3

ECOSYSTEM

Learning Objectives

After studying this chapter, you should be able to

- define ecology and ecosystem
- describe the causes and basic types of ecological succession
- enumerate and explain different types of ecosystems
- explain the roles of producer, consumer and decomposer in an ecosystem
- enumerate and explain various types of food chains
- explain the flow of energy through the various components of the ecosystem
- describe grassland ecosystem, desert ecosystem, forest ecosystem and aquatic ecosystem
- define an ecological pyramid and its various types
- explain different models of energy flow in an ecosystem
- describe why a complex ecosystem is more stable than one with few species

3.1 INTRODUCTION TO ECOLOGY AND ECOLOGICAL SUCCESSION

The term ecology is derived from the Greek word *Oikologie*. Literally, *Oikos* means 'home or surroundings' and *logos* means 'study'. Thus, ecology is the study of nature.

Ecology can be defined as "*the study of interactions between an organism and its physical environment; the relationship between animals and plants and how one species affect another.*"

3.1.1 Classification of Ecology

Ecology can be classified

(i) By Level of Complexity or Scope For example, behavioral ecology, population ecology, etc.

(ii) By Organisms under Study For example, animal ecology, plant ecology, insect ecology, etc.

(iii) By Biome under Study For example, desert ecology, forest ecology, etc.

(iv) By Geographic or Climatic Area under Study For example, tropical ecology, polar ecology, etc.

(v) By Spatial Scale under Study For example, micro ecology, macro ecology, molecular ecology, global ecology, etc.

(vi) By Phenomena under Investigation For example, chemical ecology, evolutionary ecology, etc.

(vii) By Technique used for Investigation For example, theoretical ecology, quantitative ecology, etc.

(viii) By Philosophical Approach For example, conservation ecology, restoration ecology, applied ecology, etc.

(ix) Ecology-involved Interdisciplinary Fields For example, human ecology, agro ecology, etc.

3.1.2 Evolution of Ecosystems

An ecosystem is evolved through the following evolutionary processes:
Natural selection, life history, development, adaptation, populations and inheritance.

3.1.3 Ecological Succession

Ecological succession is orderly changes in the composition or structure of an ecological community. It is more or less predictable.

(A) Causes and Basic Types of Ecological Succession

(i) Primary and Secondary Succession

(a) When the development begins on an area that has not been previously occupied by a community, the process is known as *primary succession*.
Examples A lava flow, a newly formed lake, or a newly exposed rock or sand surface.

(b) When the community development is proceeding in an area from which a community was removed, it is called *secondary succession*.
Examples It arises on cut-over forest, an abandoned crop, etc. These are the sites where the vegetation cover has been disturbed by nature or humans.

(ii) Seasonal and Cyclic Succession These are periodic changes arising from fluctuating species interactions or recurring events.

Example Vegetation changes which are not dependent on disturbance unlike secondary succession.

(B) Causes of Plant Succession

(i) Changes in the soil caused by the presence of organisms there includes change in pH of soil by plants growing there, alterations of soil nutrients, etc.

(ii) Changes in the soil caused by external environmental influences includes soil changes due to erosion, deposition of silt and clays, changes caused by animals, etc.

(iii) Changes caused by climate factors are promoted by changes in temperature and rainfall patterns, specially global warming, floods etc.

3.2 ECOSYSTEM

"*An ecosystem is defined as a natural unit that consists of living and nonliving parts which interact to form a stable system.*"

An ecosystem is generally an area within the natural environment in which physical (abiotic) factors of the environment, such as rocks and soil, function together along with interdependent (biotic) organisms, such as plants and animals, within the same habitat to create a stable system. It possesses all the characteristics required to sustain life. When we want to conserve species or to use natural resources in a sustainable manner, we need to focus on ecosystems. This is because an ecosystem is the minimal grouping of diverse organisms that interact and function together so as to sustain life.

The sizes of some ecosystems are illustrated below:

Ecosystem	Bacteria	Pond	Desert	Ocean
Size	(1 to 100) mm^2	(10 to 100) m^2	> 100 km^2	> 1000 km^2

Example 1 *How is the sun the primary sustainer of life on the earth?*
OR
Wshat sustains life in an ecosystem?

Solution The energy from the sun
(i) enables plants to produce food through photosynthesis,
(ii) evaporates water and cycle it through the biosphere,
(iii) generates winds,
(iv) warms the atmosphere and the land,
(v) drives the climate and weather systems, and
(iv) powers the cycling of carbon, nitrogen and other matter.

Balanced Ecosystem

The biotic (living) and abiotic (nonliving) parts of the ecosystem are in equilibrium in a balanced ecosystem. *Balanced ecosystem* means that the nutrients are able to cycle efficiently, and no community of organisms or natural phenomena is interrupting the flow of energy and nutrients to other parts of the ecosystem.

3.2.1 Structure of an Ecosystem

Structure of an ecosystem means:

(i) The Composition of Biological Community It includes species, their population, etc.

(ii) The Quantity and Distribution of Abiotic Materials It includes water, soil, nutrients, etc.

(iii) The Conditions of Existence It includes temperature, light, humidity, etc.

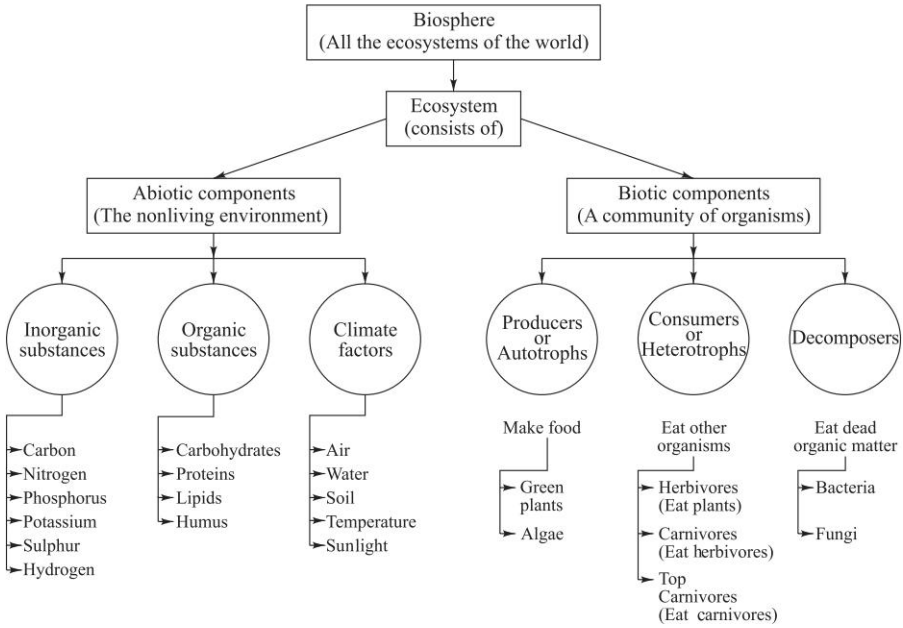


Fig. 3.1 *Structure of an ecosystem*

(A) Abiotic Components All the nonliving components of the environment constitute the *abiotic components*. It includes:

- ***Inorganic substances*** which are involved in mineral (nutrient) cycles. *Examples*: C, N, P, K, S, H, etc.
- ***Organic substances*** present in the biomass or in the environment. They form the living body and influence the functioning of the ecosystem. *Examples*: Carbohydrates, proteins, lipids, humus, etc.
- ***Climate factors*** having a strong influence on the ecosystem.

