Ecology is the branch of science that studies the distribution and abundance of living organisms, and the interactions between organisms and their environment. The environment of an organism includes both its physical habitat, which can be described as the sum of local abiotic factors like climate and geology, as well as the other organisms which share its habitat. The term was coined in 1866 by the German biologist Ernst Haeckel from the Greek *oikos* meaning "household" and *logos* meaning "science:" the "study of the household of nature."

Ecological systems are studied at several different levels from individuals and populations to ecosystems and biosphere level. Ecology is a multi-disciplinary science, drawing on many other branches of science.

Applied ecology is the practice of employing ecological principles and understanding to solve real world problems. Examples include measuring the economic worth of ecosystems, calculating fishing quotas, measuring environmental impact from construction or logging, building a case for the conservation of a species, and determining the most effective way to protect a species.

In a broader sense, **ecology** is can also mean:

- the natural environment, or
- an analysis or study using the principles and methods of ecology.

For example, human ecology looks at humans and their interactions with the natural environment. Political ecology takes on both alternative meanings, and may use ecology's methods in a new context by looking at interactions of societies and states rather than species or populations, but may also mean politics related to environmental issues.

Ecology, as a scientific discipline, does not itself dictate what is *right* or *wrong*. However maintaining *biodiversity* within ecosystems and related ecological goals (such as preventing species extinctions) have become scientific ways to express the goals of environmentalism and has given scientific methodology, measure, and terminology to environmental issues, making the two heavily linked. A holistic view is also stressed in both ecology and environmentalism.

Contents

Scope

Ecology is usually considered a branch of biology, the general science that studies living beings. These can be studied at several levels, from proteins and nucleic acids (in biochemistry and molecular biology), cells (in cellular biology), organisms (in botanics, zoology, and other similar disciplines), and finally at the level of populations, communities, and ecosystems — which are the subjects of ecology. Conversely, some people consider ecology to be the parent discipline and biology to be the sub-disciple, since ecology includes not only the interactions between organisms, but also their interactions with their surroundings.

Because of its focus on the broadest level of life and on the interrelations between living beings and their environment, ecology draws heavily on other branches of science, such as geology and geography, meteorology, pedology, chemistry, and physics. For this reason, ecology is often said to be a holistic science.

- the behavioural relationship between individuals of a species — for example, the study of the queen bee, and how it relates to the worker bees and the drones.
- the organized activity of a species — for example, the activity of the bee assures the pollination of flowering plants. A bee hive additionally produces honey which is consumed by other species, such as bears.
- and the environment of this activity — for example, the consequences of the environmental change on the bee activity. Bees may die out due to environmental changes (see pollinator decline). The environment at the same time both affects and is a consequence of this activity and is thus intertwined with the survival of the species.

Disciplines of ecology

Ecology is a broad science that encompasses many specialized branches, including

- animal ecology, plant ecology, marine ecology, and aquatic ecology;
- applied ecology, including agroecology and conservation biology
- behavioral ecology;
- chemical ecology, which deals with the ecological role of biological chemicals used in a wide range of areas including defense against predators and attraction of mates;
- community ecology or synecology, which studies the relations between one's community, in addition to individuals of different species within his environment, often using the concept of ecological succession;
- conservation ecology;
- The study of specific ecosystems;
- ecosystem ecology (or systems ecology) and biogeochemistry which focus on the flow of energy and nutrients within and among ecological units;
- ecophysiology which studies the relations between a single type of organism and the factors of its environment;
- ecotoxicology, which looks at the ecological role of toxic chemicals (often pollutants, but also naturally occurring compounds);
- evolutionary ecology or ecoevolution which looks at evolutionary changes in the context of the populations and communities in which the organisms exist;
- fire ecology, which looks at the role of fire in the environment of plants and animals and its effect on ecological communities.
- global ecology, which studies ecology on the scale of the ecosphere or biosphere (the totality of the space occupied by alive beings);
- landscape ecology, which examines ecological questions at the scale of the landscape and tries to understand how the arrangement of landscape elements (such as forest patches) influences the ecology of species within them;
- macroecology;
- molecular ecology, which attempts to address ecological questions at the molecular level, usually through by looking at DNA or allozymes;
- paleoecology, which seeks to understand the relationships between species in fossil assemblages, and in so doing gain insight into the way these species might have been shaped by their interactions with other species;
- polar ecology;
- population ecology or autecology, which studies the relations between a population of individuals of the same species and its environment;
- restoration ecology, which attempts to understand the functioning of ecosystems in order to restore human-impacted sites;
- soil ecology and microbial ecology;
- theoretical ecology is a broad term which generally refers to any approach to ecological questions which are addressed primarily in theoretical terms, usually through simulation and modelling;
- tropical ecology;
- urban ecology.

