chain through feeding process
- Phosphorus is a component of nucleic acids, ADP, ATP, NADP, Phospholipids etc
- The organic compounds of plants and animal broken down to phosphates during decomposition which later used by plants
- A part of soluble phosphate goes to sea and water bodies through runoff and deposited in marine sediments
- Biological process like formation of bones and teeth also contributes to the sea phosphate which deposited in marine sediments
- Marine fish and birds play a major role in carrying sea phosphate to the continents in form of *Guano*
- Phosphorus returned to the land as guano: 10,000 tons
- Phosphorus returned to the land in fish caught: 60,000 tons

Biogeochemical Cycle:

6. **_Sulphur cycle:_**

- It links water, air and soil
- Sulphur occurs in the soil and rocks as sulphides (FeS, ZnS etc) and crystalline sulphites
- In atmosphere sulphur occurs in the form of SO_2 and H_2S
- Plant makes use of inorganic sulphur i.e., in form of sulphates
- Microorganisms reduce the dead matter into hydrogen sulphides (H_2S) and sulphur dioxide (SO_2) i.e., Aspergillus, Neurospora etc
- By incomplete combustion of fossils fuel and volcanic eruption a part of organic sulphur (H_2S) is converted into SO_2 and released to atmosphere

Biogeochemical Cycle:

6. Sulphur cycle

- Under aerobic condition H_2S is oxidized into elemental sulphur by Baggiatoa species and then it is converted into sulphates by Thiobacillus

$$2H_2S + O_2 \xrightarrow{\text{Baggiatoa}} 2S + 2H_2O$$

$$2S + H_2O + 3O_2 \xrightarrow{\text{Thiobacillus}} 2H_2SO_4$$

- Inorganic sulphur as sulphate (SO_4) precipitated out and turns into a source of elemental sulphur in the ecosystems

- Under anaerobic condition sulphates is reduced to sulphide by Escherichia and elemental sulphur by Aerobactor

Energy Flow: Energy

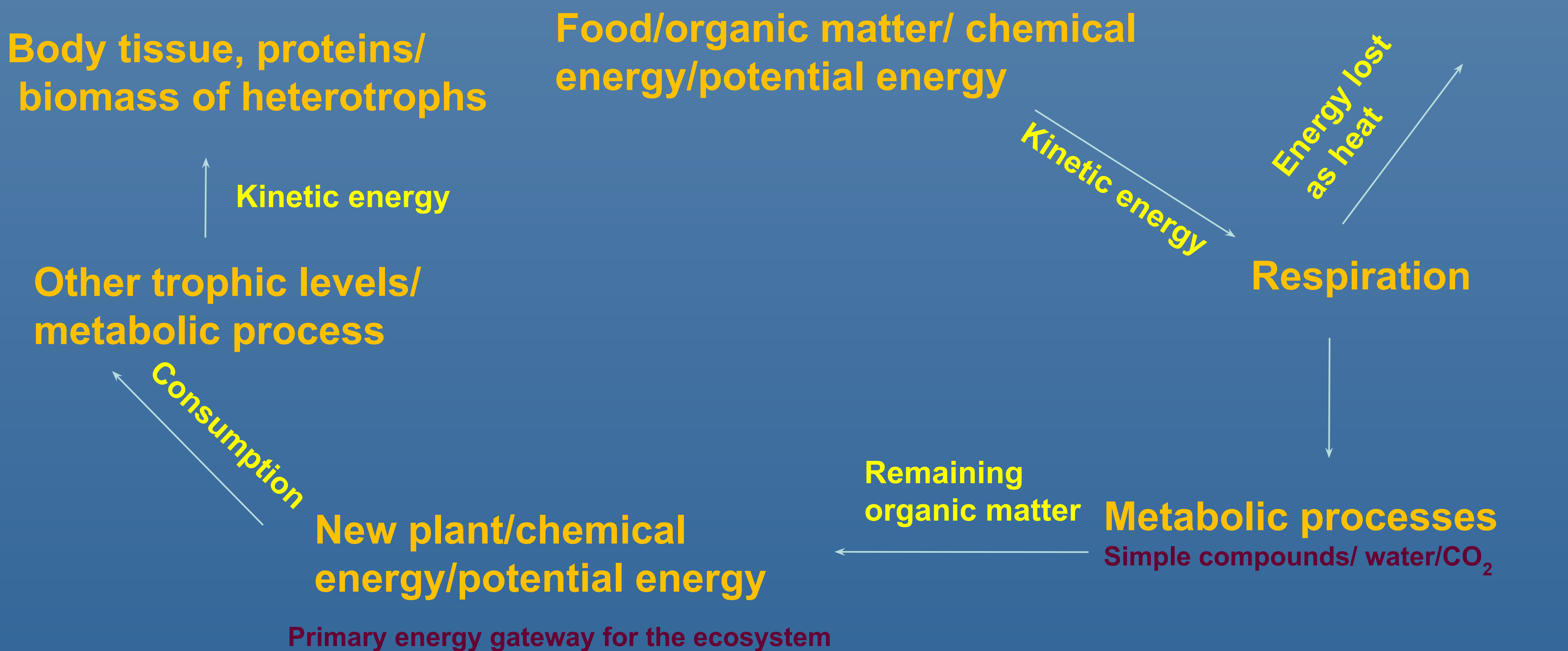
- Energy is defined as the capacity to do work
- Two types of energy: potential energy (stored energy at rest) and kinetic energy (free energy of motion)
- Kinetic energy is results in work performance at the expense of potential energy
- Source of energy required by all living organism is radiant energy (sun) and chemical energy (conversion of radiant energy)
- Radiant energy is cannot by directly used by living cells, it can be used only when gets converted into chemical energy
- The chemical energy stored in the food of living organisms is converted into potential energy in form of atoms of food
- The chemical energy of food is only source of food for all non-photosynthetic organisms