(i) Water Plants and animals receive water from the soil and the earth's surface. Water is the medium by which mineral nutrients enter and are distributed in plants. For the survival of animals, water is necessary.

(ii) Soil Soil provides nutrients and water, a structural growing medium for organisms.

(iii) Atmospheric Air Within ecosystems, the atmosphere provides oxygen for respiration of organisms and carbon dioxide for photosynthesis in plants.

(iv) Sunlight Sunlight is necessary for photosynthesis. It is used to heat the atmosphere in ecosystems.

(B) Biotic Components

All the living components of the environment constitute the biotic components.

Depending on their self-food producing capability, biotic components are of following types.

(i) Producers or Autotrophic Components Producers are self-nourishing organisms (so they are called *autotrophs*). They contain chlorophyll and are capable of converting carbon dioxide and water, in the presence of sunlight into carbohydrates through photosynthesis. In the process, they give out oxygen.

$$6CO_2 + 6H_2O + \text{Sunlight} \xrightarrow[\text{Producers}]{\text{Photosynthesis}} C_6H_{12}O_6 + 6O_2$$

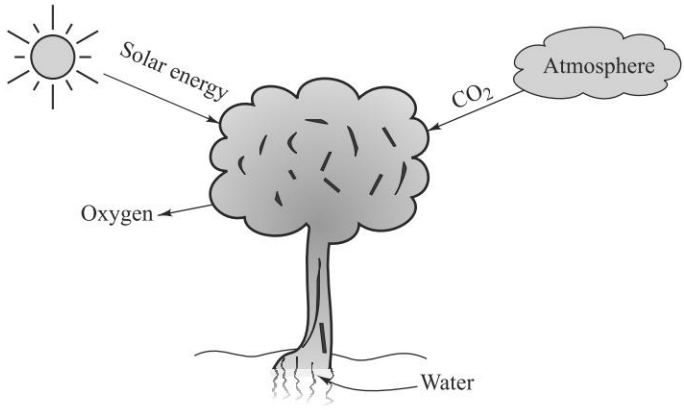
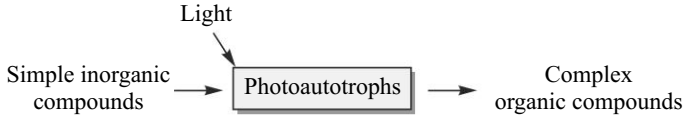


Fig. 3.2 *Process of photosynthesis*

Autotrophs are of the following two types:

(a) Photoautotrophs These are the producers who fix energy from the sun and store it in complex organic compounds.

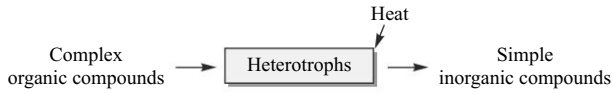


Examples Green plants, some bacteria, algae.

(b) Chemoautotrophs (Chemosynthesizers) They are bacteria that oxidise reduced inorganic substances (typically ammonia and sulphur compounds) and produce complex organic compounds.

Example Nitrifying bacteria in the soil underground.

(ii) Consumers (or Heterotrophic Components) Consumers depend on producers to obtain their energy for survival. They utilise, rearrange and decompose the organic matter produced by autotrophs.



Consumers are classified as herbivores, carnivores and top carnivores depending on their food habits.

(a) Herbivores (or Primary Consumers) They feed on green plants (autotrophs) to obtain energy for survival.

Seed-eaters are also known as *granivores*. Fruit-eaters are also known as *frugivores*.

Examples Grasshoppers, rabbits, goats, cows, horses, etc.

(b) Carnivores (or Secondary Consumers) They feed on primary consumers.

Examples Lizard, fox, hawk, etc.

(c) Top Carnivores (or Tertiary Consumers) They eat the flesh of both carnivores and herbivores and are not killed or eaten by other animals.

Examples Lions, tigers, vultures, etc.

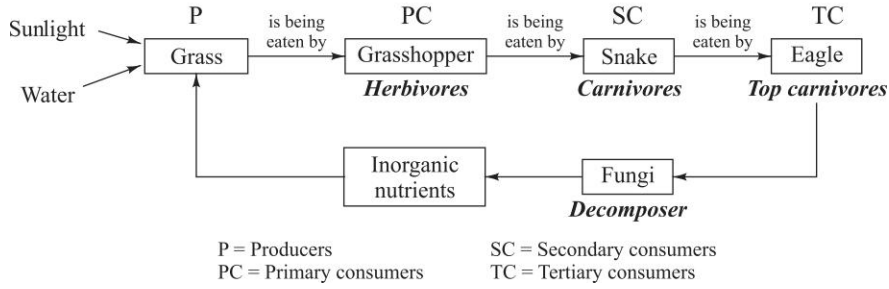


Fig. 3.3 *Structure of an ecosystem*

(iii) Decomposers The decomposers are also known as *saprotrophs* (i.e. *sapros* = rotten; *trophs* = feeder). They feed on dead organic matter (from producers and consumers). They transform complex organic compounds back into simple inorganic substances like CO_2, H_2O, phosphates, sulphates.

Examples Bacteria, fungi, other microbes, etc.

Fallen leaves, parts of dead trees, and faecal wastes of animals are termed *detritus.* The consumers that feed on detritus are known as *detrivores*.

Examples Ants, termites, earthworms, crabs, etc.

Decomposers and detrivores are essential for the long-term survival of a community. Their vital role is to complete the matter cycle. Enormous wastes of plant litter, dead animal bodies, animal excreta, and garbage would collect on the earth without them. Furthermore, important nutrients would remain indefinitely in dead matter. The producers would not get their nutrients, and life would be impossible without detrivores and decomposers.

Notes:

- Humans act as primary consumers when they eat fruits and vegetables.
- Humans act as secondary consumers when they eat meat.
- Humans act as tertiary consumers when they eat the fish that eat smaller fish that eat the algae.
- Humans can also act as omnivores by eating both plants and animals.

3.2.2 Function of an Ecosystem

Major functions of an ecosystem are as follows:

(i) It regulates flow rates of biological energy. In other words, it controls the rate of production and respiration of the community.

(ii) It regulates flow rates of nutrients. In other words, it controls the production and consumption of minerals and materials.

(iii) It helps in biological regulation including:

(a) Photoperiodism (regulation of organisms by environment)

(b) Nitrogen-fixing organisms (regulation of environment by the organism)

3.2.3 Importance of an Ecosystem

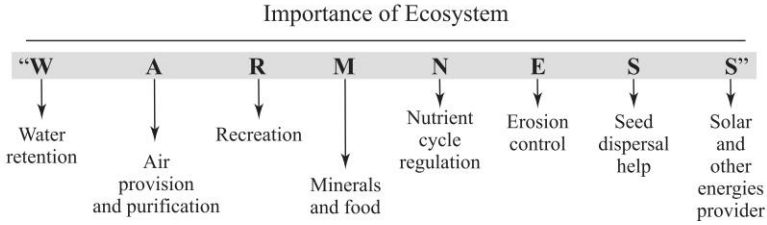
An ecosystem provides number of services for the healthy survival of humans. For example:

(i) An ecosystem helps in water retention, thus facilitating a more evenly distributed release of water.

(ii) An ecosystem provides air and does its purification.

(iii) An ecosystem provides recreation for us via eco-tourisms facilitating the enjoyment of nature.

(iv) An ecosystem provides materials like minerals and food.



(v) An ecosystem regulates nutrient recycling and waste.

(vi) An ecosystem helps in erosion control, soil building and soil renewal.

(vii) An ecosystem helps in seed dispersal.