Ecology also plays important roles in many inter-disciplinary fields:

- ecological design and ecological engineering.
- ecological economics.
- human ecology and ecological anthropology.
- social ecology, ecological health and environmental psychology.

Finally, ecology has also inspired (and lent its name to) other non-biological disciplines such as

- industrial ecology.
- software ecology and information ecology.

Fundamental principles of ecology

Biosphere and biodiversity

Main articles: Biosphere, Biodiversity, Unified neutral theory of biodiversity

For modern ecologists, ecology can be studied at several levels: population level (individuals of the same species), biocenose level (or community of species), ecosystem level, and biosphere level.

The Earth, from an ecological point of view, consists of several compartments, the hydrosphere (or sphere of water), the lithosphere (or sphere of soils and rocks) and the atmosphere (or sphere of the air). The biosphere, sometimes described as fourth envelope, is the part of the planet on which the life developed. It is a very thin surface layer, which goes down to 11000 meters of depth to rising up to 15000 meters of altitude, although the majority of life live in the zone located between -100 meters and +100 meters.

Life first developed in the hydrosphere, at low depth, in the photic zone. Multicellular organisms then appeared and colonized benthic zones. Terrestrial life developed later, after the ozone layer protecting living beings from UV rays formed. Diversification of terrestrial species is thought to be increased by the continents drifting apart, or alternately, colliding. Biosphere and biodiversity are inseparable characteristics of the Earth. Biosphere is defined as being the sphere of life, whereas biodiversity is its diversity. The sphere is the container, whereas diversity is the contents. This diversity is expressed at the same time at the ecological level (ecosystem), population level (intraspecific diversity) and species level (specific diversity).

The biosphere contains great quantities of elements such as carbon, nitrogen and oxygen. Other elements, such as phosphorus, calcium, and potassium, are also essential to life. At the ecosystem and biosphere level, there is a permanent recycling of all these elements, which alternate between the mineral state and the organic state.

While there is a slight input of geothermal energy, the bulk of the functioning of the ecosystem is primarily based on the input of solar energy. Plants convert light into chemical energy by the process of photosynthesis, which creates glucose (a simple sugar) and releases free oxygen. Glucose thus becomes the secondary energy source which drives the ecosystem. Some of this glucose is used directly by other organisms for energy. Other sugar molecules can be converted to other molecules such as amino acids. Plants use some of this sugar, concentrated in nectar to entice pollinators to aid them in reproduction. *(Honeybees concentrate the sugar still further as honey, which can be said to be "stored summer sunshine"*).

Cellular respiration is the process by which organisms (like mammals) breakdown the glucose back to its constituents, water and carbon dioxide, gaining back the stored energy the sun originally gave to the plants. The proportion of photosynthetic activity of plants to the respiration of other organisms determines the specific composition of the Earth's atmosphere, particularly its oxygen level. Global air currents mix the atmosphere and maintain nearly the same balance in areas of intense biological activity and areas of slight biological activity.

Water is also exchanged between the hydrosphere, the lithosphere, the atmosphere and the biosphere in regular cycles. The oceans are large tanks, which store water, ensure a thermal and climatic stability, as well as the transport of the chemical elements thanks to large oceanic currents.

For better understanding of how the biosphere works, and the dysfunctions related to human activity, American scientists carried out, under greenhouses, a small-scale model of the biosphere, called Biosphere II.

The concept of an ecosystem

Main article: Ecosystem

The first principle of ecology is that each living organism has an ongoing and continual relationship with every other element that makes up its environment. An ecosystem can be defined as any situation where there is interaction between organisms and their environment.

The ecosystem is composed of two entities, the entirety of life (called the biocenose) and the medium that life exists in (the biotope). Within the ecosystem, species are connected and dependent upon one another in the food chain, and exchange energy and matter between themselves and with their environment.

