ECOSYSTEMS
STRUCTURE, PROCESSES AND PRODUCTIVITY

Any ecological unit that includes all the organisms (*i.e.,* the communities in a given area) which inter act among themselves and with the physical environment, so that a flow of energy leads to clearly defined trophic structure, biotic diversity and material cycle (*i.e.,* exchange of materials) within the system, is known as **ecological system** or **ecosystem**. There exist nutritional relationships (or food links) amongst the living organisms of such a system. Keeping this in view, the earth can be considered as a giant ecosystem where abiotic and biotic components are constantly acting and reacting upon each other bringing forth structural and functional changes in it. This vast ecosystem — the **biosphere** is however, difficult to handle and, thus, for the sake of convenience, we generally study nature by making its artificial subdivisions into units of smaller ecosystems (such as **terrestrial** — forest, desert, grassland; **aquatic** — fresh water, marine; and **man-made** — cropland, etc.). An ecosystem may, thus, be as small as a single log, a pond, a cropland, or as large as an ocean, desert or forest. Though these unit ecosystems are separated from each other with time and space, but functionally they all are linked with each other, forming an integrated whole.

The term **ecosystem** was pro- posed by **A.G. Tansley** in 1935. There are many other parallel terms or synonyms for the ecosystem which have been proposed by vari- ous ecologists, *e.g.,* **biocoenonsis** (**Karl Mobius**, 1877), **microcosm** (**S.A. Forbes**, 1887), **holocoen** (**Friederichs**, 1930), **biosystem** (**Thienemann**, 1939), **geobio- coenosis** (**Sukhachev**, 1944), **bioenert body** (**Vernadsky**, 1944) and **ecosom**, etc. In recent years, ecological studies of ecosystems undertake be- sides structure, the similarities and differences in food and energy rela- tionships among living components of ecosystem. This is called **bioenergetic approach** of modern ecology.

KINDS OF ECOSYSTEM

An ecosystem can be natural or artificial, temporary or permanent and large or tiny. Thus, various constituent ecosystems of the biosphere fall into the following categories:

1. **Natural ecosystems.** These types of ecosystems operate by themselves without any major interference by man. Based upon the particular kind of habitat, these are further classified as :
   i. **Terrestrial ecosystems** such as forests, grasslands, deserts, a single log, etc.
   ii. **Aquatic ecosystems** which may be further distinguished as follows :
      a. **Fresh water ecosystems.** These may be **lotic** (running water as spring, brook, stream or river) or **lentic** (standing water as lake, pond, pool, puddle, ditch, swamp, etc.).
      b. **Marine ecosystems.** These include salt water bodies which may be deep bodies as an ocean or shallow ones as a sea or estuary.
2. **Artificial ecosystems.** These are also called **man-made** or **man-engineered ecosystems**. These are maintained artificially by man where, by addition of energy and planned manipulations, natural balance is disturbed regularly, *e.g.,* croplands

such as sugarcane, maize, wheat, ricefields; orchards, gardens, villages, cities, dams, aquarium and manned spaceship.

MICROECOSYSTEMS

Natural ecosystems are usually large in size. In them numerous variables (factors) operate at one time leading to great complexity. As a result, it becomes usually difficult to study them with the normal scientific methods. Thus, to reduce the number of variables and to work in a system with a discrete boundary, ecologists are trying to simulate microecosystems in the laboratory, which can be replicated and manipulated at will. The microsystems can be laboratory systems build by taking one or very few species, at a time, from axenic cultures (An **axenic culture** is a bacterial culture that consists of only one species) and studying them in desired combinations. Recently, the concept of polyaxenic cultures has been developed. **Odum** (1971) and others have elucidated the microecosystem concept.

STRUCTURE OF ECOSYSTEM

The structure of an ecosystem is basically a description of the species of organisms that are present, including information on their life histories, populations and distribution in space. It is a guide to who's who in the ecosystem. It also includes descriptive information on the non-living (physical) features of environment, including the amount and distribution of nutrients. An ecosystem typically has two major components:

A. Abiotic or Non-living Components

Abiotic component of the ecosystem comprises three sort of components : (1) **Climatic condition** and **physical factors** of the given region such as air, water, soil, temperature, light (*i.e.,* its duration and intensity), moisture (relative humidity), pH, etc. (2). **Inorganic substances** such as water, carbon (C), nitrogen (N), sulphur (S), phosphorus (P) and so on, all of which are involved in cycling of materials in the ecosystem (*i.e.,* biogeochemical cycles). The amount of these inorganic substances, present at any given time in an ecosystem, is designated as the **standing state** or **standing quality**. (3). **Organic substances** such as proteins, carbohydrates, lipids, humic substances, etc., present either in the biomass or in the environment, *i.e.,* **biochemical structure** that link the biotic and abiotic components of the ecosystem.