(viii) An ecosystem gives us solar energy (that accounts for 99% of the total energy used on earth). It also gives us

(a) Renewable energy like biofuels, and

(b) Non-renewable energy like fossil fuels.

(ix) Additional services provided by an ecosystem are the following:

(a) An ecosystem helps in the maintenance of the biogeochemical cycles like carbon cycle and water cycle. It also helps in the cycling of vital chemicals like sulphur, phosphorus, nitrogen and carbon.

(b) An ecosystem helps in natural pest and disease control.
(c) An ecosystem preserves genetic diversity.

3.3 FOOD CHAIN

Food chain is a feeding hierarchy in which organisms in an ecosystem are grouped into nutritional (trophic) levels and are shown in a succession to represent the flow of food energy and the feeding relationship between them. The directional flow of food energy from one organism to another is graphically represented by arrows. Food chain is just a sequence of organisms, in which each is food for the next.

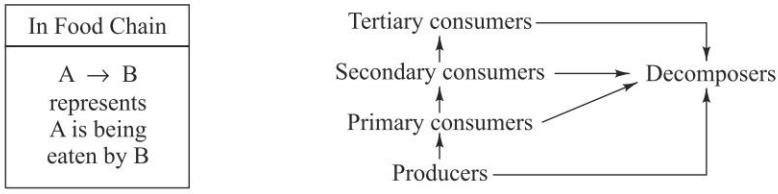


Fig. 3.4 *A food chain*

Food chains overlap, because most consumers feed on multiple species and in turn, are fed upon by multiple other species. Thus, we have a complex network of interconnected food chains called a *food web*.

For example, a snake might feed on a mouse, a lizard, or a frog. In turn, the snake might be eaten by a bird or a badger.

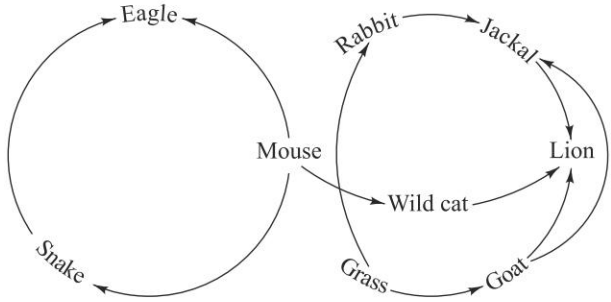


Fig. 3.5 *Food web in a forest*

Types of Food Chains

Food chains are broadly of the following two types:

(i) Grazing Food Chain The grassland and forest ecosystems follow this grazing food chain. Here, producers get energy from the sun and are grasses or green plants. They are subsequently grazed by animals.

Examples (a) Grass → Grasshopper → Frog → Snake → Hawk
(b) Green plants → Goat → Wolf → Lion

(ii) Detritus Food Chain The estuarine and mangrove leaf ecosystems follow this detritus food chain. In this chain, the dead animals, dead plants and fallen leaves are consumed by detrivores and their predators.

Examples (a) Dead plants → Soil mites → Insects → Lizards
(b) Dead organic matter → Bacteria → Protozoa → Rotifiers

Example 2 *How is balance maintained in an ecosystem?*

Solution The food chains and other such interrelationships in ecosystems create a balance in the environment, called the ecological balance.

The components of the ecosystem are part of food chains and food webs. They do not try to modify the environment to suit their needs, rather they help in maintaining a balance in the ecosystem.

However, humans try to modify the environment to suit their needs. As they are also a part of these food chains and webs, modification of environment has upset the delicate balance which was maintained in the environment.

Example 3 *What is the difference between a food chain and a food web?*

Solution

(i) Food chains follow just one path of energy as animals find food. Food webs show how plants and animals are connected in many ways to help them all survive.

(ii) A food chain is the hierarchy of consumption of food from sun to plant to herbivore to carnivore. It acknowledges only one single string of connected plants/animals. There are many food chains within a food web, and one creature is not necessarily at the top of the hierarchy. In a food web, one kind of prey may be eaten by several kinds of predators, and one predator may eat several different kinds of prey.

(iii) A food chain is very basic and doesn't show the full picture of an ecosystem. On the other hand, a food web refers to everything that goes on in the real world.

(iv) A food chain can be illustrated by a linear diagram. However, a food web can be illustrated by a complex diagram.

Example 4 *Explain the significance of studying a food chain.*

Solution

(i) The knowledge of how species are inter-dependent in a food chain is necessary. It is also necessary to understand how natural and man-made environmental pressures affect ecosystems. These include mercury, DDT, etc., which are toxic chemicals and cause destructive pollution. They can alter or break the food chain. These also include nutrient pollution which shift whole ecosystems toward nutrient-hungry species. For example, crops, fertilizers, sewage and animal waste escape into lakes causing algae blooms at the expense of fishes.

(ii) The study of food chains and webs is critical for understanding the route by which pollutants gets bio-accumulated (i.e. concentrated) up the food chain.

(iii) By studying a food chain, we can understand how balance is maintained in an ecosystem.

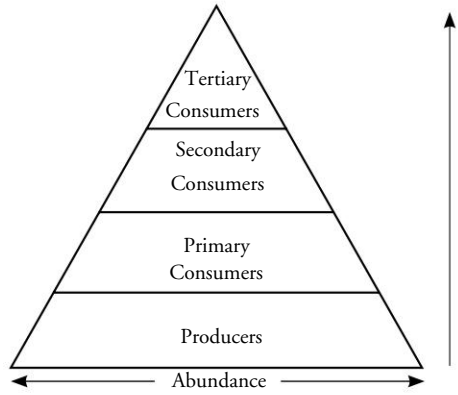
3.4 ECOLOGICAL PYRAMIDS

3.4.1 Pyramid of Numbers

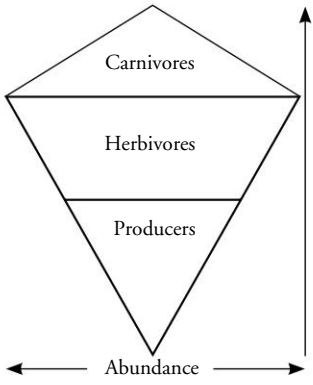
The *pyramid of numbers* represents the number of individuals at each trophic level. The shape of a pyramid of numbers can be upright, partly upright and inverted depending on the type of ecosystem.

(A) Aquatic and Grassland Ecosystem

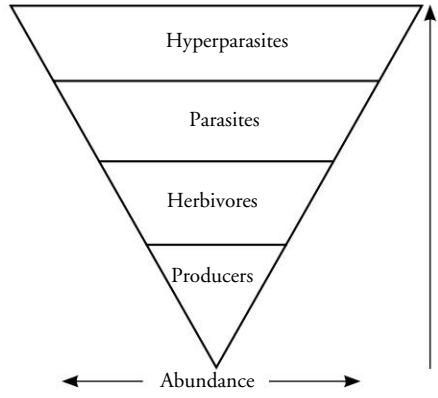
In aquatic and grassland ecosystems, the number of producers are always more than that of primary consumers. Thus, the producer organisms remain in abundance near the base of the food chain and the consumers gradually decrease in number towards the apex. As a result, the shape of the pyramid is upright (Fig. 3.6 (a)).



(a) Upright pyramid



(b) Spindle shaped



(c) Inverted pyramidal shaped

Fig. 3.6 *Pyramid of numbers*

(B) Forest Ecosystem

In a forest ecosystem, there are fewer number of producers that support a greater number of herbivores who in turn support a lesser number of carnivores. The shape of the pyramid of numbers is partly upright or spindle type (Fig. 3.6 (b)).

