Academy of Romanian Scientists
Annals Series on Biological Sciences
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Volume 15, No. 1, 2026, pp. 7 - 17
Online ISSN 2285 – 4177
ORIGINAL PAPERS

ON THE SYSTEMIC ORGANIZATION OF THE LIVING WORLD

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Abstract. This paper briefly reviews the history of ecology, emphasizing the moment of the appearance of the concept of interaction between living and non-living phenomena, as well as the influence exerted by the cosmic processes on the different levels. The seven levels of the systemic organization of the living world are reviewed: the individual, the population, the ecosystem, the landscape, the biome, the ecosphere and the anthroposphere. For each level, a definition is provided, the field of ecology dealing with it is presented, and its main characteristics are shown. The paper concludes with several general conclusions.

Keywords: history of ecology, levels of organization, fields of ecology

DOI 10.56082/annalsarscibio.2026.1.7

A brief history of ecology

In 1859, Charles Darwin laid the foundations of the theory of the evolution of the living world. This theory, subsequently called Darwinism, initiated a genuine revolution in the world of biologists, and not only in theirs (4, 5, 6, 7, 8, 9, 11,12,13, 20, 21, 22, 23, 26).

Soon after, in 1866, Ernst Haeckel, "created" a new field of biology that dealt with "the study of the relationships of plants and animals with their environment" which he called **ecology** (7).

Although ecology, as a science, was born almost 150 years ago, we are convinced that human concern for this science has existed since much earlier times.

Early scientists believed that ecology dealt with the relationships between living beings, the relationships between them and the environment in which they lived (the so-called non-living environment). Subsequently, it was noticed that human beings are able to transform the environment. They found that ecology can offer them solutions for better managing the resources which nature can offer, and can even contribute to their improvement.

In time, ecology evolved from the study of the influence of the environmental factors on the various living beings: plants, animals, fungi, protists or bacteria (this is how *autecology* emerged), to the study of the interrelationships between the different

species of living beings (*synecology*) and, subsequently, researchers began to study the associations of living beings (what we now call *associations* or *biocenoses*) (7, 21, 23, 26).

As it is well known, these associations can be very different from each other due to their great diversity arising as a result of the huge variety of environmental conditions. This field of ecology, which has begun to include, besides living beings, the knowledge of the environmental factors where living organisms live, has received the name of "*ecosystem ecology*".

Likewise, they also found that smaller or larger groups of natural associations can be distinguished in nature consisting of different types of ecosystems, which they called - depending on their size - *landscapes* (such as the Danube Delta, the Great Barrier Reef, the Sargasso Sea, the Namibian Desert, etc.).

Ecologists have noted that human activity is increasingly and aggressively changing the environment. That is why the study of newly created ecological systems, or of those modified by humans, has begun and the impact of various human activities on the environment has been highlighted. Thus, a new category of ecological systems has emerged, which constitutes a new level, called the *anthroposphere* (some call it the *noosphere*).

In 1981, the then director of the UNESCO summarized the evolution of ecology up to that moment in an article (13).

Since the mid-20th century, ecology has increasingly emphasized the interrelationships between the different fields of geography (*physical geography, hydrology, climatology, pedology*), chemistry (*the chemical composition of air, water, soil, the chemical and biochemical reactions occurring between the different components of nature*), physics (*optics, energetics, thermodynamics, the movement of fluids, the action of the various types of radiation*), mathematics (*statistics* and subsequently *mathematical modeling*, etc.).

At present, the research into the ecosphere (the aggregate of living and non-living phenomena of our planet) has two basic components, the *biosphere* (the totality of the living world) and the *toposphere* (which groups the totality of the non-living components - the atmosphere, the hydrosphere and the lithosphere). In turn, the ecosphere comes into permanent contact with the *cosmic environment*, from which it receives various radiations and solid materials (such as water, dust and meteorites) (10, 21, 22).

As early as 1922, Alexander Vernadsky showed that there was a living - nonliving interaction which becomes manifest from the ecosystem level to the planetary level. In this manner, he emphasized the branch of ecology which today we call the *ecosphere* (although at the time he called it the "biosphere"). Its name was changed when it was established that all the living beings on the planet form a living envelope, which they also called the *biosphere* (28).