The concept of an ecosystem can apply to units of variable size, such as a pond, a field, or a piece of deadwood. A unit of smaller size is called a *microecosystem*. For example, an ecosystem can be a stone and all the life under it. A *mesoecosystem* could be a forest, and a *macroecosystem* a whole ecoregion, with its watershed.

The main questions when studying an ecosystems are:

- how could be carried out the colonization of an arid area?
- What are the ecosystems dynamics and changes
- how does an ecosystem interact at local, regional and global scale
- is the current state stable?
- what is the value of an ecosystem? How does the interaction of ecological systems provide benefit to humans, especially in the provision of healthy water?

Ecosystems are often classified by reference to the biotopes concerned. The following ecosystems may be defined :

- as continental ecosystems (or terrestrial), such as forest ecosystems, meadow ecosystems (meadows, steppes, savannas), or agro-ecosystems (agricultural systems).
- as ecosystems of inland waters, such as lentic ecosystems (lakes, ponds) or lotic ecosystems (rivers)
- as oceanic ecosystems (seas, oceans).

Another classification can be done by reference to its communities (for example a human ecosystem).

Dynamics and stability

Main articles: ecological factor, geobiochemical cycle, Homeostasis, Population dynamics

The biotope is a region environmentally uniform, characterized by a whole set of geological, geographical and climatological parameters, which are called abiotic ecological factors:

- water, is at the same time, an essential element to life, as well as a milieu
- air, which provides oxygen and carbon dioxide to living species, and allows the dissemination of pollen and spores
- soil, at the same time source of nutriment and support of development
- temperature, which should not exceed certain extremes, even if tolerance to heat is significant for some species
- light, allowing photosynthesis.

Biocenose, or community, is a group of populations of plants, animals, micro-organisms. Each population is the result of procreations between individuals of same species and cohabiting in a given place and at a given time. When a population consists of an insufficient number of individuals, the species is threatened with extinction, either by underpopulation, or by because of consanguinity. A population can be reduced for several reasons, for example, disappearance of its habitat (destruction of a forest) or by excessive predation (such as the hunting of a given species).

Biocenose is characterized by biotic ecological factors of two types: intraspecific and interspecific relations.

Intraspecific relations are those which are established between individuals of the same species, forming a population. They are relations of co-operation or competition, with division of the territory, and sometimes organization in hierarchical societies.

Interspecific relations, i.e. those existing between different species, are numerous, and usually described according to their beneficial, detrimental or neutral effect (for example, symbiosis (relation ++) or competition (relation --)). The most significant relation is the relation of predation (to eat or to be eaten), which leads to the essential concepts in ecology of food chains (for example, the grass is consumed by the herbivore, itself consumed by a carnivore, itself consumed by a carnivore of larger size). Ecological niche is the area shared by two species when they live at the same place with the same type of diet.

The existing interactions between the various living beings go along with a permanent mixing of mineral and organic substances, absorbed by organisms for their growth, their maintenance and their reproduction, to be finally rejected as waste. These permanent recyclings of the elements (in particular carbon, oxygen and nitrogen) as well as the water are called biogeochemical cycles. They guarantee a durable stability of the biosphere (at least when human influence and extreme weather phenomena are left aside). This self-regulation, supported by negative feedback controls, ensures the perenniality of the ecosystems. It is shown by the very stable concentrations of most elements of each compartment. This is referred to as homeostasis. The ecosystem also tends to evolve to a state of ideal balance, reached after a succession of events, the climax (for example a pond can become a peat bog).

Spatial relationships and subdivisions of land

Main articles: Biome, ecozone

Ecosystems are not isolated from each other, but are interrelated. For example, water may circulate between ecosystems by the means of a river or ocean current. Water itself, as a liquid medium, even defines ecosystems. Some species, such as salmon or freshwater eels move between marine systems and fresh-water systems. These relationships between the ecosystems lead to the concept of a *biome*.

A biome is a homogeneous ecological formation that exists over a vast region, such as tundra or steppes. The biosphere comprises all of the Earth's biomes -- the entirety of places where life is possible -- from the highest mountains to the depths of the oceans.