(C) Parasitic Food Chain

In a parasitic food chain, one primary producer supports numbers of parasites which again support still more hyperparasites. The pyramid of numbers is inverted in shape because the producers are least in number and the predators are greater in number as we move up the food chain (Fig. 3.6 (c)).

3.4.2 Pyramid of Energy Flow (Flow of Energy in an Ecosystem)

Flow of energy in an ecosystem takes place through the food chain.

The main source of energy for most ecosystems is the sun. Solar energy is trapped by *producers.* They store it as carbohydrates, proteins and fats. When *primary*

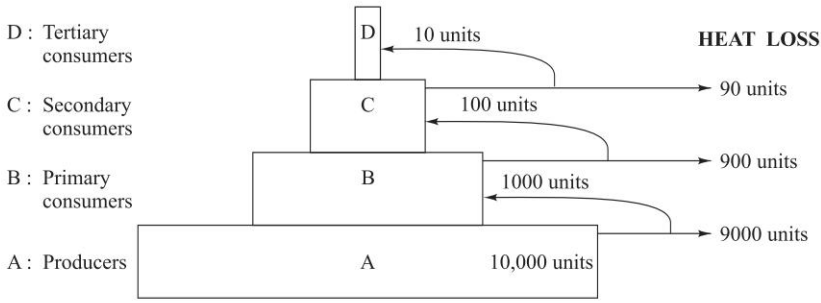


Fig. 3.7 *Pyramid of energy flow*

consumers eat the producers, the energy also moves up the trophic level. During this transfer, about 90% of the energy is lost as unusable heat to the environment.

We have an upright pyramid of energy flow as we move up the trophic levels, and the amount of usuable energy available at each stage declines.

Notes:

1. The *ecological pyramid* is the graphical representation of the organism's position in the food chain. The base of the pyramid consists of the food-producer level and the successive levels make the tiers with the top carnivore or tertiary consumers forming the apex.
2. The size of each compartment in an ecological pyramid represents the amount of organisms (or item) in each trophic level of a food chain.
3. *Trophos* is a Greek word meaning nourishment.

Suppose the producer has 10,000 units of energy. When primary consumers eat the producer, they receive only 1000 units, and the rest 9000 units are lost as heat. Similarly, the secondary and tertiary consumers gets only 100 and 10 units respectively. The loss at each stage is simply released as heat into the environment.

The flow of energy through the various components of the ecosystem is unidirectional and continuous.

Unlike the nutrients which move in a cyclic manner and are reused by the producers after flowing through the food chain, energy is not reused in the food chain.

All organisms require energy for growth, maintenance, reproduction, locomotion, etc. The flow of energy in an ecosystem follows the laws of thermodynamics.

(i) First Law of Thermodynamics Energy can never be created or destroyed, but can be converted from one form to another.

(ii) Second Law of Thermodynamics Transformations of energy always result in some loss or dissipation of energy.

The trophic structure of an ecosystem is the pattern of energy flow among different organisms as illustrated in Fig. 3.8.

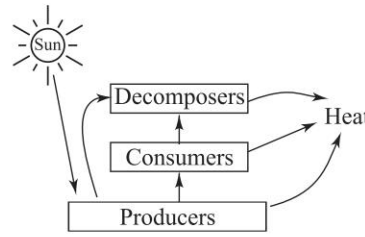


Fig. 3.8 *The trophic structure of an ecosystem*

3.4.3 Models for Energy Flow in Ecosystem

The following models can be used for explaining the flow of energy through various trophic levels in an ecosystem.

(A) Universal Energy-flow Model According to this model (as per E.P. Odum), as the flow of energy takes place, there is a gradual loss of energy at every level, thereby resulting in less energy available at the next trophic level as denoted by smaller boxes (for stored energy in biomass) and as indicated by narrower pipes (for energy flow). The energy not utilised (*NU*) is lost in excretion, locomotion, respiration (*R*). The rest of the energy is used for production (*P*).

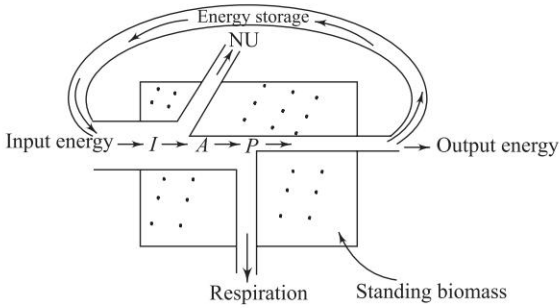


Fig. 3.9 *Universal energy-flow model*

(B) Single-channel Energy-flow Model According to this model, the flow of energy takes place in a unidirectional manner from producers to herbivores to

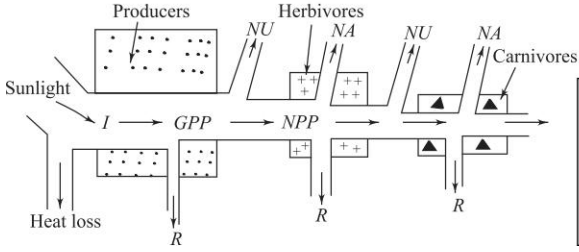


Fig. 3.10 *Single-channel energy-flow model*

carnivores. Due to loss of energy at each successive trophic level in a grazing food chain, there is gradual decline in energy.

(C) Double-channel or Y-shaped Energy-flow Model Both grazing and detritus food chain operate in the same ecosystem in nature. In a marine ecosystem, the grazing food chain predominates. In a forest ecosystem, the detritus food chain predominates. The grazing and detritus food chains are separated in space and time. A Y-shaped model of energy flow is used to show the passage of energy through these two chains.

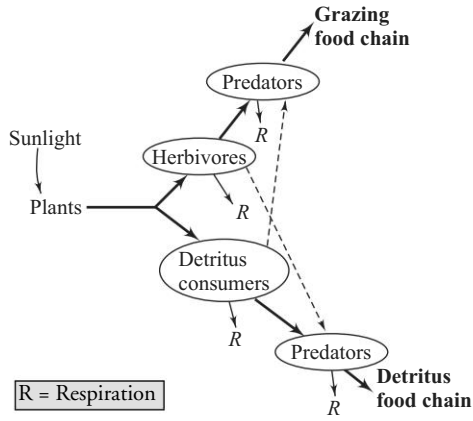


Fig. 3.11 *Y-shaped energy-flow model showing linkage between the detritus and grazing food chains*

3.4.4 Pyramid of Biomass (Flow of Matter in an Ecosystem)

Estimation of Biomass

Step (1) Collect (or trap) and weigh suitable samples at each trophic level.

Step (2) Total combined (net dry) weight (often, per unit area or volume) of all the organisms at each trophic level is *biomass*.