For a long time (even nowadays), ecology was regarded as a branch of biology, because biologists deal with living beings. With the intensification of the studies regarding the influence of the environmental factors and the increasingly intensive use of the results of the research from various fields of the other natural sciences, as well as of the results of the other applied fields related

to life (agriculture, animal husbandry, forestry, medicine, etc.), new data provided by the technical, economic and social sciences began to join these fields. Gradually, the conclusion was reached that ecology cannot be a purely biological science, but a distinct science, this time an interdisciplinary science, because it integrates into a coherent whole area from many sciences, precisely for the purpose of emphasizing the relationships, the dynamic processes that take place within the interaction between the living and the non-living world.

Although it has long been noted that human activity has been increasingly influencing the biosphere and the toposphere, it was only in the second half of the 20th century that the growing influence of human kind was recognized, as well as its impacts on all the other components of the ecosphere. Thus, a new field of ecology emerged, which was given the name of *anthroposphere* (10, 19).

Therefore, ecology is a frontier science which combines biological knowledge with numerous theoretical and applied sciences dealing with human beings, the environment, the economy, and society. Ecology has gradually moved from purely theoretical concerns (those carried out solely "for the sake of science") to concerns related to human interests, the state and the better management of the natural and anthropic environment. In time, a distinct branch of ecology emerged, applied ecology, which is concerned with all the levels of theoretical ecology (19, 26).

Consequently, **ECOLOGY is the interdisciplinary science, mainly a biological science, which studies the manner in which the different systems in which living organisms are grouped, interact with each other, respond appropriately to the action of the environmental factors and thus act as a unitary whole.**

The Levels of Organization of Ecology

Ecology approaches living matter on a pyramidal system, from the level of the *Individual* (studied mainly by biologists as the so-called Autecology), to the *Population* (studied by ecologists as the so-called Synecology), then to the *Biocenosis* (studied under the name Ecology of the ecosystems), to the *complex multi-ecosystemic areas* (studied under the name of Landscape), to the *Biome* (studied under the name of Ecology of biomes), to the *Ecosphere* (studied under the name of Ecology of the ecosphere). Likewise, for some time, it has also been dealing with the last layer of the planet, the *Anthroposphere* (studied under the name Ecology of the Anthroposphere) (14, 24, 25) (Fig.1).