Energy Flow: Photosynthesis

- This process involves two types of reactions: i) physical reaction; ii) chemical reaction
- Physical reaction is closely tied to the absorption of radiant energy
- Chemical reactions concerned with the assimilation of CO_2 and its conversion to carbohydrate and other cellular constituents
- In physical reaction, light energy is absorbed by chlorophyll and stored as chemical energy in ATP and other energy rich compounds $TPNH_2$ (triphosphopyridine)
- Energy required in second reaction is supplied by ATP and $TPNH_2$ during CO_2 reduction [ATP hydrolyzed to ADP and P (inorganic phosphate] and $TPNH_2$ is oxidized and release energy]
- Energy of ATP and $TPNH_2$ is transferred to the molecules of organic substances and stored in them as chemical energy which is now potential energy

Energy Flow: Photosynthesis

- The chemical energy is no only used in the formation of organic matter or food but also in various other processed such as nitrogen fixation etc
- A part of organic matter produced is used by the photosynthetic organism themselves



Energy Flow: Process

- Organism which can convert sun energy into potential chemical energy (food energy) are known as primary producers

- The amount of new organic matter resulting from the activity of primary producers is known as primary production

- The rate at which primary producers convert solar radiation into chemical energy by photosynthesis is referred as gross primary productivity (GPP)

Or

- The total solar energy trapped in the food material by photosynthesis is referred as GPP

- The organic matter remains after plants metabolic process is accumulated or stored and adds to biomass or net primary productivity (NPP)

Or

- The rate at which the primary producer store the organic matter in their tissue after respiratory utilization is referred as NPP

Energy Flow: Process

- NPP is equal to the difference between GPP and the respiration rate of the primary producer and denoted as: NPP = GPP – R
- The rate of storage or storage of organic matter not used by heterotrophs is known as net community productivity (NCP) and denoted as: NCP = NPP – heterotrophic consumption
- Heterotrophs use organic matter of producers and break it into simpler substances and thus energy is released
- This energy is used for the metabolic processes and formation of animal tissue and proteins etc which is known as biomass or secondary productivity
- Energy loss at heterotrophs level takes place in form of respiration (respiratory energy) and excreta (excretory energy)
- Net secondary productivity = Gross energy production – excretory and respiratory losses; NSP = GSP – R

Energy Flow: Principles

- Energy flow in any ecosystem is unidirectional and based on two important laws of Thermodynamics

1. *First law of thermodynamics*

- Amount of energy in universe is constant
- It may change from one form to another but it can neither be created nor be destroyed
- Sun light energy transformed into another type of energy, such as chemical or heat energy

$$Q = \Delta E + W$$

Where Q = energy absorbed by the organism or energy input to the system; ΔE = Change in energy of a body; W= work done by the body or system

Energy Flow: Principles

1. *First law of thermodynamics*

- **$Q = \Delta E + W$ can be applied in ecological sense as GP= NP+R**

Where GP= Gross productivity or energy input; NP= net productivity or energy stored, and R= respiration or energy utilized to perform work

- **A balance is maintained by ecosystem, when energy input (GP) equals reparation (R)**

- **If GP exceeds R with time, the ecosystem accumulates biomass (at any one time)**

- **If R exceeds GP, the biomass decreased with time, and the ecosystem will not be self-sufficient w.r.t. energy content**

Energy Flow: Principles

1. First law of thermodynamics

Energy flow across primary producer level:

$$GPP = NPP + R \text{ or } NPP = GPP - R$$

Where GPP= gross primary production (energy input); NPP= net primary production (energy stored); R= energy utilized to perform work

- **First law of thermodynamics can be presented as the principle of conservation of energy as:**

$$\Delta E = Q - W$$

Where, Δ E corresponds to NPP, Q to GPP, and W to R

Energy flow across secondary producer level:

$$GSP = NSP + R \text{ or } NSP = GSP - R$$

Energy Flow: Energy

2. *Second law of thermodynamics*

- No process involving an energy transformation will spontaneously occur unless there is a degradation of energy from a concentrated form into a dispersed form (Odum 1971)

- The energy (mechanical, chemical, radiant) which changes from one form to another form cannot be changed without some degradation into heat energy

- Energy changes in such a way that a part of energy assumes waste form (heat energy)

- In this way, after transformation, the capacity of energy to perform work is decreased and thus energy flow from higher to lower level

Energy Flow: Energy

2. *Second law of thermodynamics*

- 57 % of sun energy is absorbed in the atmosphere
- 35 % is spent to heat water, land and to evaporate water
- Of the 8% of light energy striking plant surface, 10-15% is reflected, 5% transmitted and 80-85% is absorbed
- Only 3% of light energy is absorbed by chlorophyll and used in photosynthesis
- Only 0.5 to 1.5 % of absorbed energy by chlorophyll is converted into chemical energy and rest is transformed into heat energy
- Approximately 9/10th of energy content is wasted at each trophic level (10% law)