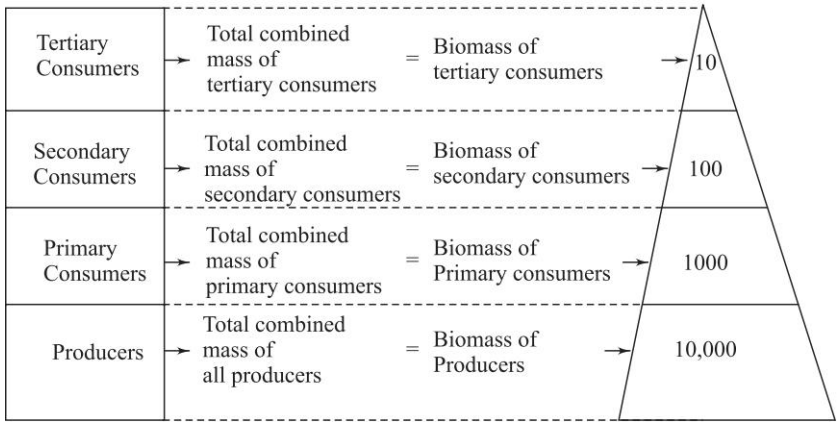


Fig. 3.12 *Depicting biomass relationship graphically at successive trophic levels gives rise to a biomass pyramid*

The dry weight of all the matter contained in the organisms is known as *biomass.* Each tropic level contains a definite amount of biomass. As we move up trophic levels, biomass decreases drastically. There is 90 to 99 per cent loss of biomass at each level. This is known as the *pyramid of biomass*.

Reasons for the decrease of biomass as we move up trophic levels are the following:

(i) Only a fraction of the food taken in by a consumer is converted into body tissue. The remaining is stored as energy to be used by the consumer when needed.

(ii) Much of the biomass, especially at the producer level, is never eaten and goes directly to the decomposers.

Example 5 *Why is the mass of water not usually included in biomass?*

Solution This is because the water content is variable and contains no usuable energy.

Example 6 *What is net primary production?*

Solution Total amount of energy captured by producers is termed Gross Primary Production (GPP).

When energy lost due to respiration is subtracted from GPP, we get Net Primary Production (NPP).

$$\text{NPP} = \text{GPP} - \text{Respiration}$$

Net primary production is the amount of energy stored by the producers and potentially available to the consumers and decomposers.

Example 7 *What is secondary productivity?*

Solution It is the rate at which consumers convert organic material into new biomass of consumers.

Example 8 *"The pyramid of total biomass produced must resemble the pyramid of energy flow". Comment.*

Solution The above statement is TRUE.

This is because biomass can be equated to energy.

Example 9 *Why can the pyramids of energy and yearly biomass production never be inverted?*

Solution Because this would violate the laws of thermodynamics.

3.5 TYPES OF ECOSYSTEMS

There are several ecosystems working at micro and macro levels in the world. The biosphere is the biggest ecosystem which combines all the ecosystems of the world. The world's smaller ecosystems are broadly divided into natural and artificial type ecosystems.

3.5.1 Natural Ecosystems

They operate by themselves under natural conditions without any interference by humans. Broadly they are subclassified into terrestrial and aquatic ecosystems.

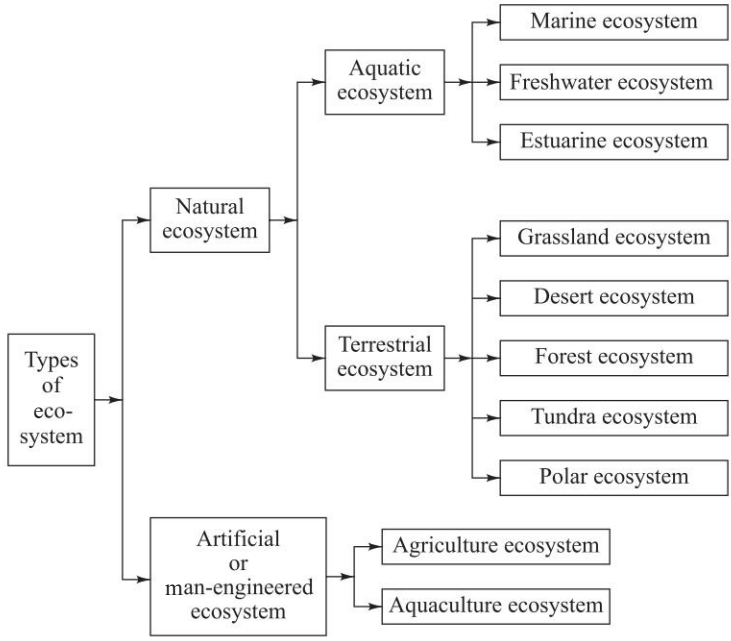


Fig. 3.13 *Classification of ecosystems*

(i) Terrestrial Ecosystems They are known by the type of main vegetation in them. For example, grassland ecosystems have grass as the main vegetation.

(ii) Aquatic Ecosystems They are known by the type of habitat. They can be of estuarine, marine and freshwater types of ecosystems.

The freshwater ecosystems can be of standing freshwater ecosystems (or *lentic ecosystems*) or running freshwater ecosystems (or *lotic ecosystems*).

Examples Ponds, lakes, etc., are examples of lentic ecosystems and rivers, springs, etc., are examples of lotic ecosystems.

3.5.2 Artificial Ecosystems

These ecosystems are controlled and manipulated by humans. These are created by humans in order to fulfill certain needs.

Broadly, they are subclassified into the following two types:

(i) Agriculture ecosystem
(ii) Aquaculture ecosystem

(A) Differences between Natural and Artificial Ecosystems

Natural ecosystems	*Artificial ecosystems*
(i) Polyculture systems	(i) Monoculture system
(ii) Stable ecosystems	(ii) Fragile ecosystems
(iii) Less productive in terms of yield of grains, milk, fish or meat	(iii) Highly productive as they are given increased supply of energy in the form of labour, extra nutrients, fossil fuels, fertilisers, pesticides, etc.

(*Contd.*)

(*Contd.*)

(iv) Pollution free	(iv) Generate lots of pollutants.
(v) *Examples:* Aquatic ecosystems and terrestrial ecosystems	(v) *Examples:* Agriculture ecosystems and aquaculture ecosystems
(vi) Functions:	(vi) Functions:
• Air purification	• To supply large quantities of grains, etc.
• Water purification	• To supply large quantities of fish, meat, milk, etc.

(B) Similarities between Natural and Arificial Ecosystems

(i) Both are open systems with no constraints of boundaries.
(ii) Both have all the essential components such as abiotic and biotic members.
(iii) Both permit constant interaction between biotic and abiotic components.

3.6 FOREST ECOSYSTEM

A *forest* is a community of trees, herbs, shrubs, and associated organisms that use oxygen, water and soil nutrients for their growth and reproduction.

A *forest ecosystem* is the organisms, soil, air and water associated with the forest.

A forest ecosystem is interdependent because every organism depends on every other living and nonliving elements of the system.

Fire, storms, drought, flood, death, disease, etc., are natural changes in a forest ecosystem. Harvesting, farming, trails, recreation and development, etc., are man-made changes in a forest ecosystem.

Components of Forest Ecosystems

The different components of the forest ecosystems are the following:

(i) Abiotic Components The minerals present in the forest and all organic (litter, debris) and inorganic substances present in the soil and the atmosphere constitute the abiotic components.

(ii) Biotic Components All living components, viz. producers, consumers and decomposers, constitute the biotic components of the forest.

(a) Producers Big trees, medium-sized bush, small herbaceous plants, or any vegetation of the forest is the producer, which performs photosynthesis.

(b) Consumers

Primary Consumers They graze over the primary producer, e.g. elephants, mongooses, squirrels, deer; birds and insects like flies, spiders, ants, etc.

Secondary Consumers They are the predators of primary consumers. They regulate the population size of primary consumers and thereby their grazing activity, e.g. jackal, fox, eagle, snake, etc.

Tertiary Consumers They feed on secondary consumers and are also known as top carnivores., e.g. lions, tigers, etc.

(c) Decomposers They have the ability to degrade all dead organisms to release nutrients into the soil which are again used by the producer. They remain confined to the soil of the forest floor.

Examples Earthworms, bacteria, fungi, protozoa, nematodes, etc.