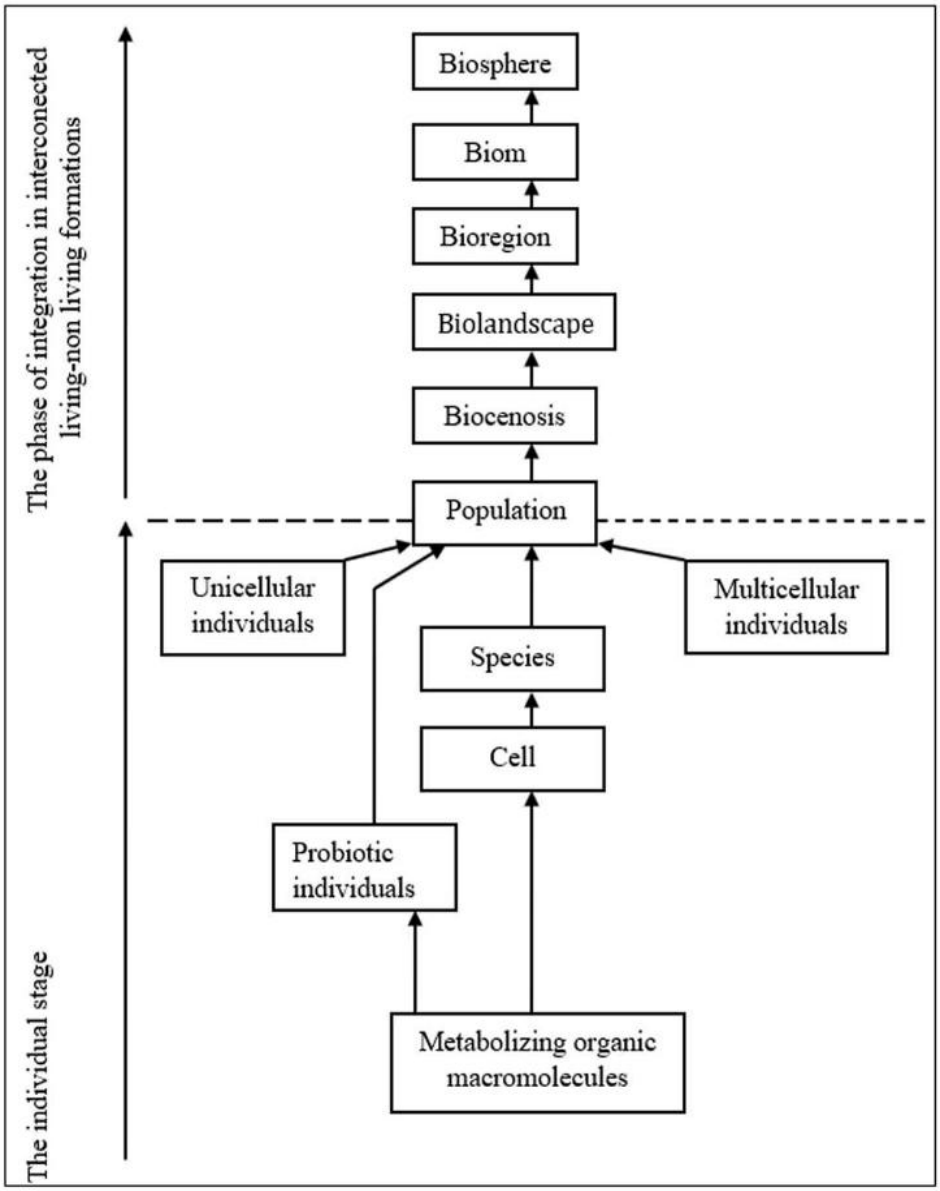

Figure 1: Different forms of the evolution of living matter in time (Godeanu & Popa, 2022).

Ecology has most intensely approached the first 3 levels (individual, populational and biocenotic), which are characterized by the existence of a very large number of ecological subunits, and, to a much lesser extent the other levels (landscape, biospheric and ecospheric). It has approached the anthropospheric level more superficially, especially from the point of view of its negative impacts on all ecology. The landscape, biospheric, and ecospheric levels have been dealt with, I repeat, only descriptively, especially by the geographers.

The fields of ecology are vast and constantly changing.

The first field – **autecology.**

Autecology deals with emphasizing the influence of the abiotic and biotic environmental factors which act on the representatives of a species. Therefore, it may also be called" the ecological study of the representatives of a population which is part of a certain species"

Autecology studies the functional characteristics of those individuals which are part of a certain species and form a so-called *population*.

The *population* consists of all the individuals from a certain species which reproduce, raise their young, inhabit a certain territory, from which they obtain their food and where they help each other (and where they are subject to the action of the same environmental factors).

The abiotic factors are: the cosmic factors (the sun and the moon), the physical factors (temperature, water, air, soil), the environmental chemistry (mineral and organic substances).

The biotic factors are: the biorhythms, the food, the circulation of the substances at the level of the species/population (turnover), the intrapopulation and interpopulation relationships, the ecological niche.

Ecology does not operate at the level of the individuals, but at the level of the populations. And this is because in the living world there is one rule: no two individuals are alike! That is why ecology studies those groups of individuals of any species who live together (thus forming a population). From a genetic point of view, a population is a group of individuals who are very similar (or better said, related) genetically.

If the populations are relatively close geographically speaking, direct relationships between the individuals and exchanges of genetic information may occur. For this reason, the populations from a certain territory which is better delimited geographically, which have relatively similar characters, can be grouped into the so-called metapopulations.

If the populations are geographically more distant, the exchanges of individuals or the exchanges of genetic information may no longer occur between them. In such a case, the differences between the populations are greater, more obvious, but they are not enough to enable systematists to create new species. Due to the fact that there are great differences between the populations, the biologists who deal with systematics consider that we are dealing with different *subspecies* of the same species.

The purpose of autecology is also to emphasize the specific environmental conditions which have led to the emergence of the metapopulations and the subspecies of every species and to clearly specify the relationships in which each subspecies lives.

