Ecology

The term "Ecology" was coined by Earnst Haeckel in 1869. It is derived from the Greek words Oikos- home + logos- study. Ecology deals with the study of organisms in their natural home interacting with their surroundings. The surroundings or environment consists of living organisms (biotic) and physical (abiotic) components. Modern ecologists believe that an adequate definition of ecology must specify some unit of study and one such basic unit described by Tansley (1935) was ecosystem. According to other definition-an ecosystem is a self-regulating group of biotic communities of species interacting with one another and with their non-living environment exchanging energy and matter. Now ecology is often defined as "the study of ecosystems".

There are many examples of ecosystems a pond, a forest, an estuary, a grassland etc. Usually the boundaries of an ecosystem are chosen for practical reasons having to do with the goals of the particular study. The study of ecosystems mainly consists of the study of certain processes that link the living, or biotic, components to the non-living, or abiotic, components.

Energy transformations and biogeochemical cycling are the main processes that comprise the field of ecosystem/ecology. We can study ecology at the level of the individual, the population, the community, and the ecosystem.

Studies of individuals are concerned mostly about physiology, reproduction, development or behaviour, and studies of populations usually focus on the habitat and resource needs of individual species, their group behaviours, population growth, and what limits their abundance or causes extinction.

Studies of communities examine how populations of many species interact with one another, such as predators and their prey, or competitors that share common needs or resources. In ecosystem, we try to focus on major functional aspects of the system.

These functional aspects include such things as the amount of energy that is produced by photosynthesis, how energy or materials flow along the many steps in a food chain, or what controls the rate of decomposition of materials or the rate at which nutrients are recycled in the system.

The definition is unique in that it emphasizes several things:

- A starting focus on organisms, aggregations of organisms, or systems incorporating organisms or their by-products
- The bounding of ecology by both the biological and physical sciences
- The breadth of subject matters within ecology

- The joint consideration of both biotic and abiotic aspects of nature
- Depending on the ecological specialty, the focus can be on different proportions of biotic or abiotic aspects of nature
- The relationships between organisms and the physical world can be bidirectional, although different specialties may emphasize the effect of the organisms (and systems containing them) on the physical world, or the effect of the physical world on the organisms
- The boundary between the abiotic and the biotic aspects of ecology is blurry
- The disciplinary focus is on "processes", "interactions" and "relations" rather than on the physical entities per se

Ecology was originally defined in the mid-19th century, when biology was a vastly different discipline than it is today.

The original definition is from Ernst Haeckel, who defined ecology as the study of the relationship of organisms with their environment. In the intervening century and a half, other definitions of ecology have been proposed to reflect growth of the discipline, to found new specialties, or to mark out disciplinary territory.

There are three pervasive definitions of ecology
The first definition stems from the Haeckelian form -- the study of the relationship between organisms and environment. The second definition, which is perhaps the most commonly repeated, considers ecology to be the study of the distribution and abundance of organisms (Andrewartha and Birch 1954). The third definition focuses ecology on the study of ecosystems (Odum 1971). The 3 kinds of definitions each have their limits and advantages. The hallmark of ecology is its encompassing and synthetic view of nature, not a fragmented view.

Our definition of ecology is a blend of the second and third definitions. This new overarching definition attempts to bridge the spectrum of ecological approaches, with the goal of promoting synthesis and integration.

1st definition: The classical Haeckelian definition emphasizes both the living and the non-living components of the natural world. However, as a reflection of its vintage, it emphasizes that organisms are the relevant manifestation of the biotic world.
The mid-19th century, with its largely macroscopic view of the world, neglected inconspicuous organisms, such as microbes, the chemical products of organisms in the environment, and ecological systems at larger scales or higher hierarchical levels than organisms.

2nd definition: Andrewartha and Birch (1954) reinforced the focus on the organism as the core of ecology. Their work clearly includes the abiotic environment as well as the biotic environment as factors influencing distribution and abundance.

This is shown by their recognition of the importance of climatic fluctuations, for example. However, in its application, the definition of Andrewartha and Birch has often been associated with a predominately biotic focus.

This definition has become somewhat of a rallying cry for community and population centered ecology. Clearly, this definition has not stimulated exploration of the frontier of ecology with the sciences of the physical environment.

3rd definition: Odum (1971) began with the Haeckelian definition, but his desire to establish a new kind of ecology -- ecosystem ecology -- led him further from that cornerstone than most.
He provided several statements of the scope of ecology, including the difficult-to-interpret statement that ecology was simply environmental biology. Truest to his brand of ecosystem thinking was his definition of ecology as the study of the structure and function of nature.

Although Odum's extreme reliance on emergent properties and resuscitation of superorganismic thinking have proven problematic to many ecologists, his loosening of the bonds of Haeckel's focus on the organism is useful.

The limits and advantages of the 3 definitions of ecology
The positive side of the first definition is that it is simple and it emphasizes both biotic and abiotic aspects of nature.