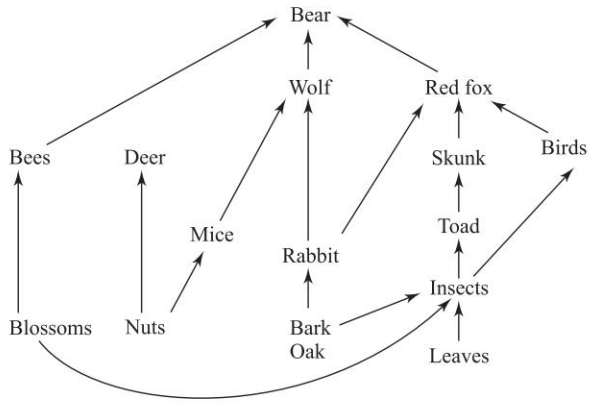


Fig. 3.14 *Interconnection between food chain and food web in a forest ecosystem*

3.7 AQUATIC ECOSYSTEM

An *aquatic ecosystem* is an ecosystem located in a body of water.

Biotic and abiotic components (which are self-regulating and self-sufficient) constitute an aquatic ecosystem. About 70% of the earth's total surface is under the aquatic ecosystem. Broadly, an aquatic ecosystem is of the following three types: Freshwater ecosystem, marine ecosystem and estuarine ecosystem.

3.7.1 Pond Ecosystem (or Freshwater Ecosystem)

The different components of a pond ecosystem are as follows:

(i) Abiotic Components Oxygen, carbon dioxide, water, nitrogen, phosphorus, calcium, amino acids, etc., are abiotic components of a pond ecosystem.

(ii) Biotic Components They consist of the following:

(a) Producers Some photosynthetic bacteria and the autotrophic green plants fix the solar energy with the help of nutrients obtained from the mud of the pond.

(b) Consumers

Primary Consumers They feed on the producers.
Examples Herbivores like zoo plankton and small invertebrates like copepod.

Secondary Consumers They feed on primary consumers.
Examples Small carnivores like small fishes.

Tertiary Consumers They feed on secondary consumers.
Examples Large fishes.

(c) Decomposers They help in the release and recycling of nutrients. They decompose the organisms and are present at the base of the pond.
Examples Bacteria, fungi, etc.

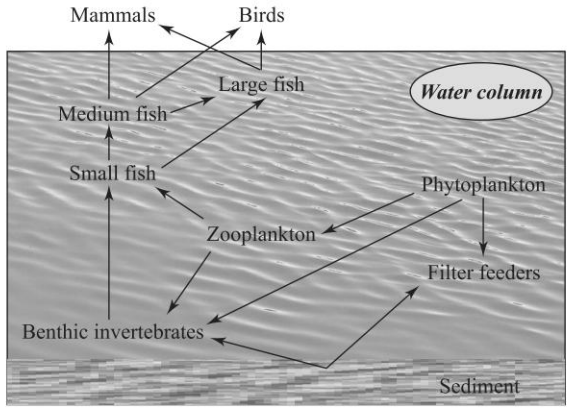


Fig. 3.15 *How food chain and food web are interconnected in an aquatic ecosystem*

Functions An aquatic ecosystem performs the following environmental functions:

- Recycle nutrients
- Purify water
- Recharge ground water
- Provide habitats for wildlife
- Attenuate floods
- Used for human recreation

3.7.2 Marine or Ocean Ecosystem

Oceans are gigantic reservoirs of water covering nearly 70% of the earth's surface. A marine ecosystem is different from a freshwater ecosystem mainly because of its salty water and also because the sea is deep, and the water is in continuous circulation.

A marine ecosystem can be divided into the following zones:

(A) Littoral Zone It is the shoreline between the land and the open sea. Waves and tides have maximum effect in a littoral zone. Various regions of this zone are tabulated below along with the important organisms:

Region	*Organisms*
(i) Rocky shore region	Starfish, barnacles, algae
(ii) Sandy shore region	Snails, clams
(iii) Bays	Algae

Often photosynthetic bacteria are present below the algae. Moreover, by colonial coelenterates, coral reefs are also formed.

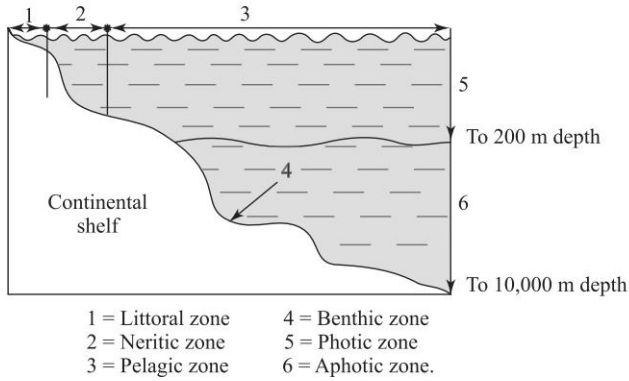


Fig. 3.16 *Horizontal and vertical zonation in the ocean*

(B) Neritic Zone This zone lies just above the continental shelf. The nutrients washed from land are found in this zone. Thus this zone is rich in species. The productivity of this zone is high because sunlight can penetrate through this zone. Zooplankton and phytoplankton are abundant here and support fishing grounds. Pollution also affects the neritic zone first.

(C) Pelagic Zone The open sea constituting 90 per cent of the total ocean surface forms this zone. Phytoplanktons, zooplanktons, shrimps, jelly fish, fin, deep-water fishes and blue whale are found here.

Organisms of this zone are present below the light penetration zone and totally depend on the rain of detritus of upper regions for their nutrition.

(D) Benthic Zone

The floor of the ocean constitutes this zone. It stretches from the edge of the continental shelf to the deepest ocean trenches.

Sponges, sea lilies, sea fans, snails, clams, starfish, sea cucumbers and sea urchins are found in this zone.

The components of marine ecosystem are the following:

(i) Abiotic Components High sodium, potassium, calcium and magnesium salt concentrations, variable dissolved oxygen content, light and temperature make a unique physico-chemical condition in marine water.

The size of marine populations is low because concentration of dissolved nutrients is less.

(ii) Biotic Components

(a) Producers Phytoplankton, seaweeds and mangrove vegetations are main producers in marine ecosystems.

(b) Consumers Crustaceans, molluscs, fishes and other herbivorous which feed directly on producers are primary consumers.

Carnivorous fishes like herring, sahd and mackerel, etc., are secondary consumers.

Cod, haddock and other top carnivorous fishes are tertiary consumers.

(iii) Decomposers These are microorganisms like fungi and bacteria.

3.7.3 Estuarine Ecosystem

Estuaries are semi-enclosed coastal bodies of water connected on the one side with a river and on the other side with the open sea. Thus, estuarine is characterised as an ecosystem having fluctuating water level.

The organisms present in estuaries are known as *eurythermal* (which show a wide range of tolerance to temperature) and *eurysaline* (which show a wide range of tolerance to salinity).

Due to nutrient and energy inputs from both river water and sea water, estuaries are highly productive. They also offer high food potential for human beings. Deep-water fishes use estuaries as nurseries to bring up their younger ones.

The component of an estuarine ecosystem are the following:

(i) Abiotic Components A mixture of fresh and marine ecosystems.

(ii) Biotic Components

(a) Producers Phytoplankton, benthic algae, sea grasses, seaweeds and marsh grasses.

(b) Consumers Fishes, oysters, crabs, shrimp, etc.

(c) Decomposers Bacteria and fungi.