Biomes correspond rather well to subdivisions distributed along the latitudes, from the equator towards the poles, with differences based on to the physical environment (for example, oceans or mountain ranges) and to the climate. Their variation is generally related to the distribution of species according to their ability to tolerate temperature and/or dryness. For example, one may find photosynthetic algae only in the *photic* part of the ocean (where light penetrates), while conifers are mostly found in mountains.

Though this is a simplification of more complicated scheme, latitude and altitude approximate a good representation of the distribution of biodiversity within the biosphere. Very generally, the richness of biodiversity (as well for animal than plant species) is decreasing most rapidly near the equator (as in Brazil) and less rapidly as one approaches the poles.

The biosphere may also be divided into ecozone, which are very well defined today and primarily follow the continental borders. The ecozones are themselves divided into ecoregions, though there is not agreement on their limits.

Ecosystem productivity

In an ecosystem, the connections between species are generally related to food and their role in the food chain. There are three categories of organisms:

- *producers* -- plants which are capable of photosynthesis
- *consumers* -- animals, which can be primary consumers (herbivorous), or secondary or tertiary consumers (carnivorous).
- *decomposers* -- bacteria, mushrooms which degrade organic matter of all categories, and restore minerals to the environment.

These relations form sequences, in which each individual consumes the preceding one and is consumed by the one following, in what are called food chains or food network. In a food network, there will be fewer organisms at each level as one follows the links of the network up the chain.

These concepts lead to the idea of biomass (the total living matter in a given place), of primary productivity (the increase in the mass of plants during a given time) and of secondary productivity (the living matter produced by consumers and the decomposers in a given time).

These two last ideas are key, since they make it possible to evaluate the load capacity -- the number of organisms which can be supported by a given ecosystem. In any food network, the energy contained in the level of the producers is not completely transferred to the consumers. Thus, from an energy point of view, it is more efficient for humans to be primary consumers (to get nourishment from grains and vegetables) than as secondary consumers (from herbivores such as beef and veal), and more still than as a tertiary consumer (from eating carnivores).

The productivity of ecosystems is sometimes estimated by comparing three types of land-based ecosystems and the total of aquatic ecosystems:

- the forests (1/3 of the Earth's land area) contain dense biomasses and are very productive. The total production of the world's forests corresponds to half of the primary production.
- savannas, meadows, and marshes (1/3 of the Earth's land area) contain less dense biomasses, but are productive. These ecosystems represent the major part of what humans depend on for food.
- extreme ecosystems in the areas with more extreme climates -- deserts and semi-deserts, tundra, alpine meadows, and steppes -- (1/3 of the Earth's surface) have very sparse biomasses and low productivity
- finally, the marine and fresh water ecosystems (3/4 of Earth's surface) contain very sparse biomasses (apart from the coastal zones).

Humanity's actions over the last few centuries have seriously reduced the amount of the Earth covered by forests (deforestation), and have increased agro-ecosystems (agriculture). In recent decades, an increase in the areas occupied by extreme ecosystems has occurred (desertification).

Ecological crisis

Generally, an ecological crisis is what occurs when the environment of life of a species or a population evolves in an unfavourable way to its survival.

It may be that the environment quality degrades compared to the species needs, after a change of abiotic ecological factor (for example, an increase of temperature, less significant rainfalls).
It may be that the environment becomes unfavourable for the survival of a species (or a population) due to an increase pressure of predation (for example overfishing).
Lastly, it may be that the situation becomes unfavourable to the quality of life of the species (or the population) due to rise in the number of individuals (overpopulation).

Ecological crises may be more or less brutal (occurring between a few months to a few million years). They can also be of natural or anthropic origin. They may relate to one unique species or on the contrary, to a high number of species (see the article on Extinction event).

Lastly, an ecological crisis may be local (as an oil spill) or global (a rise in the sea level related to global warming).

According to its degree of endemism, a local crisis will have more or less significant consequences, from the death of many individuals to the total extinction of a species. Whatever its origin, disappearance of one or several species often will involve a rupture in the food chain, further impacting the survival of other species.

In the case of a global crisis, the consequences can be much more significant; some extinction events showed the disappearance of more than 90% of existing species at that time. However, it should be noted that the disappearance of certain species, such as the dinosaurs, by freeing an ecological niche, allowed the development and the diversification of the mammals. An ecological crisis thus paradoxically favored biodiversity.