On the negative side is its overemphasis on the organism as the focus. Haeckelian statements should always be cast as the study of relationships rather than the study of organisms in relation to environment. The difference in emphasis may appear to be minor, but it indicates the deficiency of Haeckel's definition.

The second definition is positive in its emphasis on quantifiable and unambiguous parameters, but it falls short because it omits a range of critical ecological subjects.

To its credit, the third definition is not restricted to patterns or organisms and recognizes that ecology is about processes.

All of the definitions take organisms as their starting point. However, they are not in all cases explicit that ecology can consider all manner of systems (in the broadest sense) that include organisms and their products.

The three definitions have limits or connotations imposed by their vintage and history of use.

Haeckel operated in a time when biology was dominated by focus on organisms as anatomical, physiological or taxonomic subjects. Many of the modern concerns of ecology, and indeed of biology, were far in the future when Haeckel wrote.

Odum was concerned with the justification of ecosystem ecology as an academic specialty. He highlighted ways in which ecology differed from other university departments in the immediate post-World War II era.

Concepts of Ecology: Structural and Functional Concept of Ecology

Based on structural components and their relationships, ecology and ecosystem can be explained in two ways: structural concepts and functional concepts.

1. **Structural Concepts:**

The different types of organisms living in a particular environment are not only independent and mutually reactive but also react with the environment. Though organisms of a species maintain uniformity in their structure and functions through having a common gene pool, they have sufficient plasticity to modify themselves according to changing environment by modifications in somatic characters (ecads) or genetic characters (ecotypes).

Due to their activities, organisms modify the environment to make it more congenial for their growth, development, reproduction and dispersal. The modified environment may become less suitable for the community already living in it. This invites another community that also changes the environment may become less suitable for the community already living in it.

This invites another community that also changes the environment further beyond its most favorable limit. The development of different communities over a period of time at the same site is called succession. The process of succession and change in environment would continue till equilibrium is established between the changed environment and a community called climax community.

Under similar climatic conditions, different types of communities grow. Some of them have reached their climax stage while others occur in different stages of succession. The complex of many communities growing in a particular area and sharing a common climate is called biome.

2. Functional Concepts:

The biological community consists of a number of organisms and/or populations. Each population occupies a specific volume of the habitat circumscribed by the interaction of various environmental factors and trophic level of the organisms.

It is called ecological niche. The degree of success of a particular population in an area is determined by the parameters of both abiotic factors as well as interaction with other types of populations. The interactions amongst the populations can be positive, negative or neutral.

The flow of energy in the ecosystem is unidirectional or non-cyclic. Radiant energy is trapped by autotrophic plants or primarily producers. From there the energy is transferred to consumers and decomposers. Energy is lost during its transfer from one trophic level to the next. Organisms use the energy in respiration.

A number of inorganic substances are taken by the living beings for their metabolism and body building. They are called biogenetic nutrients. The biogenetic nutrients keep on circulating between the biotic and abiotic components of the ecosystem.

The phenomenon is called biogeochemical cycling. Human beings exploit the ecosphere for their own benefits. As a result, only the economically important plants are allowed to grow in an ecosystem. Species diversity and natural interactions amongst the various components are reduced. When neglected, such an ecosystem deteriorates.

A disturbed or deteriorated ecosystem shows changes due to interactions inside, the assemblage of living being and their abiotic environment, modifying and changing both abiotic and biotic components. The change continues till a stable climax community develops. Where a disturbance continues, the deteriorated ecosystem changes the environment completely.

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Trophic structure

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Explanation:

Trophic structure describes the system or organization of organisms into different trophic levels based on the amount of energy the organism consumes. Organisms can be categorized into different trophic levels within the trophic structure.

Essentially, trophic structure shows us the the feeding relationships between different organisms, both producers and consumers, within a set area and time.

A trophic pyramid, a food web, and a food chain could all be used to describe trophic structure, although there are important differences between the three.

A trophic level is the group of organisms within an *ecosystem* which occupy the same level in a *food chain*. There are five main trophic levels within a food chain, each of which differs in its nutritional relationship with the *primary energy source*. The primary energy source in any ecosystem is the Sun (although there are exceptions in deep sea ecosystems).

The *solar radiation* from the Sun provides the input of energy which is used by *primary producers*, also known as *autotrophs*. Primary producers are usually plants and algae, which perform *photosynthesis* in order to manufacture their own food source. Primary producers make up the first trophic level.

The rest of the trophic levels are made up of *consumers*, also known as *heterotrophs*; heterotrophs cannot produce their own food, so must consume other organisms in order to acquire nutrition.

The second trophic level consists of *herbivores*, these organisms gain energy by eating primary producers and are called *primary consumers*.

Trophic levels three, four and five consist of *carnivores* and *omnivores*. Carnivores are animals that survive only by eating other animals, whereas omnivores eat animals and plant material.