3.7.4 Streams and River Ecosystems or Flowing-water Ecosystems

The water flows rapidly in mountain reaches. The lower reaches of rivers sustain phytoplankton, zooplankton, crustaceans, small fishes and big fishes. The river bottoms are covered by algae and bacteria.

The trophic levels in a river ecosystem are shown in Fig. 3.17.

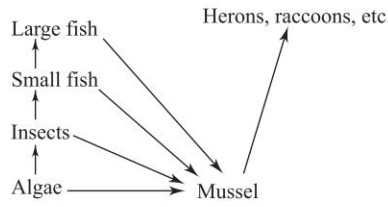


Fig. 3.17 *River ecosystem*

3.8 GRASSLAND ECOSYSTEM

Grasslands are areas where the vegetation is dominated by grasses and other nonwoody plants.

A grassland ecosystem is a biological community that contains grasslands.

About 32% of the plant cover of the world is covered with grasslands. The most fertile and productive soils in the world have developed under grasslands. Generally, the natural species have been replaced by cereals (cultivated grasses).

Grasslands occur in regions too moist for deserts and too dry for forests. The annual rainfall in grasslands is usually seasonal. It ranges between 25 cm to 75 cm.

The principal grasslands include

(i) Steppes (Europe and Asia)

(ii) Prairies (Canada, USA)
(iii) Pampas (South America)
(iv) Veldts (Africa)

The dominant animal species in grassland ecosystems include large mammals in highest abundance and greatest diversity.

Examples Horses, asses, antelope, herds of bison, etc.

3.8.1 Components of a Grassland Ecosystem

The components of a grassland ecosystem are briefly discussed below:

(A) Biotic Components

(i) Producer Organisms Mainly grasses and a few herbs and shrubs contribute to primary production of biomass.

(ii) Consumers Three main types of consumers in a grassland are

Primary Consumers They are herbivores feeding directly on grasses. These are grazing animals.

Examples Cows, buffaloes, goats, sheeps, deer, rabbits, etc.

Secondary Consumers They are carnivores that feed on herbivores.

Examples Frogs, snakes, birds, foxes, lizards, etc.

Tertiary Consumers They feed on secondary consumers.

Examples Hawks, tigers, lions, etc.

(iii) Decomposers They attack the dead or decayed bodies of organisms, and play an active role in their decomposition. In this decomposition process, nutrients are released for reuse by producers.

Examples Bacteria, fungi, Actinomycetes, etc.

(B) Abiotic Components Abiotic components include inorganic and organic compounds present in the soil and aerial environment.

The essential elements like C, H, N, O, P, S, etc., are supplied by water; nitrates, sulphates, and phosphates are present in the soil and nitrogen is present in the atmosphere.

3.9 DESERT ECOSYSTEM

Desert refers to a region or landscape in which the rainfall is negligible; and annual rainfall is less than 250 millimetres. They occupy about 17% of the earth's surface.

Deserts are characterised by

(i) scanty flora and fauna,
(ii) hot days and cold nights, and
(iii) soils with abundant nutrients but little or no organic matter.

Structure and Functions of a Desert Ecosystem

The structure and functions of biotic and abiotic components of a desert ecosystem are as follows.

(i) Abiotic Components Nutrients present in the soil and air are abiotic components. The organic substances are poorly present in the soil because of very low rainfall and high temperature.

(ii) Biotic Components Biotic components are producers, consumers and decomposers.

(a) Producers In a desert, producers are mainly shrubs/bushes, some grasses and a few trees.
Examples Water-retaining plants adapted to arid climate or soil conditions (succulents), hard grasses.

(b) Consumers They include animals which are capable of living in xeric conditions.
Examples Insects, reptiles, etc.
Some nocturnal rodents, birds and some mammals like camel, etc., are also found.

(c) Decomposers In a desert ecosystem, decomposers are very few due to less vegetation and very low amount of dead organic matter.
Examples Bacteria and thermophillic bacteria.

Important Definitions

- *Ecology* is the study of interactions between an organism and its physical environment; the relationship between animals and plants and how one species affect another.
- *Ecological succession* is orderly changes in the composition or structure of an ecological community.
- When the development begins on an area that has not been previously occupied by a community, the process is known as *primary succession*.
- When the community development is proceeding in an area from which a community was removed, it is called *secondary succession*.
- *Seasonal and Cyclic Succession* are periodic changes arising from fluctuating species interactions or recurring events.
- An *ecosystem* is defined as a natural unit that consists of living and nonliving parts which interact to form a stable system.
- *Balanced ecosystem* means that the nutrients are able to cycle efficiently, and no community of organisms or natural phenomena is interrupting the flow of energy and nutrients to other parts of the ecosystem.
- All the nonliving components of the environment constitute the *abiotic components*.
- All the living components of the environment constitute the *biotic components*.
- *Producers* are self-nourishing organisms (so they are called *autotrophs*). They contain chlorophyll and are capable of converting carbon dioxide and water, in the presence of sunlight into carbohydrates through photosynthesis. In the process, they give out oxygen.
- *Photoautotrophs* are the producers who fix energy from the sun and store it in complex organic compounds.
- *Chemoautotrophs (chemosynthesisers)* are bacteria that oxidise reduced inorganic substances (typically ammonia and sulphur compounds) and produce complex organic compounds.

- *Consumers* depend on producers to obtain their energy for survival. They utilize, rearrange and decompose the organic matter produced by autotrophs.
- *Herbivores (or primary consumers)* feed on green plants (autotrophs) to obtain energy for survival.
- *Top carnivores (or tertiary consumers)* eat the flesh of both carnivores and herbivores are not killed or eaten by other animals.
- The *decomposers* are also known as *saprotrophs* (i.e. *sapros* = rotten; *trophs* = feeder). They feed on dead organic matter (from producers and consumers).
- Fallen leaves, parts of dead trees, and faecal wastes of animals are termed *detritus*. The consumers that feed on detritus are known as *detrivores*.
- *Food chain* is a feeding hierarchy in which organisms in an ecosystem are grouped into nutritional (trophic) levels and are shown in a succession to represent the flow of food energy and the feeding relationship between them.
- Food chains overlap, because most consumers feed on multiple species and in turn, are fed upon by multiple other species. Thus, we have a complex network of interconnected food chains called a *food web*.
- The *pyramid of numbers* represents the number of individuals at each trophic level. The shape of a pyramid of numbers can be upright, partly upright and inverted depending on the type of ecosystem.
- Flow of energy in an ecosystem takes place through the food chain.
- The *ecological pyramid* is the graphical representation of the organism's position in the food chain. The base of the pyramid consists of the food-producer level and the successive levels make the tiers with the top carnivore or tertiary consumers forming the apex.
- The size of each compartment in an ecological pyramid represents the amount of organisms (or item) in each trophic level of a food chain. *Trophos* is a Greek word meaning nourishment.
- *First Law of Thermodynamics:* Energy can never be created or destroyed, but can be converted from one form to another.
- *Second law of Thermodynamics:* Transformations of energy always result in some loss or dissipation of energy.
- The dry weight of all the matter contained in the organisms is known as *biomass*. Each tropic level contains a definite amount of biomass. As we move up trophic levels, biomass decreases drastically. There is 90 to 99 per cent loss of biomass at each level. This is known as the *pyramid of biomass*.
- *Natural ecosystems* operate by themselves under natural conditions without any interference by humans.
- *Artificial ecosystems* are controlled and manipulated by humans. These are created by humans in order to fulfill certain needs.
- A *forest* is a community of trees, herbs, shrubs, and associated organisms that use oxygen, water and soil nutrients for their growth and reproduction. A *forest ecosystem* is the organisms, soil, air and water associated with the forest.
- An *aquatic ecosystem* is an ecosystem located in a body of water.
- A *marine ecosystem* is different from a freshwater ecosystem mainly because of its salty water and also because the sea is deep, and the water is in continuous circulation.
- *Estuaries* are semi-enclosed coastal bodies of water connected on the one side with a river and on the other side with the open sea. Thus, estuarine is characterised as an ecosystem having fluctuating water level.
- *Grasslands* are areas where the vegetation is dominated by grasses and other nonwoody plants. A *grassland ecosystem* is a biological community that contains grasslands.
- *Desert* refers to a region or landscape in which the rainfall is negligible; and annual rainfall is less than 250 millimetres. They occupy about 17% of the earth's surface.