Sometimes, an ecological crisis can be a specific and reversible phenomenon at the ecosystem scale. But more generally, the crises impact will last. Indeed, it rather is a connected series of events, that occur till a final point. From this stage, no return to the previous stable state is possible, and a new stable state will be set up gradually (see homeorhesy).

Lastly, if an ecological crisis can cause extinction, it can also more simply reduce the quality of life of the remaining

individuals. Thus, even if the diversity of the human population is sometimes considered threatened (see in particular indigenous people), few people envision human disappearance at short span. However, epidemic diseases, famines, impact on health of reduction of air quality, food crises, reduction of living space, accumulation of toxic or non degradable wastes, threats on keystone species (great apes, panda, whales) are also factors influencing the well-being of people.

During the past decades, this increasing responsibility of humanity in some ecological crises has been clearly observed. Due to the increases in technology and a rapidly increasing population, humans have more influence on their own environment than any other ecosystem engineer.

Some usually quoted examples as ecological crises are

- Permian-Triassic extinction event 250 million of years ago
- Cretaceous-Tertiary extinction event 65 million years ago
- global warming related to the greenhouse effect. Warming could involve flooding of the Asian deltas (see also ecorefugees), multiplication of extreme weather phenomena and changes in the nature and quantity of the food resources (see Global warming and agriculture)
- Ozone layer hole issue
- Deforestation and desertification, with disappearance of many species.
- The nuclear meltdown at Chernobyl in 1986 caused the death of many people and animals from cancer, and caused mutations in a large number of animals and people. The area around the plant is now abandoned because of the large amount of radiation generated by the meltdown.

History of ecology

One of the first ecologists may have been Aristotle who had interest in many species of animals. He was followed by numerous naturalists such as Buffon and Carolus Linnaeus, whose work is usually considered the origin of modern ecology.

The botanical geography and Alexander von Humboldt

Throughout the 18th and the beginning of the 19th century, the great maritime powers such as Britain, Spain, and Portugal launched many world exploratory expeditions to develop maritime commerce with other countries, and to discover new natural resources, as well as to catalog them. At the beginning of the 18th century, about twenty thousand plant species were known, versus forty thousand at the beginning of the 19th century, and almost 400,000 today.

These expeditions were joined by many scientists, including botanists, such as the German explorer Alexander von Humboldt. Humboldt is often considered the true father of ecology. He was the first to take on the study of the relationship between organisms and their environment. He exposed the existing relationships between observed plant species and climate, and described vegetation zones using latitude and altitude, a discipline now known as geobotany.

In 1804, for example, he reported an impressive number of species, particularly plants, for which he sought to explain their geographic distribution with respect to geological data. One of Humboldt's famous works was "Idea for a Plant Geography" (1805).

Other important botanists include Aimé Bonpland and Eugenius Warming.

The notion of biocenose: Charles Darwin and Alfred Wallace

Towards 1850 there was a breakthrough in the field with the publishing of the work of Charles Darwin on The Origin of Species: Ecology passed from a repetitive, mechanical model to a biological, organic, and hence evolutionary model.

Alfred Russel Wallace, contemporary and competitor to Darwin, was first to propose a "geography" of animal species. Several authors recognized at the time that species were not independent of each other, and grouped them into plant species, animal species, and later into communities of living beings or biocenose. This term was coined in 1877 by Karl Möbius.

The biosphere - Eduard Suess and Vladimir Vernadsky

By the 19th century, ecology blossomed due to new discoveries in chemistry by Lavoisier and de Saussure, notably the nitrogen cycle. After observing the fact that life developed only within strict limits of each compartment that makes up the atmosphere, hydrosphere, and lithosphere, the Austrian geologist Eduard Suess proposed the term biosphere in 1875. Suess proposed the name biosphere for the conditions promoting life, such as those found on Earth, which includes flora, fauna, minerals, matter cycles, et cetera.

In the 1920s Vladimir I. Vernadsky, a Russian geologist who had defected to France, detailed the idea of the biosphere in his work "The biosphere" (1926), and described the fundamental principles of the biogeochemical cycles. He thus redefined the biosphere as the sum of all ecosystems.

First ecological damages were reported in the 18th century, as the multiplication of colonies caused deforestation. Since the 19th century, with the industrial revolution, more and more pressing concerns have grown about the impact of human activity on the environment. The term ecologist has been in use since the end of the 19th century.