Trophic level three consists of carnivores and omnivores which eat herbivores; these are the *secondary consumers*.

Trophic level four contains carnivores and omnivores which eat secondary consumers and are known as *tertiary consumers*.

Trophic level five consists of *apex predators*; these animals have no natural predators and are therefore at the top of the food chain.

Decomposers or *detritivores* are organisms which consume dead plant and animal material, converting it into energy and nutrients that plants can use for effective growth. Although they do not fill an independent trophic level, decomposers and detritivores, such as fungi, bacteria, earthworms and flies, recycle waste material from all other trophic levels and are an important part of a functioning ecosystem.

Due to the way that energy is utilized as it is transferred between levels, the total *biomass* of organisms on each trophic level decreases from the bottom-up. Only around 10% of energy consumed is converted into biomass, whereas the rest is lost as heat, as well as to movement and other biological functions. Because of this gradual loss of energy, the biomass of each trophic level is often viewed as a pyramid, called a *trophic pyramid*.

It is important to note that organisms within the trophic levels of natural ecosystems do not generally form a uniform chain, and that many animals can have multiple *prey* and multiple *predators*; the non-linear interactions of trophic levels can therefore be best viewed as a *food web* rather than a food chain. However, disruption within one of the trophic levels, for example, the extinction of a predator, or the introduction of a new species, can have a drastic effect on either the lower or higher trophic levels.

Examples of Trophic Level

Primary Producers

Primary producers, or *"autotrophs"*, are organisms that produce biomass from *inorganic compounds*. In general, these are *photosynthesizing* organisms such as plants or algae, which convert energy from the sun, using carbon dioxide and water, into glucose. This glucose is then stored within the plant as energy, and oxygen, which is released into the atmosphere.

In terrestrial ecosystems, almost all of the primary production comes from *vascular plants* such as trees, ferns, and flowering plants. In marine ecosystems, algae and seaweed fill the role of primary production.

There are also some deep-sea primary producers that perform oxidization of chemical inorganic compounds instead of using photosynthesis; these organisms are called *"chemoautotrophs"*.

Primary Consumers

Primary consumers are herbivores, that is, animals that are adapted to consuming and digesting plants and algae (autotrophs). Herbivores are generally split into two categories: *grazers*, such as cows, sheep and rabbits, whose diets consist at least 90% of grass, and *browsers*, such as deer and goats, whose diets consist at least 90% of tree leaves or twigs.

Primary consumers may also consume other forms of plant material. Many bats, birds and monkeys eat fruit (*frugivores*); birds, insects, bats and arachnids (spiders) eat nectar (*nectarivores*); and termites and beetles eat wood (*xylophages*).

In marine ecosystems, primary consumers are *zooplankton*, tiny crustaceans which feed off photosynthesizing algae known as *phytoplankton*.

Secondary Consumers

Secondary consumers, at trophic level three, are carnivores and omnivores, which obtain at least part of their nutrients from the tissue of herbivores. This includes animals and carnivorous plants that feed on herbivorous insects (*insectivores*).

Secondary consumers are usually small animals, fish and birds such as frogs, weasels, and snakes, although larger apex predators, such as lions and eagles, may consume herbivores, and can also exist within the second trophic level of an ecosystem.

In marine ecosystems, all species that consume zooplankton are secondary consumers; this ranges from jellyfish to small fish such as sardines and larger crustaceans such as crabs and lobsters, as well as whales, which filter feed, and basking sharks.

Tertiary Consumers

Tertiary consumers acquire energy by eating other carnivores but may be preyed upon. Owls are an example of tertiary consumers; although they feed off mice and other herbivores, they also eat secondary consumers such as stoats. In turn, owls may be hunted by eagles and hawks, and are therefore not apex predators.

Apex Predators

Apex predators are organisms at the top of the food chain, and which do not have any natural predators. Eagles, wolves, large cats such as lions, jaguars and cheetahs, and marine animals such as sharks, tuna, killer whales and dolphins are all examples of apex predators, although there are many more. Apex predators often have specific adaptions, which make them highly efficient hunters, such as sharp teeth and claws, speed and agility and stealth; sometimes they work within groups, enhancing the success of their hunting abilities. However, not all apex predators are vicious hunters. Whale sharks are large filter feeders, consuming only small fish and plankton, although because they have no natural predators, they are apex predators in their environment.

Apex predators play an extremely important role in an ecosystem; through predation they control populations of the lower trophic levels. If apex predators are removed from an ecosystem, organisms such as grazing herbivores can over-populate, therefore placing intense grazing and browsing pressure on the plants within a habitat. If there are fewer available plant resources, other organisms that depend on the plants (although are not hunted by the apex predator), such as insects and small mammals, will suffer population declines, and in turn can affect all trophic levels within an ecosystem. This disturbance is called a *top-down trophic cascade*, and can lead to *ecosystem collapse*.