B. Biotic or Living Components

In the trophic structure of any ecosystem, living organisms are distinguished on the basis of their nutritional relationships, which are discussed as follows:

1. **Autotrophic component.** Autotrophic (*auto* = self ; *trough* = nourishing) component of ecosystem includes the **producers** or **energy transducers** which convert solar energy into chemical energy (that becomes locked in complex organic substances such as carbohydrate, lipid, protein, etc.) with the help of simple inorganic substances such as water and carbon dioxide and organic substances such as enzymes. Autotrophs fall into following two groups : (i) **photoautotrophs** which contain green photosynthetic pigment **chlorophyll** to transduct the solar or light energy of sun, *e.g.,* trees, grasses,

algae, other tiny phytoplanktons and photosynthetic bacteria and cyanobacteria (=blue green algae).
(ii) **Chemoautotrophs** which use energy generated in oxidation - reduction process, but their significance in the ecosystem as producers is minimal, *e.g.,* microorganisms such as *Beggiatoa,* sulphur bacteria, etc.

2. **Heterotrophic component.** In the heterotrophic (*hetero* = other; *trophic* = nourishing) organisms predominate the activities of utilization, rearrangement and decomposition of complex organic materials. Heterotrophic organisms are also called **consumers**, as they consume the matter built up by the producers (autotrophs). The consumers are of following two main types :

a. **Macroconsumers.** These are also called **phagotrophs** (phago = to eat) and include mainly animals which ingest other organisms or chunks of organic matter. Depending on their food habits, consumers may either be **herbivores** (plant eaters) or **carnivores** (flesh eaters). Herbivores live on living plants and are also known as **primary consumers** , *e.g.,* insects, zooplanktons and animals such as deer, cattle, elephant, etc. **Secondary** and **tertiary consumers**, if present in the food chain of the ecosystem, are carnivores or omnivores, *e.g.,* insects such as preying mantis, dragon flies; spiders and large animals such as tiger, lion, leopard, wolf, etc. Secondary consumers are the carnivores which feed
on primary consumers or herbivores. Carnivores are, often, recognized as carnivore order - 1 (C1), carnivore order - 2 (C2) and so on, depending on their food habits.
Ticks and mites, leeches and blood-sucking insects (mosquito, bed-bug) are dependent on herbivores, carnivores and omnivores.

b. **Microconsumers.** These are also called **decomposers**, **reducers**, **saprotrophs** (*sapro* = decompose), **osmotrophs** (osmo = to pass through a membrane) and **scavengers**. **Wiegert** and **Owen** (1971) have coined the term, **biophages** for heterotrophic decomposers which feed on the dead organic matter. Microconsumers include microorganisms such as bacteria, actinomycetes and fungi. Microconsumers breakdown complex organic compounds of dead or living protoplasm, absorb some of the decomposition or breakdown products and release inorganic nutrients in the environment, making them available again to autotrophs or producers. Some invertebrate animals such as protozoa, oligochaeta such as earthworms, etc., use the dead organic matter for their food, as they have the essential enzymes and, hence, can be classified as decomposer organ- isms. Some ecologists believe that micro- organisms are **primary decomposers**, while invertebrates are **secondary decomposers**. The disintegrating dead organic matter is also known as **organic detritus** (Latin word *deterere* means to wear away). By the action of **detritivores** (=decomposers), the disintegrating detritus result into particulate organic matter (POM) and dissolved organic matter (DOM) which play important role in the maintenance of the edaphic environment.

PRODUCTIVITY OF ECOSYSTEM

The productivity of an ecosystem refers to the rate of production, *i.e.,* the amount of organic matter accumulated in any unit time. It is of following types :

1. **Primary productivity.** It is defined as the rate at which radiant energy is stored by photosynthetic and chemosynthetic activity of producers. Primary productivity is of following types:

i. **Gross primary productivity.** It refers to the total rate of photosynthesis including the organic matter used up in respiration during the measurement period. GPP depends on the chlorophyll content. The rate of primary productivity are estimated in terms of either chlorophyll content as chl/g dry weight/ unit area or photosynthetic number, *i.e.,* amount of CO_2 fixed/g chl/hour.

ii. **Net primary productivity.** It is the rate of storage of organic matter in plant tissues in excess of the respiratory utilization by plants during the measurement period. Primary production is measured by following methods — harvest method, oxygen measurement method (or light or dark method), oxygen diurnal curve method, carbon dioxide measurement method (enclosure method), the aerodynamic method, the pH method, radioisotope method, chlorophyll estimation method (see **Dash**, 1993).

2. **Secondary productivity.** It is the rate of energy storage at consumer's levels— herbivores, carnivores and decomposers. Consumers tend to utilise already produced food materials in their respiration and also convert the food matter to different tissues by an overall process. So, secondary productivity is not divided into 'gross' and 'net' amounts. Due to this fact some ecologists such as **Odum** (1971), prefer to use the term **assimilation** rather than production at this level – the consumers level. Secondary productivity, in fact, remains mobile (*i.e.,* keeps on moving from one organism to another) and does not live *in situ* like the primary productivity.

3. **Net productivity.** It is the rate of storage of organic matter not used by the heterotrophs or consumers, *i.e.,* equivalent to net primary production minus consumption by the heterotrophs during the unit period as a season or year, etc.