Only thus it will be possible to determine with greater accuracy at some point what the specific environmental conditions of every species are on the systematics established.

The second level of ecology is **synecology**.

Synecology deals with the study of the relationships between the populations of different species which coexist in a given environment and which together form a so-called biocenosis.

The relationships studied by synecology are: neutralism, feeding manner, cooperation relations, predation, parasitism.

The functions are: the circulation of substances in the living world (levels, food chains and networks), the effects of interspecific relations, the efficiency of the transfer of matter and energy at the biocenotic level, the role and functions of information at the synecological level.

The third level of ecology is the **ecosystem**.

The ecosystem is the smallest unit in which life and the environment form a unitary whole. They are interdependent, clearly delimited from other neighbouring units, and function as such for a certain period of time. (7, 20).

In any ecosystem there are two components:

a) a non-living component, represented by the geographical area where the same organisms always exist, which have a specific climate, the waters and terrain in this geographical area, and which contains various dead substances (in different degrees of decomposition). This component is called the **biotope**;

b) a living component, represented by the associations of organisms specific to this type of biotope, which interact with each other, and with which, as a result, it functions as a unitary, stable whole, through which matter circulates and a flow of energy occurs. This component is called the **biocenosis**.

The processes presented in autecology and synecology occur only within a biocenosis. Living beings can never be removed from the context of the biocenosis to which they belong.

An ecosystem has three characteristics:

1. general characteristics = its peculiarities distinguishing it from other ecosystems (historicity, counteraction of the disruptive biotic and abiotic factors, types of natural (aquatic, terrestrial and underground), anthropogenic and anthropized ecosystems,
2. structural characteristics = the diversity of its components,
3. functional characteristics = the manner in which they work as a unitary whole (the flows of substance, energy and information).

The fourth level of ecology is the **biogeographical territory**.

Taking into account the specialty geographical literature and the Wikypedia (English, French, German, etc.) sites on the internet from several countries, we noted that the term currently used, that of landscape, has a very wide range of uses. Since it has become generalized, and numerous treatises and even specialty magazines have

been published with this name, we shall not maintain the term of landscape (1, 2, 16, 18, 27, 29, 30, 31, 32), but shall propose the term biogeographical territory.

*A **biogeographical territory** is a large, relatively unitary, distinct territory (therefore well-delimited geographically), where different types of ecosystems - natural, anthropized or built by human beings - function in interdependence, coexist and influence each other and constitute a biogeographical unit distinct from those around it.*

The first thing when delimiting a biogeographical territory is that of obvious delimitation, from the ecological and geographical points of view. Its name must be taken from the specific names of the respective region, which have been used by the local population for a long time, but also taking into account the main functional factor which is defining for the respective geographical area.

Similarly to the study of the ecosystemic level, the biogeographical territory may have variable dimensions, from tens, to hundreds or thousands of square kilometers, and contain different types of ecosystems - natural, anthropized or created by man - but which, however, function in an obvious interdependence and which are all subordinated to a dominant environmental factor (biotic or abiotic). They may belong to a specific environment (terrestrial, aquatic or underground), or to a mixture of such environments, but they constitute a unitary ecological level, situated between the ecosystem and the biome.

We emphasize once again that when researching the natural systems of the planet, it is obvious that they can no longer be studied only descriptively, but increasingly from a functional point of view (and therefore necessarily from an ecological point of view). We must determine the manner in which they contribute - in time - to the evolution and functioning of the processes occurring in the biogeographical territories, the biomes, the ecosphere and the anthroposphere, as well as the manner in which they evolve.

The biogeographical territories are much fewer than the ecosystems, but more numerous than the components of the higher levels. Examples include the Danube Delta, the Apuseni Mountains, the large islands (Ceylon, Taiwan, Tasmania), the Great Barrier Reef, the Norwegian fjords, the Dead Sea, the Great African Rift, etc.

The fifth level of ecology is the **biome**.

***Biomes** are large ecological systems that function by carrying out interdependent activities between several types of ecosystems*. (26).

Ecologists and geographers give different names to the biomes established at the planetary level.

The ecologists have established the existence of the following 11 biomes: the tundra, the taiga, the temperate forest, the temperate steppe, the Mediterranean area, the desert, the tropical deciduous forest, the tropical shrubland, the savanna, the arid steppe, and the mountain area.