EXERCISES

1. (a) What are the different tropic levels of organisms in an ecosystem?
(b) Why is a complex ecosystem more stable than one with few species?
2. Explain in detail the different components of ecology.
3. Describe the concept of ecosystem and explain the relationship among its different parts using a schematic diagram.
4. How is an ecosystem evolved? Give component parts of an ecosystem.
5. Give a classification of ecology.
6. Give examples of aquatic and terrestrial ecosystems.
7. How is balance maintained in an ecosystem? Why is an ecosystem with a large population of one species considered to be not healthy?
8. "Decomposers are very important in an ecosystem". Give reasons for validity.
9. What do you understand by decomposers? Describe different types of decomposers explaining their functions.
10. Enlist types of ecosystems. Describe in detail the structure and functions of an ecosystem.
11. Narrate in detail energy flow in an ecosystem, Explain with one of the models of energy flow you have learnt in the class.
12. Explain the concept of food chain, food web and ecological pyramid.
13. What is an ecological pyramid? Describe the pyramid of mass and energy with a sketch.
14. Differentiate between food chain and food web.
15. Explain pyramids of number in parasitic food-chain energy flow with a neat sketch.
16. Explain the significance of studying food chains.
17. How are food chains and food webs interconnected? Explain this with an example of aquatic or terrestrial ecosystem.
18. Discuss the structure and function of a desert ecosystem.
19. Write a short note on 'marine ecosystem'.
20. Explain pond ecosystem.
21. Enumerate the aquatic ecosystems and describe the structure of a pond ecosystem stating its characteristic features.

OBJECTIVE TYPE QUESTIONS

I. Fill in the Blanks

1. Herbivores are _____ consumers.
2. Autotrophic planktons are called _____ .
3. Dead plant parts and animal remains are called _____ .
4. Each stage in a food chain is called a _____ .
5. A food chain starts with _____ .
6. Producers produce _____ gas during photosynthesis.
7. Trophical rainforests occur in places where rainfall is more than _____ cm/annum.
8. In terrestrial ecosystems, 1000 kg of vegetation can support (a) _____ kg of herbivores, which can support (b) _____ kg of carnivores.

9. Pyramid of _____ is always upright.
10. Tropical forests occurs in India in _____ .
11. The tundra biome occurs in _____ .
12. The concept of _____ was introduced by Charles Elton.

II. Match the following terms.
Match the terms of column I with appropriate terms of column II.

A.

Column I	Column II
1. Wetlands	(a) African veldt
2. Conifer forests	(b) Cactus
3. Tropical rainforests	(c) bamboo
4. Desert biome	(d) pine
5. Grassland	(e) swamps

B.

Column I	Column II
1. Wetland	(a) River
2. Deltas	(b) Coral reefs
3. Ponds	(c) seasonal
4. Marine ecosystem	(d) Fan shaped
5. Flowing water ecosystem	(e) Paddy field

III. Multiple Choice Questions

1. The most stable ecosystem is
(a) ocean (b) forest
(c) desert (d) mountain

2. Increase in fauna and decrease in flora would be harmful due to increase in
(a) O_2 (b) CO_2
(c) N_2 (d) S

3. The food chain in which micro-organisms breakdown dead producers is called
(a) Predator food chain
(b) Consumer food chain
(c) Detritus food chain
(d) Parasitic food chain

4. Which one of following is an abiotic component of the ecosystem?
(a) Plants (b) Bacteria
(c) Fungi (d) Humus

5. Which one is the correct food chain?
(a) Phytoplankton → zooplankton → fish
(b) Fish → zooplankton → phyto-plankton
(c) Zooplankton → phytoplankton → fish
(d) Phytoplankton → fish → zoo-plankton

6. An ecosystem consists of
(a) producers and consumers
(b) producers, consumers, decom-posers, and abiotic environment
(c) producers and decomposers
(d) consumers and decomposers

7. The main source of energy in an ecosystem is
(a) mechanical energy
(b) heat energy
(c) solar energy
(d) chemical energy

8. The graphical representation of the interrelation of producer and consumer in an ecosystem is termed the
(a) food web
(b) trophic levels
(c) ecological niche
(d) ecological pyramid

9. The shape of the pyramid of biomass for a pond or any aquatic ecosystem is
(a) inverted (b) linear
(c) upright (d) not certain

10. The shape of the pyramid of numbers for a parasitic food chain is
(a) linear (b) inverted
(c) upright (d) Not certain

11. The importance of an ecosystem lies in the
(a) flow of energy
(b) cycling of materials
(c) both (a) and (b)
(d) none of (a) and (b)

12. The food chain in an ecosystem helps to maintain
(a) flow of energy in the ecosystem
(b) passage of nutrients in the ecosystem
(c) the feeding relationship in nature, thus biodiversity
(d) all of the above

13. The interdependence of the living organisms among themselves and with the environment is called
(a) ecosystem (b) ecology
(c) chemistry (d) biology

14. Ecosystem consists of
(a) abiotic components
(b) biotic and abiotic components
(c) biotic components
(d) none of the above

IV. Indicate True or False for the following statements:

1. Green plants make high-potential-energy organic molecules from low-potential-energy raw material. True/False

2. Temperature affects the morphology, physiology and biochemistry of flora and fauna. True/False

3. The most important function of an ecosystem is gas regulation. True/False

4. Inorganic molecules do have C-C and C-H bonds. True/False

5. The most abundant element present both in humans and the ecosphere is oxygen. True/False

6. Grass → Mouse → Snake → Eagle is a typical food chain. True/False

7. Phytoplankton → zooplankton → small fish → large fish → Bacteria is a typical food chain in pond ecosystem. True/False

8. An ecosystem is defined as a natural unit that consists of living and non-living parts which interact to form a stable system. True/False

9. A food chain is just a sequence of organisms, in which each is food for the next. True/False

10. The dry weight of all the matter contained in organisms is known as biomass. True/False

Answers to Objective Type Questions

I. Fill in the Blanks
1. primary
2. phytoplankton
3. detritus
4 trophic level
5. producer
6. oxygen
7. 200
8. (a) 100, (b) 10
9. energy
10 Kerala and Assam
11. Arctic zone
12. Ecological pyramids

II. Matching the terms
A. 1. (e) 2. (d) 3. (c) 4. (b) 5. (a)
B. 1. (e) 2. (d) 3. (c) 4. (b) 5. (a)

III. Multiple Choice Questions
1. (a) 2. (b) 3. (c) 4. (d)
5. (a) 6. (b) 7. (c) 8. (d)
9. (a) 10. (b) 11. (c) 12. (d)
13. (a) 14. (b)

IV. True or False
1. True 2. True 3. False 4. False
5. True 6. True 7. True 8. True
9. True 10. True