The ecosystem: Arthur Tansley

Over the 19th century, botanical geography and zoogeography combined to form the basis of biogeography. This science, which deals with habitats of species, seeks to explain the reasons for the presence of certain species in a given location.

It was in 1935 that Arthur Tansley, the British ecologist, coined the term ecosystem, the interactive system established between the biocenose (the group of living creatures), and their biotope, the environment in which they live. Ecology thus became the science of ecosystems.

Tansley's concept of the ecosystem was adopted by the energetic and influential biology educator Eugene Odum. Along with his brother, Howard Odum, Eugene P. Odum wrote a textbook which (starting in 1953) educated more than one generation of biologists and ecologists in North America.

Human ecology

Human ecology began in the 1920s, through the study of changes in vegetation succession in the city of Chicago. It became a distinct field of study in the 1970s. This marked the first recognition that humans, who had colonized all of the Earth's continents, were a major ecological factor. Humans greatly modify the environment through the development of the habitat (in particular urban planning), by intensive exploitation activities such as logging and fishing, and as side effects of agriculture, mining, and industry. Besides ecology and biology, this discipline involved many other natural and social sciences, such as anthropology and ethnology, economics, demography, architecture and urban planning, medicine and psychology, and many more. The development of human ecology led to the increasing role of ecological science in the design and management of cities.

James Lovelock and the Gaia hypothesis

The Gaia theory, proposed by James Lovelock, in his work *Gaia: A New Look at Life on Earth*, advanced the view that the Earth should be regarded as a single living macro-organism. In particular, it argued that the ensemble of living organisms has jointly evolved an ability to control the global environment — by influencing major physical parameters as the composition of the atmosphere, the evaporation rate, the chemistry of soils and oceans — so as to maintain conditions favorable to life.

This vision was largely a sign of the times, in particular the growing perception after the Second World War that human activities such as nuclear energy, industrialization, pollution, and overexploitation of natural resources, fueled by exponential population growth, were threatening to create catastrophes on a planetary scale. Thus Lovelock's Gaia hypothesis, while controversial among scientists, was embraced by many environmental movements as an inspiring view: their *Earth-mother*, Gaia, was "becoming sick from humans and their activities".

Conservation and environmental movements

Indeed, since the 19th century, ecology has been obviously relevant to social and philosophical movements related to protection of the natural environment, such as conservationism and environmentalism. Today ecology is a major political topic, and a source of ideology for major political organizations such as the Green Party and Greenpeace.

Ecology and global policy

Ecology became a central part of the World's politics as early as 1971, UNESCO launched a research program called *Man and Biosphere*, with the objective of increasing knowledge about the mutual relationship between humans and nature. A few years later it defined the concept of Biosphere Reserve.

In 1972, the United Nations held the first international conference on the human environment in Stockholm, prepared by Rene Dubos and other experts. This conference was the origin of the phrase "Think Globally, Act Locally". The next major events in ecology were the development of the concept of biosphere and the appearance of terms "biological diversity" -- or now more commonly biodiversity -- in the 1980s. These terms were developed during the Earth Summit in Rio de Janeiro in 1992, where the concept of the biosphere was recognized by the major international organizations, and risks associated with reductions in biodiversity were publicly acknowledged.

Then, in 1997, the dangers the biosphere was facing were recognized from an international point of view at the conference leading to the Kyoto Protocol. In particular, this conference highlighted the increasing dangers of the greenhouse effect -- related to the increasing concentration of greenhouse gases in the atmosphere, leading to global changes in climate. In Kyoto, most of the world's nations recognized the importance of looking at ecology from a global point of view, on a worldwide scale, and to take into account the impact of humans on the Earth's environment.

See also

- ELDIS, a database on ecological aspects of economical development.
- List of ecology topics
- List of environment topics
- List of biology topics
- List of planned cities

- Important publications in ecology

External links

- *Dictionary of the History of Ideas*: Environment
- *Environmental Portal*: Environmental Portal
- Ecology Database

General subfields within biology

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ecological succession	eclipsis	econometrics	Economic and Social Council commission
ecological niche	eclipse	econometrist	Economic Commission for Africa
ecologically	eclectic method	economic	Economic Commission for Asia and the Far East
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