The ecologists believe that within them certain ecosystems are more numerous, therefore they have a dominant role (26). They "set the tone"/"give character" to the biome, because they are those that lead the ecological processes at the zonal level.

Usually, most of the names given to them are based on the dominant vegetation of these biogeographic territories.

The geographers distinguish only 5 biomes: Nearctic, Neotropical, Palearctic, Ethiopian, Oriental and Australian.

The biomes specify the major terrestrial areas of the planet, but do not include the marine/oceanic environment.

A common agreement between the specialists in these two fields of natural sciences remains to be reached concerning their future name.

The sixth level of ecology is the **ecosphere**.

The ecosphere *is the most complex layer of the earth, because its structure includes all the other living and non-living layers of the planet, which function as an integrated ecological system.* Everything on the surface of this planet depends on it. The ecosphere determines the uniqueness of planet Earth in the solar system. (22).

It determines the climate of the Earth, the biogeochemical circuits at the planetary level, all the energy flows, and the circulation of the information in the biosphere and toposphere.

The ecosphere is currently influenced by a new layer, the anthroposphere, a layer unconsciously created by humans and which is capable of producing serious disruptions to all the components of the current ecosphere.

The seventh level of ecology is the **anthroposphere**.

The species **Homo habilis** appeared approximately 200,000 years ago. The first humans were gatherers and hunters. They gradually spread from Africa, gradually conquering the entire planet. At present they occupy the entire terrestrial environment, many areas of the oceanic environment, they use the atmosphere, the pedosphere, the lithosphere and the hydrosphere, which they modify according to their will, launching transformations in varying degrees of all the natural systems of the plant, or even creating new biogeographical systems or areas. The anthroposphere began to form less than 10,000 years ago, and, at present, it is developing explosively, with only one goal: the strict satisfaction of the interests of *Homo sapiens*.

The main types of anthroposphere are:

- populations of "domesticated" or genetically modified plants, animals and protists (crops, domesticated animals, protists),
- natural terrestrial ecosystems transformed to develop only those organisms which are of human interest (ecosystems cultivated to provide food for humans or domestic animals),
- natural terrestrial or aquatic ecosystems on which at most 1-2 artificial ecosystems develop (for the in vivo or in vitro growth of a single species that is only of human interest) because the natural ones "become harmful" for the respective ecosystem,

- artificial ecological systems created and maintained entirely by humans, which produce only organisms or parts thereof that are for strictly human use (for food, used in medicine, or as biological weapons).

The present components of the anthroposphere at the populational and ecosystemic levels are: managed pastures, managed forests and forest nurseries, tree, shrub and vine plantations, agricultural crops, greenhouse crops, industrially raised plants and animals, fish farming, aquaculture, wastewater treatment plants, solid waste management plants, human settlements (from villages to megalopolises), developed tourist areas, anthropogenic corridors (air, water, soil and subsoil communication routes) and mines from which minerals useful to human kind are extracted.

Unfortunately, the effects of the anthroposphere, given the purpose of the emergence and the stimulation of its increasingly accentuated expansion, make its impacts to have, most of the time, very many negative effects, which affect not only all the living environments, but also all the levels of organization of the living matter and therefore, in the long term, all the ecological balances, from the local to the planetary level (3, 22).

Conclusions

Considering the levels of organization of the living matter as a whole, we must note that complex, interdisciplinary research of all the levels of organization of the living systems must be rapidly expanded, especially of those from the landscape level upwards (17).

These actions must be carried out simultaneously at the local and international levels, taking into account the major disruptive factor - the immediate human interests - as well as the effects that may reverberate at the cosmic level (because we are currently a being conquering the cosmos and we must not repeat elsewhere the mistakes we have made and are now making on our planet, consciously or unconsciously, for strictly selfish-human reasons).

This process must be carried out as fast as possible, starting now, because all the demographic studies on humans continue to predict an exponential increase of the density of the human population, simultaneously with the acceleration of the development of the technosphere, as well as of the most diverse technologies, such as AIs. Unfortunately, there is a lot of discussion on environmental protection, but it is done it too slowly, incorrectly, because, anyway, we are only interested in the interest of the human species.

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