Topic #2

The body as a living holistic system. Levels of biological organization as objects of study in ecology. Trophic levels: concept and ecological functions

Motivation

Any living being is an organism. It differs from inanimate nature by a certain set of properties inherent only in living matter: cellular organization, metabolism with the leading role of proteins and nucleic acids, which ensures homeostasis organism - self-renewal and maintenance of the constancy of its internal environment. Living organisms are characterized by movement, irritability, growth, development, reproduction and heredity, as well as adaptability to the conditions of existence - adaptation.

Gene, cell, organ, organism, population, community (biocenosis) —are the main levels of life organization. Ecology studies the levels of biological organization from organism to ecosystems. It is based, like all biology, on the theory of the evolutionary development of the organic world by Charles Darwin, based on the ideas of natural selection. In a simplified form, it can be represented as follows: as a result of the struggle for existence, the most adapted organisms survive, which transmit beneficial traits that ensure survival to their offspring, which can develop them further, ensuring the stable existence of this type of organisms in given specific environmental conditions. If these conditions change, then organisms with traits that are more favorable for the new conditions, transmitted to them by inheritance, survive, etc.

The purpose is: to study the basic properties and levels of organization of living matter. To form an idea of trophic relationships in the biosphere and the logic of energy transitions along trophic levels.

Question for oral questioning:

1. Connections in Nature
2. General ecological maxims
3. The boundaries between living and non-living matter. Phenomena of anabiosis.
4. Levels of organization of the living, features of the ecological approach to their study.
5. Trophic chain in an ecosystem.

Topic for personal report:

1. Generalized Lotka-Volterra model

List of knowledge and practical skills

After mastering the topic, the student should know: the concepts of levels of organization of living things, trophic levels and their ecological functions.

After mastering the topic, the student should be able to: identify the fundamental properties of living and inanimate matter, evaluate the spatial structure of the organization of trophic relationships in ecosystems, identify differences between different levels of organization of living things and evaluate ecological approaches to their study.

Independent work of students in the classroom

1. Solving a situational professionally oriented problem, documenting the solution in a protocol.
2. Watch an educational video on the topic of the lesson.
3. Completing assignments on the topic “ The body as a living integral system.” Levels of biological organization as objects of study in ecology. Trophic levels: concept and ecological functions ."

Tasks

1. After becoming familiar with the basic theoretical axioms of biology, take part in the discussion "**Can viruses be considered living organisms?** "
2. Solve test questions.

1. The organisms that make up the food chain and receive food through an equal number of links in this chain belong to the same ...

a) trophic level

b) trophic structure

2. As a result of the successive transfer of matter and energy through trophic levels, each ecosystem establishes its own ...

a) food chain

b) trophic structure

3. Ecologists depict the trophic structure:

a) around

b) a pyramid

c) a square

4. In the process of the circulation of substances in the biosphere, decomposers ...

a) participate in the formation of organic substances from inorganic

b) use sunlight to synthesize nutrients

c) decompose organic residues and use the energy contained in them

4) absorb carbon dioxide and oxygen

5. Which food chain correctly reflects the transfer of energy in it?

a) fox → earthworm → shrew → leaf litter

b) leaf litter → earthworm → shrew → fox

c) shrew → earthworm → leaf litter → fox

d) shrew → fox → earthworm → leaf litter

6. In detrital food chains, the following occurs:

a) mineralization of organic residues

b) reduction of carbon dioxide

c) consumption of live plants

d) the formation of organic substances

7. The first link in the grazing chains of terrestrial communities is represented by ...

a) bacteria

b) mushrooms

c) animals

d) plants

8. The level at which the processes of biogenic migration of atoms are studied is called:

a) biogeocenotic

b) biospheric

c) population-species

d) molecular genetic

9. At the population-species level, they study

a) gene mutations

b) organ systems

c) the relationship of organisms of the same species

d) metabolic processes in the body

10. The water cycle in nature is observed at the level of life organization:

a) population-species

b) biospheric

c) organism

11. The living matter of the land reflects the level of organization of the living:

a) ecosystem

b) organism

c) biosphere

12. The similarity of the elementary composition of a cell and bodies of inanimate nature indicates :

a) the material unity of living and inanimate nature

b) dependence of living nature on inanimate

c) the complex chemical composition of living and inanimate bodies

13. Establish a correspondence between the levels of organization of living things and their characteristics and phenomena occurring at these levels: biocenotic:

a) transfer of energy from producers to consumers

b) processes cover the entire planet

c) interspecies struggle for existence

14. Establish a correspondence between the levels of organization of living things and their characteristics and phenomena occurring at these levels: biospheric:

a) symbiosis

b) processes cover the entire planet

c) interspecies struggle for existence

15. Living from non-living is different:

a) the ability to change the properties of an object under the influence of the environment

b) the ability to participate in the cycle of substances

c) the ability to reproduce their own kind

16. Living from non-living is different:

a) openness to substances, energy and information

b) the ability to change the properties of an object under the influence of the environment

c) change the size of an object under the influence of the environment

17. All living organisms are characterized by:

a) the formation of organic substances from inorganic substances

b) active movement in space

c) irritability

18. The cellular level of organization coincides with the organismic level in:

a) the polio virus

b) amoeba dysentery

c) bacteriophages

Reference material

Classification of interspecies relationships

In biocenoses, certain connections (biotic relationships) arise between different types of organisms. The main form of these connections are food relations (trophic connections). *Trophic* relationships occur between species when one

species feeds on others: living individuals, dead remains, waste products. Of course, in each system there are also topical connections (manifested in a change in the living conditions of another species by one species), and *phoric* connections (they arise when one species participates in the spread of another), and *factory* connections (consist in the fact that one species uses for of their structures, excreta, dead remains, or even living individuals of another species).

1. According to trophic indicators, i.e., the nutritional relationships of organisms that regulate the entire energy of biotic communities and the entire ecosystem as a whole. Autotrophic organisms use inorganic sources for their existence, thereby creating organic matter from inorganic matter. Such organisms include photosynthetic green plants of land and aquatic environments, blue-green algae, some bacteria due to chemosynthesis, etc. Heterotrophic organisms consume only ready-made organic substances. These include all animals and humans, fungi, etc. Heterotrophs that consume dead organic matter are called saprotrophs (for example, fungi), and those that can live and develop in living organisms at the expense of living tissues are called —parasites (for example, ticks).

2. Since organisms are quite diverse in types and forms of nutrition, they enter into complex trophic interactions with each other, thereby performing the most important ecological functions in biotic communities. Some of them produce products, others consume, others convert it into an inorganic form. They are called respectively: *producers* , *consumers* and *decomposers* .

Producers —producers of products that all other organisms then feed on —are terrestrial green plants, microscopic sea and freshwater algae, producing organic substances from inorganic compounds.

Consumers —These are consumers of organic substances. Among them there are animals that eat only plant foods —- herbivores (cows) or carnivores (carnivores) that eat only the meat of other animals , as well as —"omnivores" (humans, bears) who consume both .—

Reducers (destructors) —reducers. They return substances from dead organisms back to inanimate nature, decomposing organic matter into simple inorganic compounds and elements (for example, into CO_2, NO_2 and H_2O). By returning nutrients to the soil or aquatic environment, they complete the biochemical cycle. This is done mainly by bacteria, most other microorganisms and fungi.

1. By type of respiration (participation of O_2). Microorganisms, bacteria and other more complex forms, depending on the habitat, are divided into aerobic, that is, living in the presence of oxygen, and anaerobic —living in an oxygen-free environment.

Food chains are divided into two main types - *grazing* (consumption chains) and *detrital* (decomposition chains). Grazing chains start with a green plant and lead to the organisms that eat those plants—grazing herbivores—and then to herbivorous predators or parasites. An example would be meadow communities with herbivores grazing on them, which are hunted by predators. Detrital chains start from the organic matter of dead organisms or their parts and then lead to organisms that feed on this decaying ("dead") organic matter (*detritivores*) and their consumers (*predators*).

The detritus food chain is characteristic of aquatic ecosystems. In forests, there are grazing and detrital food chains, which are interconnected by predators that eat both herbivores and animals that feed on fallen organic matter. Food chains are not isolated from each other, but are closely intertwined. Their plexuses are often called the food web. In a complex natural community, organisms that obtain their food from plants through the same number of stages are considered to belong to the same trophic level.

The trophic level is also defined as a set of organisms united by one type of nutrition, occupying a certain position in the general food chain. Green plants occupy the first trophic level - the level *of producers* , herbivores - the second, or the level *of consumers of the 1st order* (these include various animals - many insects, rodents, ungulates, etc.), predators that eat herbivorous animals - the third (*level 2nd order consumers* , secondary consumers), secondary predators - fourth (level of 3rd order

consumers , *tertiary consumers*), etc. For example, a predatory beetle eating a herbivorous caterpillar belongs to the first order predators; an insectivorous bird eating a predatory beetle is a predator of the second order, and a falcon attacking it is a predator of the third order. So, the first consumers of energy in ecosystems are plants, the second - herbivorous animals or phytophages. Subsequent consumers of energy are animals that feed on other animals (zoophages, including parasites, predators). After the death of organisms, dead organic matter, semi-decomposed remains are used by bacteria, fungi, and some animals - *decomposers* (dead beetles, dung beetles, vultures, hyenas, etc.).

At each stage of energy transfer, a significant part of it (on average 90%) is lost, since in any part of the food chain food is used for growth, is spent on meeting energy costs for respiration, movement, reproduction, and maintaining body temperature. Let us assume that at the first trophic level, in the process of photosynthesis, green plants store 1,000,000 units of conventional energy, then only 100 will remain at the fifth level. The efficiency of product transfer between neighboring trophic levels is, therefore, on average 10%. The action in nature of this pattern limits the possible number of links in the food chain, usually to 4–5. The shorter the food chain, the greater the amount of final, available energy, the greater the production can be removed at the next link.

If the species included in the trophic network are ordered by groups (producers, consumers) and by trophic levels (consumers of the first order, second, etc.), then we can talk about the trophic structure of a given biocenosis, ecosystem (biogeocenosis).

There are different levels of existence of living matter - from large molecules to plants and animals of various organizations.

1. *Molecular (genetic)* - the lowest level at which a biological system manifests itself in the form of the functioning of biologically active large molecules - proteins, nucleic acids, carbohydrates. From this level, properties that are

characteristic exclusively of living matter are observed: the metabolism that occurs during the transformation of radiant and chemical energy, the transmission of heredity with the help of DNA and RNA. This level is characterized by the stability of structures in generations.

2. *Cellular* - the level at which biologically active molecules are combined into a single system. With regard to cellular organization, all organisms are divided into unicellular and multicellular.

3. *Tissue* - the level at which the combination of homogeneous cells forms tissue. It covers a collection of cells united by a common origin and functions.

4. *Organ* - the level at which several types of tissues functionally interact and form a specific organ.

5. *Organismic* - the level at which the interaction of a number of organs is reduced into a single system of the individual organism. Represented by certain types of organisms.

6. *Population-species* , where there is a set of certain homogeneous organisms related by unity of origin, way of life and habitat. At this level, elementary evolutionary changes in general occur.

7. *Biocenosis and biogeocenosis (ecosystem)* - a higher level of organization of living matter, uniting organisms of different species composition. In biogeocenosis, they interact with each other on a certain area of the earth's surface with homogeneous abiotic factors.

8. *Biospheric* - the level at which a natural system of the highest rank was formed, covering all manifestations of life within our planet. At this level, all cycles of matter occur on a global scale, associated with the vital activity of organisms.

Features of the living *B. M. Mednikov (1982)* formulated in the form of **axioms of theoretical biology:**

1. All living organisms turn out to be a unity of a phenotype and a program for its construction (genotype), which is inherited from generation to generation *(A. Weisman's axiom).*

2. The genetic program is formed in a matrix way. The gene of the previous generation is used as a matrix on which the gene of the future generation is built *(N.K. Koltsov's axiom).*

non-directionally as a result of various reasons , and only by chance can such changes be successful in a given environment *(Ch. Darwin's 1st axiom).*

4. Random changes in genetic programs during the formation of the phenotype increase many times over *(axiom of N. V. Timofeev-Resovsky).*

5. Repeatedly enhanced changes in genetic programs are subject to selection by environmental conditions *(2nd axiom of Charles Darwin).*

From these axioms one can derive all the basic properties of living nature, and primarily such as discreteness and integrity - two fundamental properties of the organization of life on Earth. Among living systems there are no two identical individuals, populations and species. This unique manifestation of discreteness and integrity is based on the phenomenon of convariant reduplication.

Convariant reduplication (self-reproduction with changes) is carried out on the basis of the matrix principle (the sum of the first three axioms). This is probably the only property specific to life, in the form of its existence on Earth known to us. It is based on the unique ability for self-reproduction of the main control systems (DNA, chromosomes, genes).